STUDIES ON THE QUALITY AND PROCESS CONTROL FACTORS DURING THE PRODUCTION AND STORAGE OF SALTED DRIED FISH PRODUCTS

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CERTIFICATE

This is to certify that this thesis is an authentic record of research work carried out by Shri. **N.John Chellappan**, under my supervision and guidance in the **School of Industrial Fisheries, Cochin University of Science and Technology** in partial fulfillment of the requirements for the degree of Doctor of Philosophy and no part there of has been submitted for any other degree.

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Chapter 1

GENERAL INTRODUCTION

1. Introduction

1.1.India

India has a total coastline of about 8129 km along the East and West Coasts. The continental shelf area is 0.512 million Sq k.m. with an exclusive economic zone of 20.2 lakh sq. km (Anon 1993a). India ranks seventh in the marine fish production and 2nd in the inland fish production in the world. The total active fisherman population is 5.5 million and about 6.8 million people are employed in fishing and related activities. The fishing activities are carried out in the West and East Coasts. According to Diwan (2000) harvestable marine resource in EEZ was estimated as 3.93 tonnes and consists of 2.02 million tonnes of demersal, 1.67 million of pelagic fishes and 0.24 million of oceanic resources. Monsoon season from June to August lands pelagic and crustacean fishes. The general catch composition is predominated by pelagic fishes (45%) followed by demersal fishes (41%) crustaceans (12%) and cephalopods (2%) (Anon, 1997).

1.1.2. Fish utilisation

The utilisation of fish depends on the type of fish landed. The fish landing during 1997, 1998 and 1999 2001 and 2002 in India was mackerel 8.2, 6.64, 8.62, 3.87 and 3.62 % ribbonfish; 6.41, 4.26, 5.12, 7.56 and 7.41 % and shark 1.64, 1.78, 1.71, 1.49 and 1.40 % in the respective years of the total catch (Anon., 1999, 2000b, 2003a). Most of the fishes landed (66 %) are consumed in fresh condition, 16 % is used for drying or curing, only 7 % is used for freezing and 1 % is used for canning. The per capita consumption of fish is 3.3 kg in 1997 (Anon., 1997). The current per capita consumption is 10 kg / annum and 56 % of the Indian population is fish consumers (Diwan, 2000). The total quantity of dried items exported during 2000 – 01 was 7532.21 tonnes and value was 7022.15 Rs in lakh, of which 4.91% was dried shark and 52.64% was dried fish. The total quantity of dried items exported during 2001 – 02 was 8306.69 tonnes and value was 6795.54 Rs in lakh, of which 1.69% was dried shark and 39.89% was dried

1.2.2. Present status

The state has 9 maritime districts. They are Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Trichur, Kozhikode, Kasargode, Malappuram and Kannur. Important landing centres are Neendakara in Kollam district, Munambam in Ernakulam district and Calicut in Kozhikode district. There are 222 fishing villages in these districts (Anon., 2000a). The people of these districts are engaged in fish curing / drying activities. The landing of mackerel in Quilon district was 4.83, 6.10 and 9.54 % and ribbonfish was 5.06, 6.56 and 4.47 % and shark was 2.10, 1.86 and 1.03 % respectively during 1997, '98 and '99. The landing of mackerel in Ernakulam district was 10.24, 3.83 and 6.13 % and ribbonfish was 6.80, 1.97 and 4.66 % and shark was 0.45, 0.45 and 0.59 % respectively during above period. The landing of mackerel in Kozhikode District was 13.01, 7.45 and 10.55 and ribbonfish 5.25, 4.19 and 0.95 % and shark 0.71, 0.42 and 0.92 % respectively during the above years out of the district – wise total landings (Anon., 2000a).

The state has many landing centres and fishing villages along the coast. About 61 % of the total landings are consumed in the fresh condition and the remaining part is utilised by various fish based industries. The arrival of the Indo-Norwegian Project during 1962, in the state helped heavy movement in the offshore fishing and allied fields and also in fish processing. The important fishes landed are shrimp, cuttlefish, squid, and other fishes. The important species of fish as sardine, prawns, mackerel, sharks, silver bellies, horse mackerel, sole and ribbon fish. But boat owners as well as the crew do not care about bycatch fishes or low value fishes. In most centres, low value fishes are thrown out in the sea. This weakens the preparation and production of dry fish. During the peak season, facility to preserve the fishes is not usually available. In order to avoid the difficulties, fishes are used as manure for coconut, palm or for other plantations. Further large-scale drying units are not available in Kerala Coast. According to Anon

(1984) salting and drying do not require much investment and is unorganised and the margin is also less.

1.3. Fish salting, drying and storage

Fish salting is a primitive and easy method to preserve fish at low expenditure and minimum manpower only is required to produce good quality preserved fish. It can be stored at room temperature for a short period without extra cost. The common salt is added and mixed and kept for short or long period and the water content is reduced in fish by the process called 'osmosis' and salty taste is added to the fish. By reducing water content in the fish, the bacterial action on the fish is reduced to some extent (Nair & Govindan 1978). According to Anon. (1969) there were 67 fish curing yards all along the coast and salt was issued to the fish curing yards at subsidised rates. The main type of fishes used for salting and drying are mackerel, ribbonfish, shark, silver belly, anchovies, lizard fish, kilimeen, malabar sole, sardine and lesser sardine. The quantity of drying of these fishes depends on the landings, demand and quality of fresh fish availability. Frozen and canned seafood form 86 % of seafood exports and dried marine products form only 14 %. A scheme for voluntary pre-shipment inspection of dried fish is also in operation Anon., (1969). But presently there is no clear data about the number of curing yards in the State.

Balasuramaniam & Kaul (1982) developed method to collect information and (Rao & Prakash, 2000) studied the marketing of dried fish in Kerala. Post mortem changes of fish was reported by Setty (1985). Salting Methods were suggested by (Anon., 1982, Syme, 1966, Gerasimov & Antonova, 1979). The survey conducted along Madras coast was reported by Srinivasan & Joseph (1966) and Joseph *et al.* (1986) showed that people use 1: 4 to 1: 6 salt to fish. Antony & Govindan (1983) used 1: 5 salts to fish for lizardfish. Kalaimani *et al.* (1988) suggested 25 % salt for salting. 1:1salt to fish for anchovies was suggested for sun drying by Reddy et al. (1991). Prabhu &

Kandoran (1991) suggested 5 % brine solution for wet salting of anchovies. 1:4 salt to fish was recommended by Indian standard institution (1967a, 1967b, 1969, 1974 and Keay 1986) for salting of thread fin bream, Jew fish, shark, mackerel. Thomas & Balachandran (1989) reported 1: 3 to 1: 10 salt to fish depending on size of fish. They further reported that people of Kerala use 1: 4 salt to fish and in Tamilnadu, people use 1: 5 salt to fish and the salting time is 12 to 24 hours. Salting is reported to change structural and mechanical feature of muscle tissue (Anon 1982., Stansby, 1963 & Voskresensky, 1965). Salt intake of fish was reported by Ramachandran & Solanki (1991), Serro *et al.*, (1992) and Sankar & Solanki (1992). Chakrabarti *et al.* 1991: Reddy *et al.* 1991 and Gupta & Chakrabarti (1994) reported that brine salting reduced a_w from 0.96 to 0.82. Sikorski et al. (1995), Kleimannov *et al.* (1958) and Devadasan (2000) reported the loss of substantial amount of soluble protein in self-brine. The changes in urea in shark were reported by Kandoran *et al.*, (1965) and Ramachandran & Solanki (1991). Krishnakumar *et al.* (1986) and Sankar & Nair (1988) reported the formation of FFA and PV. Sanjeev & Surendran (1993) and Hanumanthappa & Chandrasekhar (1987) studied the growth of bacteria using total plate count method in fish.

Devadasan *et al.*, (1975) reported the effect of using 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 life of dried fish using natural preservative and anti-oxidant effect of betel leaf extract on dry cured fish was reported by Kalaimani *et al.* (1984). Hersom & Hullard (1981) suggested that the action of spices and herbs are greater than the chemicals preservatives, cloves, cinnamon and mustard exert greater preservative action than other spices. Further cardamom, cummin, coriander, pimento and ginger have little effect. Bay leaves, cloves oils are effective against bacteria (Hersom & Hullard, 1981).

fish. The total quantity of dried items exported during 2002 – 03 was 8177.70 tonnes and value was 8422.51 Rs. in lakh, of which 0.05% was dried shark and 62.34% was dried fish (Anon, 2004).

There is a change in the utilisation pattern of marine catches. There was a drop in the consumption of sun dried and salt cured products and fresh fish consumption increased. Further it showed that as regards the quality of cured fish, curing has often served merely as an outlet for utilisation of unwholesome fish. The cured fish products continued to play an important role in the diet for the weaker sections all over the country as it is comparatively cheaper and are easily transportable. This calls for curing methods, which improve the quality of the end product. The present major productions associated with traditional method, bring considerable wastage during storage due to infestation by insects and fungi and spoilage due to bacteria.

1.2.1. Kerala State

Kerala is the one of the smallest state in the whole of India. Anon (1984) noted that Kerala is a leading marine producer. It has a continental shelf of 40.000 sq km. and the coastal line of nearly 590 km (Anon., 1993a). The state is broadly classified into three natural sub - divisions, the highland, the midland and the lowland. The production of fish in India during 2001 was 1,23,175 tonnes and the state contributed 43,112 tonnes (35.0%) of mackerel (Anon. 2004). Fish curing is popular in this state. About four / fifths of the population are accustomed to take fish regularly. George *et al.* (1978) reported that the fish landing along Kerala Coast comprises pelagic and demersal fishes and consists mainly of oil sardines, mackerel, other sardines, sciaenids, cat fishes, elasmobranchs, silver bellies, anchoviella, kalava, ribbon fishes, tuna- like fishes thread fin, rock cods, etc.

The storage temperature for dry fish was recommended by Rubbi *et al.* (1983) as 13^0C for superior quality than at room temperature. Camu *et al.* (1983) for 18^0C and Tressler & Lemon (1951) recommended low temperature. Ramachandran & Solanki (1991) and Anon. (1956) studied the organoleptic changes of dried fishes.

The cured fish have very short storage life than dried fish as the water content in the fish is not removed at the surface and the chances of growth of salt loving bacteria are high. Further the salt content on the dried fish absorbs moisture resulting in pink colouration and dun formation, which reduce storage life. Chemical changes due to oxidation of lipids in the muscle tissue cause brown colour at belly region where the fat content of the fish is normally more. This causes rancid odour and discolouration to product and causes less consumer acceptance. So the processor is forced to sell the product even at a low price when the physical appearance of the product is not attractive. The prolonged storage of fish in salt water causes breakage and reduces the original shape and brings less revenue.

There are 58 fresh fish and 9 important dry fish markets in Kerala (Anon., 2000a). The important dried fish / cured fish markets are Alwaye, Changanacherry, Kottayam, Athirumpuzha, Vaniyankulam, Iddukki & Palghat (Anon., 1969, 1984) and Parakkode and Kasargode (Anon., 2000a). In coastal areas, consumption of dried fish is confined mostly to off-season, when fishing is totally stopped. In the interior parts of the state, owing to lack of transport facilities, cured fish is sold for the major part of the year. The population density in the state is the highest among the states in Indian union. The highest pressure in population gives raise to formidable problems both economical and social (Anon., 1984).

1.3.1. Transportation of dry fish

It is an important process to reach product to the destination in time for better price and sales. Various kind of transportation used are train, truck and cars by road

(Anon., 1984). The salted fishes are usually packed in vallam made by using dried coconut leaves or using dried bamboo sticks. This is due to the fact that the packing materials are easily available at low price. The price in market is always flexible even due to simple variation in stock or new arrival. Dry fish from other states influence the dry fish market in state. The latest developments in communication system cause rush of the product in market. So the dry fish processors really have to be more vigilant to sell their product at a high price and to check with the market movements.

During monsoon season, the landing of fresh fish is usually low and demand for salted fish is more. During this period, price of cured fish increases. The price varies to a large extent and it varies with variety of fishes. The consumer has to pay high price. The cost of linear transportation adds enormously to the cost of the product. As a result, the consumers in the hilly and interior region have to pay high price to cured products even though made from low cost fish. This necessitates the need for proper transportation and marketing system.

1.3.2. Aims of present study

- To compare processing strategies of cured fish processors in dry fish processing units at important centres.
- Market analysis of processed, dried or cured fish products. Analysis of risk factors in the business to evolve strategies to overcome the risk.
- Processing of common commercial cured and dried fish using standard Methods and to study the storage characteristics.
- Introduction of HACCP principles for dry fish processing and storage

Chapter 2

PRESENT STATUS OF FISH DRYING IN KERALA

2.1. Introduction

Kerala coast has 3 major fish landing centres namely Kollam, Ernakulam and Calicut (Anon 1969). Fish catches contain quality fishes, which brings high revenue to the state. The export-oriented industry needs quality fishes like prawn, squid and cuttle fish. The seafood export industry survives on these items. The low quality fishes like ribbonfish, lizardfish, anchovies and trash fish are also fishes, which are to be better utilized. These fishes also have all nutritive and mineral value and bring revenue if processing and preservative methods are improved. The most common practice of anti oxidizing such fish is through preservation by drying and curing. The production, profit and economics of anchovies and shark in small scale units were reported by Balakrishnan (1981) at Thiruvananthapuram region. Suseelan (1984) studied the economic feasibility of sun drying of ribbonfish and anchovies.

2.1.1.Packaging

Fishes are bulk packed using palm or coconut dried leaves usually called as 'vallum', contain 15 to 20 kg and are easy to handle. It is observed that polyethane bags containing 100gm packs sold in city have good acceptance. Antony *et al.* (1988) and Gopakumar (1996) reported that dried leaves of coconut and palm and jute bags are used for bulk packing and transportation of dried fish. Prabhu & Gopal (1990), Antony *et al.* (1988), Kumar (1990) reported the various packing materials like papers and paper boards, cellophane, plastics, vinyl films, metalised plastics and aluminium foils. Low-density polyethylene bags are widely used for packing dried fish due to low cost, transparent quality and better appearance (Antony, 1990). According to Prabhu & Gopal (1990) Low density polyethane or polypropylene are commonly used to pack the dried fish due to its low cost, ready availability, good tearing and bursting strength. The dried fish products in Integrated Fisheries Project are packed in 200 gauge polyethane bags with some instruction to handle the fish in 100 gm, 200 gm, and 500 gm packages.

2.1.2. Storage and storage facility of product

Storage of dried fish products are a riskful job. The people in coastal region sell the product when they get a little improvement in price as the cured or dried fish spoil in a short period resulting in revenue loss. So fish has to be stored in a protected area under hygienic condition. The spoilage of fish will adversely affect profit of the processors, traders and consumers. So principles of good quality storage practice are important. This depends on climate, local practice and type of the product to be stored. Yet there are some important basic requirements of storage practice and design of package. The store should be away from fish processing and heavy contamination area. It shall be in a dry and water and wind proof area. Good ventilation will reduce mould growth by preventing moisture up take by the fish and it should not permit the entry of flies, rodents and birds. All packaging materials must be clean and checked for insect contamination. ' First come ' 'first out' should apply to stored product and 'dead' areas in the store (zugarramurdi *et al.*, 1993).

2. 2. Aim

This chapter is aimed to assess the following:

To study,

- The economically important fishes used for curing and drying process by the local fishermen.
- The low value fishes and by catches used for curing and drying process by the local fishermen.
- The practical problems associated in fishermen work for better handling, quality control, and products development.
- Approach towards govt. support expected.

2. 3. Materials and Methods

Three major landing centres in different coastal districts namely. Neendakara and Sakthikulangara were considered as one centre in Kollam district, Munambam in Ernakulam district and Puthiappa village in Calicut district were selected for the study. A questionnaire, which is a modified version as developed by Balasubramaiam & Kaul (1982) and Kaul & Balasubramaniam (1985) were used for collecting information. A questionnaire (Annexure A) was used to collect data from 8 major fish drying plants and 4 minor plants at Munambam, 10 major plants and 5 minor plants at Quilon and 10 major plants and 5 minor plants at Calicut. In addition to the information collected through questionnaire they were also asked to add purchase or sales information in quantity wise and the price of various products in every week. The weekly purchase and sales value was calculated as monthly average. This was collected for the years 1997 – 98 and 98 – 99. The average purchase and sales values were estimated. The major products considered for the study were mackerel (*Rastrelliger Kanagurta*), ribbonfish (*Trichiurus* sp), shark (*Scoliodon* sp), anchovies (*Stolephorus* sp, silver belly (*Leiognathus* sp), malabar sole (*Cynoglossus* sp), sardines (*Sardinella longiceps*), lesser sardines (*Sardinella gibbosa*), lizardfish (*Saurida tumbil*) and kilimeen (*Numipterus* sp). The plants cure more than 75,000 Kg / year was considered as major plants and less than the quantity is considered as medium plants.

2. 4. Results

2. 4.1. Quilon Centre (Major Plants)

Information collected through questionnaire shows that there are about 108 fish curing units in and around Quilon centre. There are a number of small curing units available in the region which operate on the quantity and cost of fish landed. The fisherman aims only on the export quality fish considering their share. Only one shark curing centre is run by an INP trained person. 75% of the owners have their own curing yards, 25% are rented or leased. 25% have electricity and all other facilities like water supply and curing tanks but others have only curing tanks. Curing tanks were arranged in the sides of the houses. They do not have any technical persons other than the owner and majority of workers are owner's relatives. There are no permanent employees. They are engaged on casual or contract or piecework basis. Only during peak seasons they engage more people and are paid Rs. 70 – 80 per day. Usually they take auctioned fish and transported through head load or autos. The fishes were salted immediately. They use 1: 4 to 1:6 ratio of salt to fish and the salting time depends on the demands of cured fish. The gills and intestines in small type fish are not removed. Big type fishes are cleaned, washed before salting and arranged in layer by layer. About 75% of the curing sheds are thatched, with coconut leaves. They use corporation water and there are water problems during March to April.

Crystal salt from Tuticorin is used instead of powder or sterilized salt to reduce the cost. The cemented or wooden tanks having the capacity of 250 to 1,500 kg were used. No preservatives are added during or after salting of fish. They wash the fish in self-brine and sun dried for 1 or 2 days on coir mats depending on demands. The yield of mackerel is 75 to 88%, ribbonfish 72 to 83% and shark 65 to 72% (Anon 1984). The packing was carried out in coconut leaves at a cost of about Rs .4/- `kuttai` and they store for 3 to 4 days only. The storage period was less and there was no report on the formation of pink or dun on the products. They inspect the quality of their product right from production to sales. Their experience and family background are their added merit and run the plant without any technical hand. They follow their own method and their concept regarding quality is good colour and appearance of their product, which in turn gives movement of the products. Their profit is around 5 to 7% per annum of fresh fish purchase value. The plants are not registered under any State or Central departments or co – operative societies act. They sell the products to agents as per the market demands. No Central or State govt. helps them in their work providing sufficient loan etc.

The average percentage of fish handled by major plants during the year 1977 to 98 and 1998 to 1999 are as follows. The total average fish handled was 1,67,920 kg and value was Rs.14,12,782/-. The total sales quantity was 1,27,750 kg and value was Rs 18,06,546/-. The average purchase and sale of fish in varieties and value and in percentage composition of the same in major plants are in figure – (2.1. & 2.2.). The samples collected in this centre were mackerel, ribbonfish and shark. Mackerel had 0.01%, Ribbonfish had 0.08% and shark had 2.05% insoluble ash and $4.2x10^3$, $3.3x10^3$ and $3x10^3$ total plate counts respectively.

2.4.2. Medium Plants

They cure and sun dry the fish in their own land at the side of their house (Anon., 1984). They do not have any separate facilities and capacity of the curing tank is about 250 – 1,000 kg. They adopt salting, drying, storing and packing methods as in major plants. The workers are their family members and they work without any fixed hours on request. They do not keep fish for long time because they have to pay their loan in time and sell them through brokers. The brokers who lend amount may reduce the price. So their expected profit is very much less than the major plants. No work during lean season. Their annual turn over was less than Rs 50,000 to 70,000/- per annum and profit was around 3 to 4 %. Above all, they only care about colour of the product. Fish curing and drying methods are the same as in major plants and they are not supported by any Central or State agency.

The total average quantity handled was 62,725.5 kg valued at Rs 4,34,250.4/- and the sales quantity was 52,804.5 kg having the value of Rs 4,93,876.4/- during the year 1977 to 1998 and 1998 to1999. The average percentage quantities of different variety of fish handled by the medium plants are mackerel, ribbonfish, priacanthus, sardine, lesser sardine, silver belly, anchovies, lizardfish and kilimeen. The sale composition shows that only sardine had little increase and remaining are equal to purchase composition. The average purchase and sale value depend on the availability and high cost (Figure – 2.3. & 2.4).

2.4.3. Workers

Studies showed that 80% of workers are above 35 years and belong to the Christian community. They earn an average of Rs 40 to 45 per day and have no work during off-season. They get only 100 to 130 days work per year and most of them do not have any entertainment facility. Most of them are forced to work at the lower rate because there is no other work for income. They do not have any separate trade union to deal with their problems.

2.4. 2.1. Munambam centre (Major plants)

About 105 fish curing centres are available and 75% are in their own land and remaining is leased land. 50% have separate office and there is no separate ice or dry fish storage. The electricity used for the house is extended to the curing yard. They have 8 to 10 cents of land. No permanent staff for office or technical side. The casual workers are engaged continuously and strength increases during peak season and decreases during off- season. 25 days work are noted during peak season per month and is less during off- season. Their duty hours were normally 9 am to 5 pm. Female workers get Rs. 70/- to 80/- per day and male workers get Rs. 120/- to 150/- per day. The curers are from different religion and caste like christian, vala and araya. Majority of plants do not have any work during off-season.

Majority of fishes are landed at private fishing harbour than the fishing harbor run by the government. They salt fish as soon as it reaches the station. They use corporation water and water is less during March and April. They remove intestine of the larger fish like mackerel, ribbonfish, shark and lizardfish. Some time they use semi spoiled fish also and dry salting is preferred in the ratio of 1: 4 to 1:6 salt to fish depending on the nature of salting. They have 5 to 7 cemented tanks having capacity of 500 to 2000 kg and use salt from Tuticorin. Salting time depends on the demand of cured fish and extended up to months. Normally cured fishes were washed in self brine and some excess salt was added before packing. Drying was done in special case only, by spreading cured fish on mats. The yield of mackerel was 75 to 78%, ribbonfish 80 to 82% and shark 65 to 70%. In most cases, cured fish is packed in coconut leaves. 3 pieces of coconut leaves cost Rs 7/- and store for one or two days depending on the arrival of broker. There is no possibility of formation of pink or dun. They gained knowledge and experience from their family and they check quality at every stages of processing. They are not trained and not adopting any standard method as approved but following their own methods. They have the view that quality means appearance and colour of fish. They are not registered with any of the Central or State Govt. organization for any guidance. They market their product through brokers to Alwaye, Changanacherry, etc. They do not have any quality control laboratory.

The average fish purchase in major plants was 2,15,145.5 kg valued at Rs. 22,52,778/-. The sales quantity was 2,21,225 kg of Rs 39,22,752/- during the year 1977 to 1998 and 1998 to 1999. The purchase had following composition of fishes - mackerel, shark, ribbonfish, sardine, lesser sardine, silver belly, anchovies, lizardfish, kilimeen and malabar sole. The purchase and sales values are represented in figure (2.5 & 2.6). The samples collected show the following percentage of acid insoluble ash and TPC 4.08% and 7×10^3 in mackerel, 0.296% and 9.02×10^3 in ribbonfish and 3.91% and 6.02×10^3 in shark.

2.4.2.2. Munambam (Medium plants)

The plants have separate curing tanks and no other facilities available. They have 5 to 7 cents of land. The owners play all roles with family members and rarely employ casual workers. The work continues until it is finished. Salting, drying, packing and storing are as in the case of major plants. 80% of the owners associate with fishing and allied activities during off-season irrespective of community and 20% continues in fishing. They have good demand for cured fish during April to July. Usually cured fish exhaust before monsoon as they sell them before monsoon to remit loan amount and they are not able to get good profit. They do not have sufficient money to purchase fish. The expenditure is between Rs 50,000/- to 70,000/- and their profit is between 3 to 4% of the turnover per annum. They do not keep any records for reference. They use corporation water. They use fresh or semi spoiled fish for curing, as cost will be less. The crystal salt from Tuticorin is used. The capacity of the salting tanks and their number are less than major plants. The dry salting system is used and salting time depends on the demand of products.

The average purchase of medium plants was 64,903.5 kg of Rs 5,64,906.4/- and the sale quantity was 53,276 kg valued at Rs 5,68,158/- during the year 1977 to 1998 and 1998 to 1999. The following fishes were sold; mackerel, ribbonfish, shark, priacanthus, sardine, lesser sardine, silver belly, anchovies, lizardfish and kilimeen (Figure – 2.7 & 2.8).

2.4.2.3. Workers

The workers are over 35 years except in case of some families. Majority are illiterate and some studied up to 5th standard. They have more than 10 to 12 years experience and have no work during monsoon season. Yet, out board engine bring fish but not as much as the peak season. They get a salary of Rs 60/- to 80/- per day and get more than 200 days work in a year. 40% of the workers have entertainments like television and the remaining have radio or newspaper. They continue to work because they have no other work. They do not have any trade union activities.

2.4.3.1. Calicut (Major plants)

About 100 fish curing units are available in the village near harbour. 50% people cure the fish in their own land and 25% are on leased land. Only 25% have office. Unlike Quilon or Ernakulam they have separate curing place at sea shore. The cured fish were dried on mats on sand at sea shore. 50% units have electricity and separate store and others do not have it. No permanent workers for any nature of work in the office or yard. In some plants, there are some permanent casual workers, continue for years together as they have no other work. During peak season owners admit a good number of casual workers according to the in take of fish. But during off - season they reduce them to 3 to 5 nos. During peak season workers get 24 days work and get Rs 2600/- per month. Some works are handled in piece- work basis and relatives were also engaged for this purpose.

They purchase fish through auction and transported to the plants through autos or mini lorry. Many units are engaged in this field through the experience gained from their family. The community mostly engaged in this field is Araya. The peak season for dry fish is usually from April to August and heavy demand is from Malappuram, Trichur, Palghat and Kunnamkulam markets. The annual expenditure goes up to Rs. 1 lakh to 2 lakh per annum with a profit of 5 to 7%. Only 35% plants keep some records. The curing plants are huts with clay and coconut leaves. 50% use potable water and others use seawater (Balasubramaiam & Kaul 1982). About 25% add chlorine or bleaching powder in water to chlorinate the water. All medium type fishes are cleaned without intestine and blood vessels and washed before salting. They use fresh or semi - spoiled fish (Balasubramaniam & Kaul, 1982) for curing and check the quality by experience. Crystal salt from Tuticorin is purchased and 1: 4 to 1:6 ratio of salt and fish are used for salting. Neither wet salting is practiced nor sterilized salt is used. They use wooden tank or clay pot or cemented tanks having capacity of 100 to 1000 kg. Salting time depends on demand of the cured fish and usually it continues from 5 to 6 hours to 3 to 4 months.

They use calcium propionate of 0.3 to 0.5% as preservative of cured fish and keep it as trade secret and this was taught by Central Institute of Fisheries Technology, Calicut centre. They do not cure shark because fresh shark costs high price of about Rs 90/- to 100/- per Kg. Fresh shark is transported to Calicut market, after sales the remaining quantity is cured and dried. Unlike other places, fishes are specially dried and packed in polyethane bags and sealed and marketed. The quality means appearance and they think it is a good motivation for buying. They are not registered with any Central or State Govt. agencies or departments. The average purchase quantity was 2,17,546.9 kg of Rs.16,91,898/- and the sale quantity was 1,71,223 kg of Rs 21,53,067/- during the year 1977 to 1998 and 1998 to 1999. Mackerel, ribbonfish, malabar sole, sardine, lesser sardine, silver belly, anchovies, lizardfish and kilimeen contribute major quantity (Figure - 2.9 & 2.10). The sample collected had insoluble acid and TPC as 10.67% and 7.8×10^3 mackerel, 8.32% and 9.2×10^3 in ribbonfish and 0.29% and 6.5×10^3.

2.4.3.2 Calicut (Medium plants)

They have curing sheds constructed with coconut leaves and dry the fishes on mat or net on seashore. They work as a family and only during peak season they engage casual workers and some works are carried out on piecework basis. During off-season they have no work. During peak season they work 24 days. Mostly they have no fixed working hours and the work will be continued until it finishes. Owners and family carry out works. So sharing problem will not arise. Usually low cost fishes are purchased through auction and transported to centre by autos in 10 to 15 minutes. They get 3 to 5% profit. The financial conditions do not permit them to keep cured fish for long time, i.e., up to off-season when the dried fish have more demand. 65% use potable water or seawater directly and the remaining use chlorinated water for cleaning and salting purpose. Crystal salt from Tuticorin was used for salting. Dry salting is mostly practiced and salting time depends on the demands of cured fish up to several months. Since the products were sold at once there is no spoilage noted. They check the quality of the products at every stage and giving more importance to colour and appearance. They sell the product through brokers. The average purchase quantity was 67,535.9 kg and value was Rs 4,58,979.7 and the sale quantity was 52,010kg and sales value was Rs. 5,05,507.6 during the year 1977 to 98 and 1998 to 1999. The composition of fishes composed of mackerel, ribbonfish, malabar sole, sardine, lesser sardine, silver belly, anchovies, lizardfish and kilimeen (Figure – 2.11 & 2.12).

2.4.3.3 Workers

The workers are of 28 to 45 years. About 50% attended middle school level and the remaining are illiterate. They are from fisherman community and can read and write. Balasubramaniam & Kaul (1982) reported that majority of the fisherman community are educationally poor and financially backward. They work for years and residing with in the radius of 3 km. Their monthly income is Rs 2500/- and they are granted incentive during festivals and get 22 to 25 days work in a month during peak season. Television and newspaper as their sources of entertainment. There is no separate organization to work for them for solving their problems.

2.5. Discussion

The centre showed 23.92% loss in sales quantity than purchase quantity and this may be due to weight loss during salting and subsequent changes. The sales value showed 27.87% profit than purchase price. Most of the fishes used are demersal fishes (Anon., 1984). They got profit from ribbonfish, shark and anchovies and more profit from shark as reported by Balakrishnan (1981) and Suseelan (1984). Suseelan (1984) stated that sun drying is more economical and profitable even for internal marketing and remaining products had equal or less profit. So the loss from one product was adjusted from other products. This is due to the market effect and other factors. The report showed that the export of dry fish is less due to less production (Gopakumar & Devadasan, 1983). According to the workers, they are less paid than the workers in freezing companies. Results from medium plants showed that sales quantity was 15.81% less than the purchase quantity and the sale value was 13.73% more than the purchase value. This is due to the weight loss during salting process. The centre had profit. The mackerel and anchovies had high share of profit. The remaining had less or equal status. The comparative profit showed that major plants have more profit than medium plants. This is due to the fact that major plants had more financial commitment such as capacity, number of tanks etc. than the minor plants as reported by Kaul & Balasubramaniam (1985) and lesser investment would likely be taken as a way of life rather than economic enterprises (Firth, 1946), cited in (Kaul & Balasubramaniam, 1985).

The sale in the major plants at Munambam showed that sales quantity was more than the purchase quantity by 2.83%. The additional quantity should be from the previous year is unsold product. The sale value was 74.12% more than purchase value. The major plants have the facility to store product. The data showed that purchase price of raw fish was less during the landing season from August to January. The price increased during remaining period. According to statements of fisherman they get all type of fish at every season but quantity and size will be less. They take all type of fish for curing irrespective of sizes. Here the quantity purchased was sold without much loss. Mackerel, ribbonfish, sardine, lesser sardine and anchovies bring only marginal profit and shark bring more and the other fish bring no loss no profit. This shows that the arrival of fishes from out side market cause diminishing profit to the processors. The medium plant results showed that sales quantity was 17.92% less than purchase quantity and the profit was 0.57%. The loss in quantity is due to the salting loss. The purchase and sales composition shows that they are same and only marginal difference in ribbonfish. The increase or decrease of purchase and sales in other variety of fish affects only marginally. The percentage value showed that mackerel has less sales effect and ribbonfish more. Shark and lizardfish have less effect than purchase and the remaining have equal effect at purchase and sales. The difference in purchase and sales value of certain fish showed that entry of out side fish affects sale price of local market. So less profit was achieved. The lizardfish always maintained medium value in purchase and sales.

The results at Calicut showed that average percentage sales of fish in the period had 2.13% less in sales than purchase. This showed that plants sold the previous year stock during this year. The sales value increased 27.26%. Mackerel maintained low percentage at purchase and sales and may be due to the previous year stock. The purchase and sales value are maintainable in all cases. The purchase and sales value showed that ribbonfish and lizardfish had more value than others and kilimeen had lesser sales value. Financial loss in one product was maintained by other. There was good demand for anchovies, ribbonfish and mackerel. It was observed that fishermen adopted the preservative technique from Central Institute of Fisheries Technology (CIFT), Calicut. Medium plant result showed that there was 22.99% weight loss in salted fish than purchased fresh fish with a profit of 10.47%. The weight loss during salting is an important factor. Being medium plant sale of earlier year stock was not possible. The important items of profit were malabar sole and anchovies. The products earned neither loss nor much profit. They have not adopted any management technique and financially and educationally also they are poor.

The study showed that financially sound persons only can preserve cured fish long time until the monsoon season, when the demand for cured fish is high. During monsoon season landing of fresh fish is less and there is a ban for fishing. So persons, who have sufficient stock can sell fish at high rate and can make profit. Poor people cannot wait until this chance, as borrowed money from commission agents (Anon., 1969, Singh & Gupta, 1983) has to be paid with interest. So they sell the product at a lower rate.

The fish purchase rate in all 3 centres shows that the rate is low from September to January in case of mackerel, ribbonfish, lesser sardines, kilimeen, and sardines. Landing of shark starts from December to April and also anchovies and silver bellies. The landing of lizardfish and lesser sardines may be small in size in all season except during ban period. They expect loan from banks or Govt. as over draft to purchase fresh fish for salting and the loan amount will be remitted in installments. Financial support to units are complicated as most of the plants are unhygienic and do not have sufficient arrangements such as records, office, storeroom, electricity, quality control room and equipments. Roof made out of coconut leaves cause falling of rain water in curing tank and spoil cured fish. There is no proper drainage system and fishes were dried in the courtyard of houses. The study showed that less than 1% people use preservative in Kerala and that too only at Calicut centre.

Problems & Quality Assurance

No plants in any centre have any quality control laboratory to assure the quality of products. The Govt. is also not very serious about the situation. Corporation or Panchayat authorities only care for taxes but not on hygienic condition of products. No certificate was issued to assure quality with the product. All assure that their products are good. The study showed that no plants export their product but only do the internal marketing to the interior places. The State Fisheries Department has to provide the minimum facilities available and grant financial assistance for improvement.

Curing yards have little concern on maintaining quality. They do not take care in handling and packing of fish. Since salting, washing, drying and packing are done in open place, fly, sand and mud particles are easily attached to the products. The cured products are simply handled without any care. The plants do not have any required facilities. The products have high content of salt during drying and have white salt crystal on the fish. MPEDA and State Fisheries Departments may provide technical assistance to the curers in preparation of quality and hygienic products as in the freezing plants (Rao & Prakash, 2000). The State Govt. may take steps to popularize the products through stalls.

The labour system is not protected because the work is seasonal. The fishermen at Quilon depend on the quality fish and they do not bring trash fish and by catch fish for curing. So works in the curing units are affected. Since most of the women are engaged in curing, Govt. may train them in hygienic production of dry cured fish through societies. The labourers are not cared by the Govt. as they have no chance to bring their negligence to the attention of the authority. The employees may be granted EPF and other benefit as other workers in factories by registering the units under State Govt. Department. So the present system may be reviewed to grant better benefit to employees with out affecting the fish curing units.

The Govt. may grant aids to curing units to improve quality of cured fish and may help them to provide loan to purchase fresh fish during peak season, which may be repaid after sales of cured products. The quality of products may be checked either by Govt. authorized laboratory before purchase and sales or Govt. may help curing units to set up a quality control unit in the plants. Further the Govt. may purchase cured fish from curers and market to interior places of the State at low cost than private sector people. The low quality fish are sold at lower rate due to carelessness of the marketing people. The Govt. may set up societies for purchase of cured fish and arrange trained fish quality inspectors to check the quality of dried products before purchase and sales. The MPEDA may register curing plants and provide financial support to them to purchase fish at peak season at a lower interest rate as in the case of the processors and exporters of frozen fishes (Rao & Prakash, 2000).

The Kerala festivals like Onam affect the sale of cured fish as reported by Gupta *et al.* (1983). During these period people take only vegetable and demand for cured fish and dry fish is less. During fasting seasons like Ester, Bakrid or Ramsan and Sabarimala people prefer only vegetable and demands for the fish is reduced. When fresh fish is available at low cost the people will normally prefer fresh fish only. This affects the sales of cured fish and the cost.

Trained technician are the important need to curing units to produce good quality cured product. The fisherman may be trained for the purpose. They may be trained to prepare good quality product with in the adequate time and use sterilized salt. Further the Govt. may help the fishermen forum or the society to purchase the fish and market the same with passing of quality check. This may be sold through society to interior part of the State at low price. Storage of the dried products are an important problem as reported by Gupta *et al.* (1983) because during rainy season relative humidity of the atmosphere is high and air contain more water molecules. So it is easy to the salt contained fish to absorb moisture from air and speed up the formation of dun and pink. Further during summer season fish may over dry due to the absorption of moisture from fish to the atmosphere. So the storage of the products needed a closed temperature and relative humidity to keep the products safe to increase the shelf life.

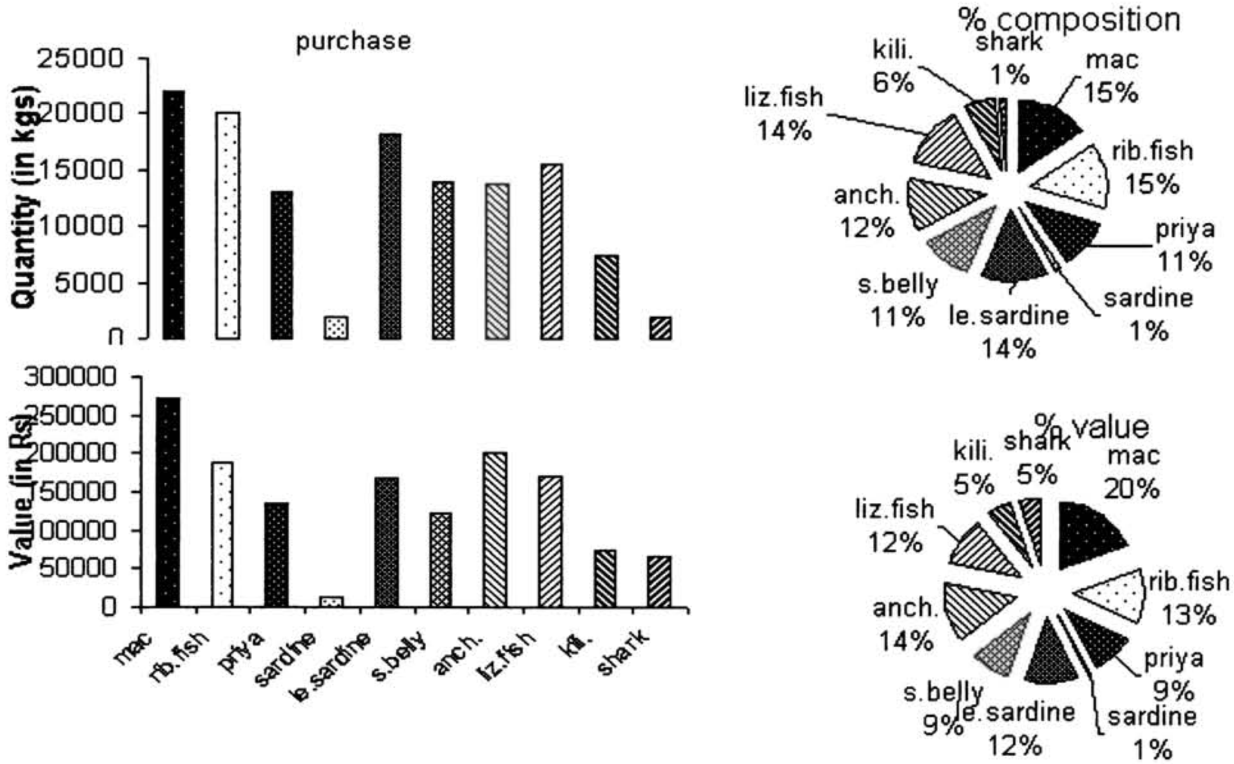


Figure – 2.1. Average purchase and value and both in % composition and in major plants at Kollam centre

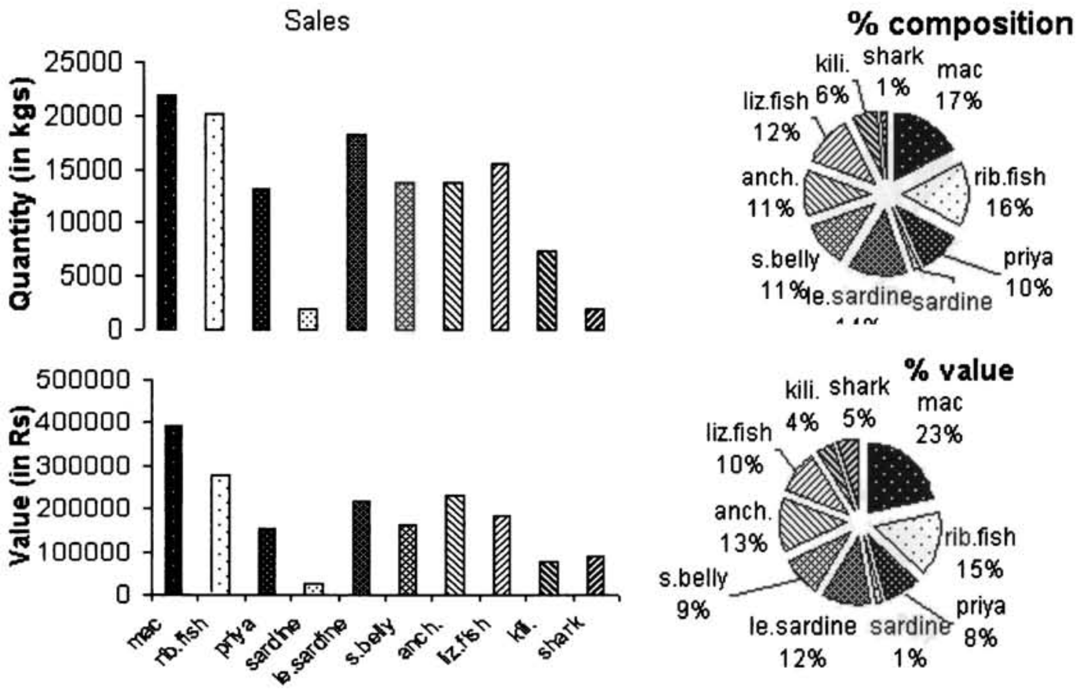


Figure – 2.2. Average sales and value and both in % composition in major plants at Kollam centre

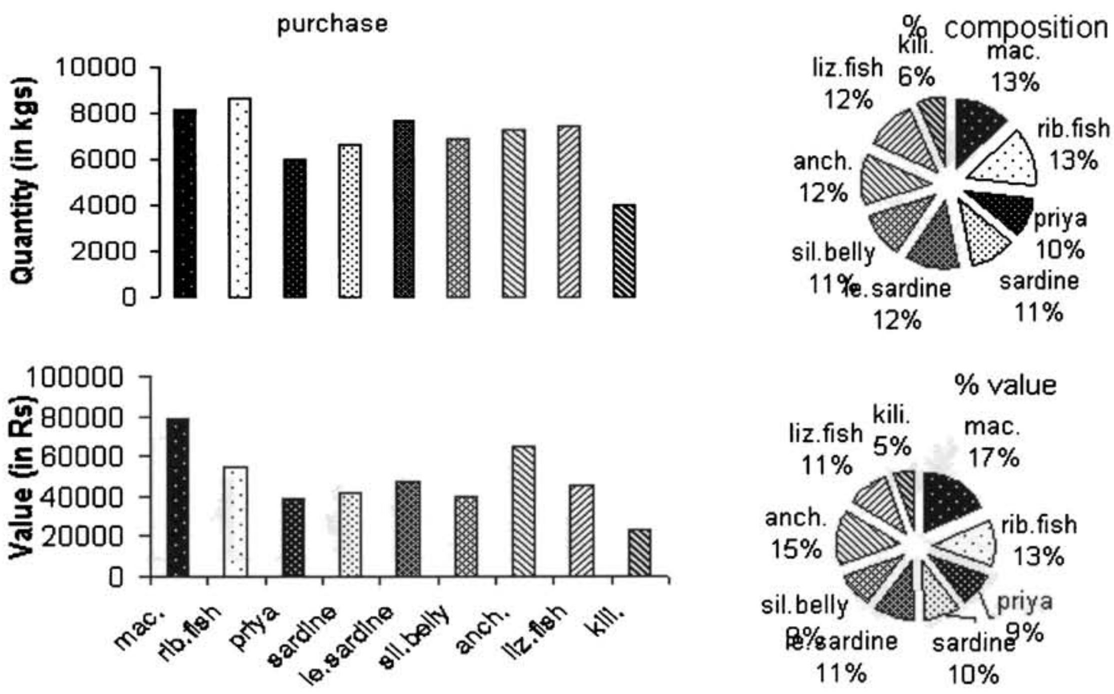


Figure – 2.3. Average purchase and value and both in % composition in medium plants at Kollam centre

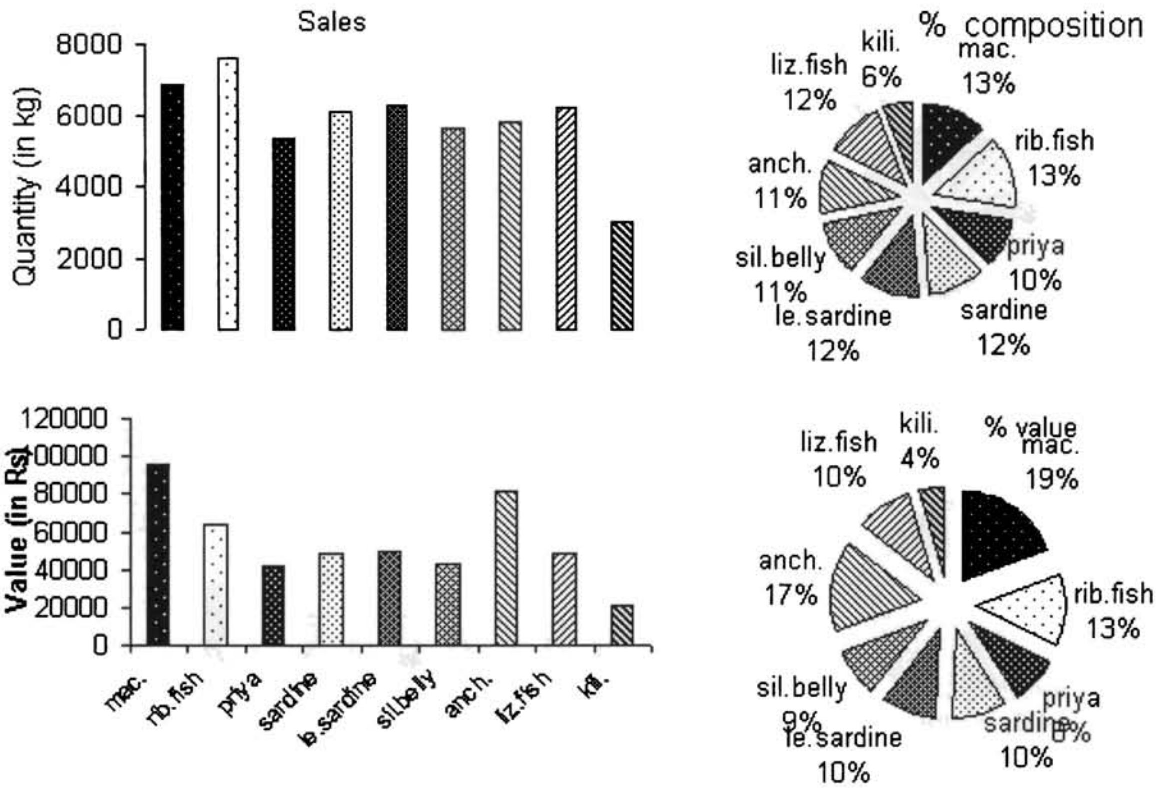


Figure – 2.4. . Average sales and value and both in % composition in medium plants at Kollam centre

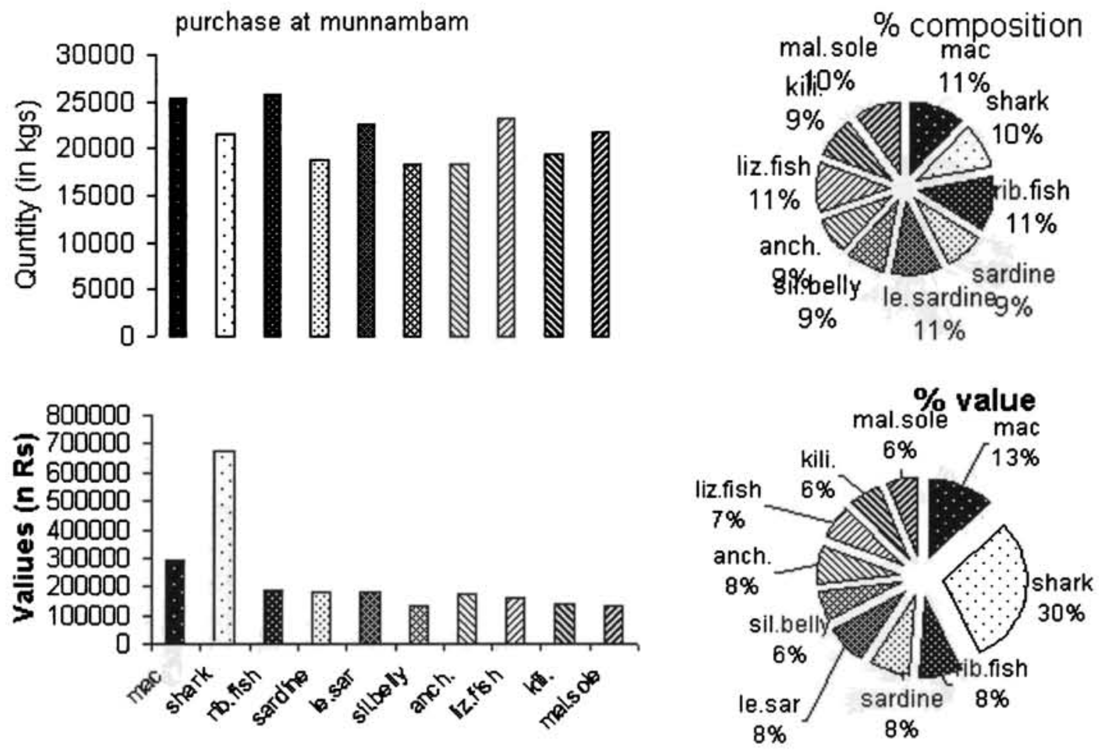


Figure.2.5. Average purchase and value and both in % composition of major plants at Munambam centre

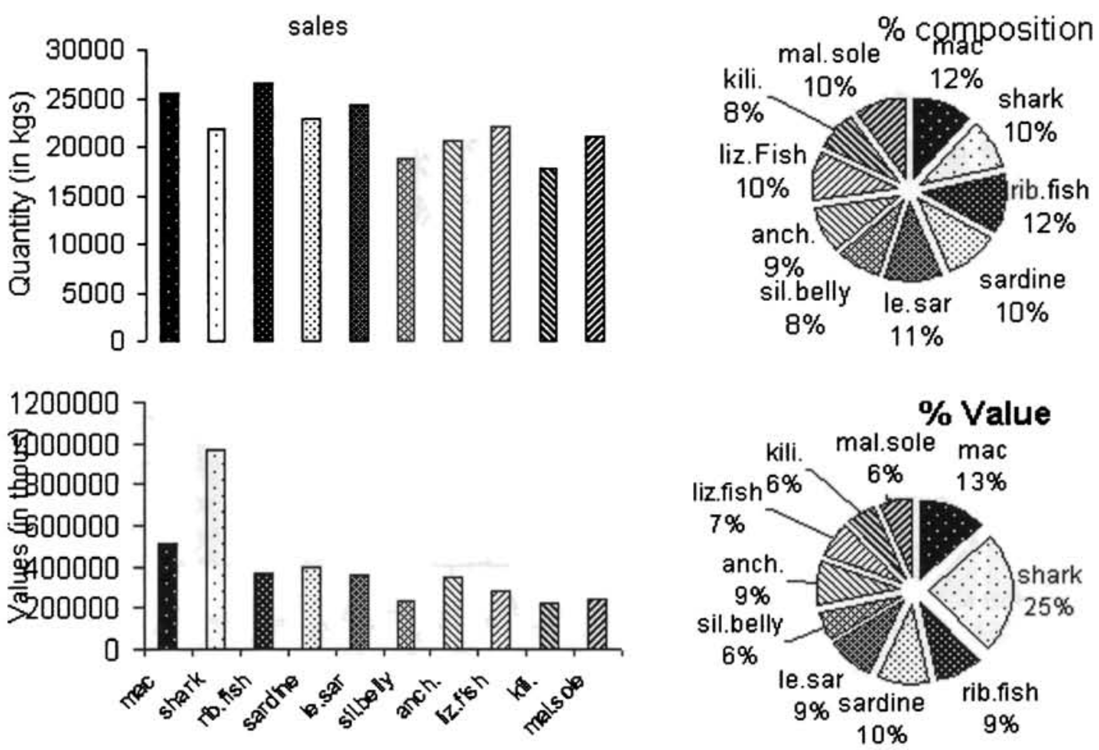


Figure – 2.6. Average sales and value and both in % composition of major plants at Munambam centre

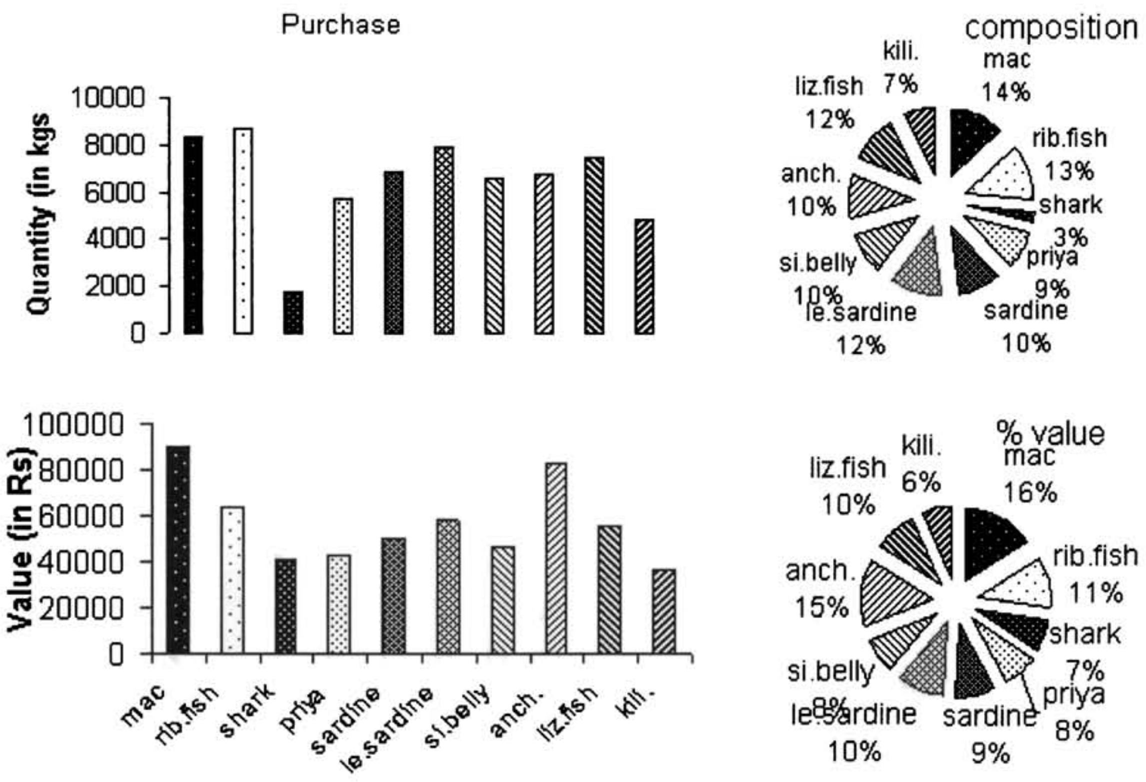


Figure – 2.7. Average purchase and value and both in % composition of medium plants at Munambam

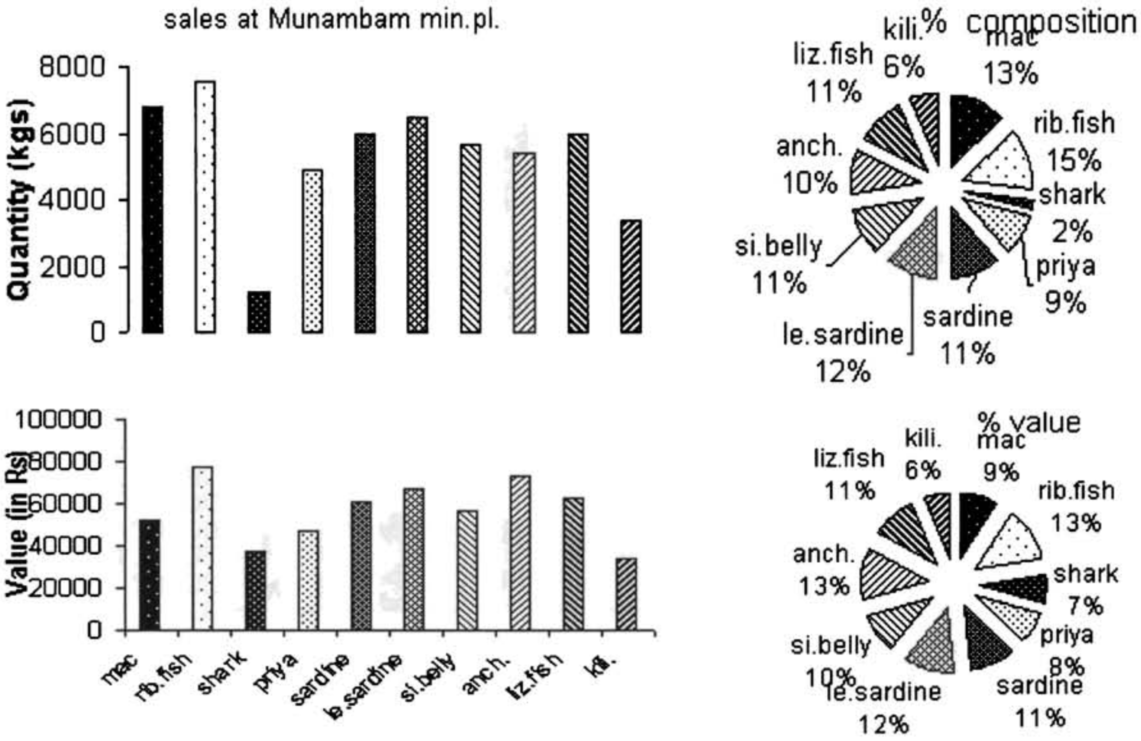


Figure – 2.8. Average sales and value and both in % composition of medium plants at Munambam

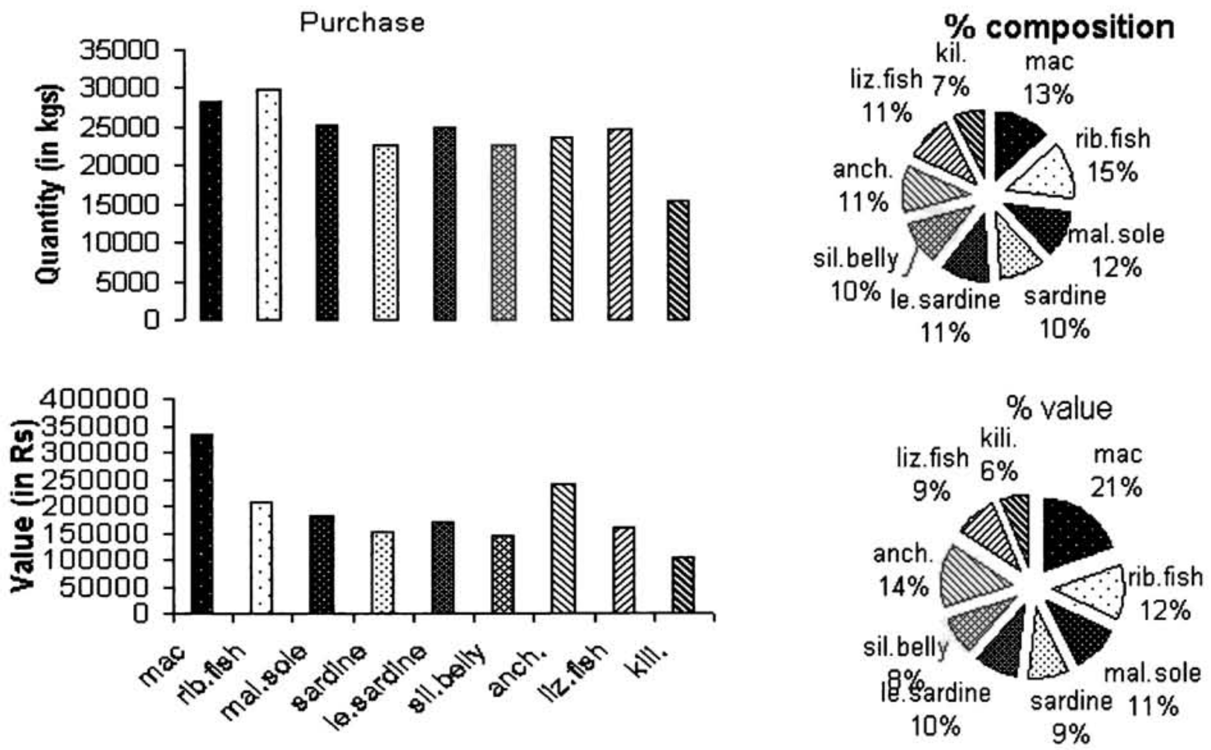


Figure – 2.9. Average purchase and value and both in % composition of major plants at Calicut centre

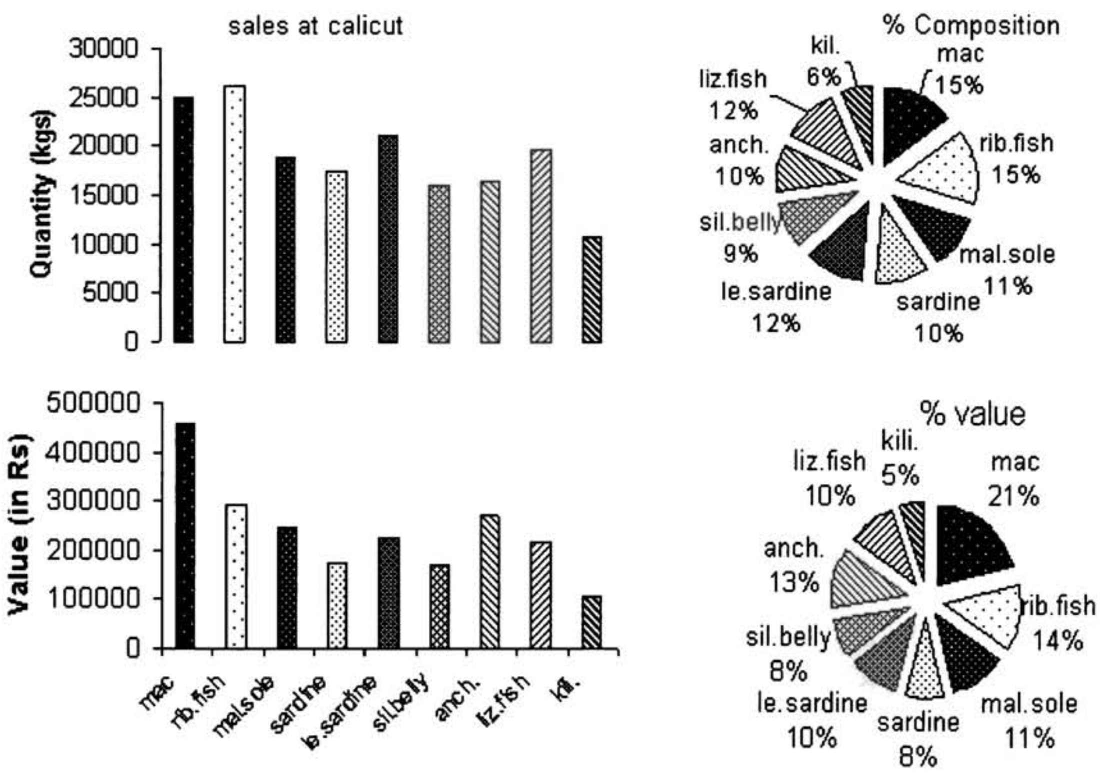


Figure – 2.10. Average sales and value and both in % composition of major plants at Calicut centre

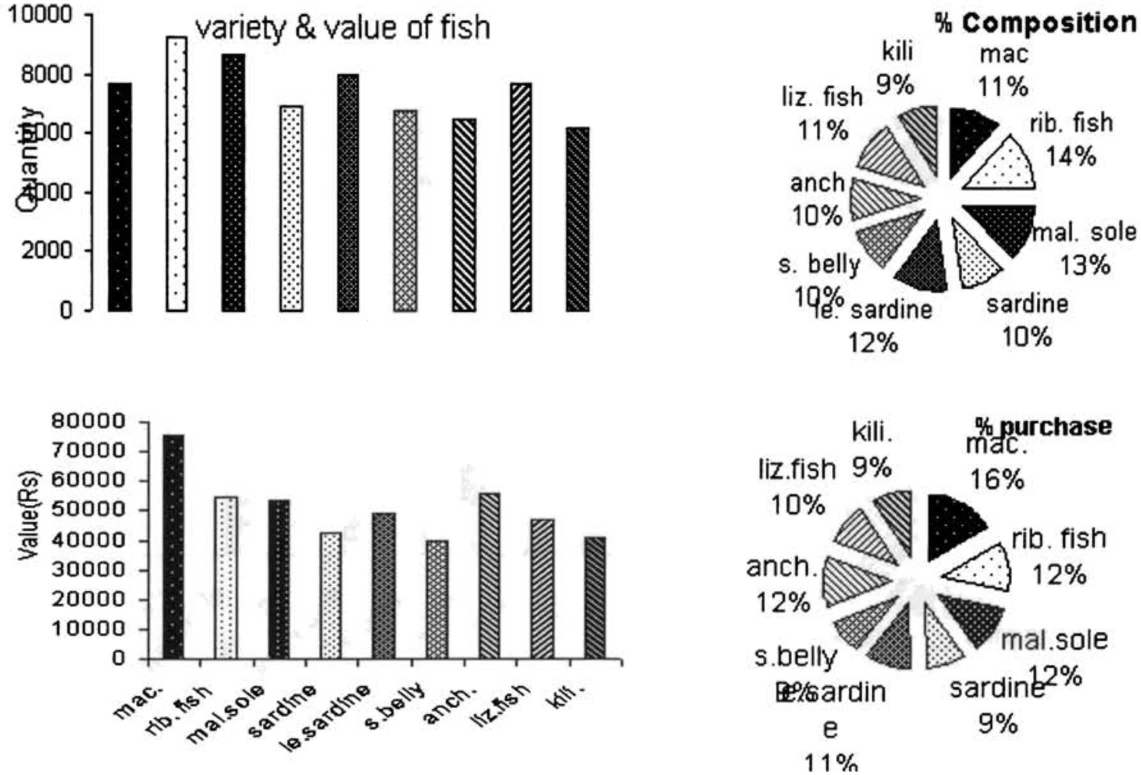


Figure – 2.11. Average purchase and value and both in % composition of medium plants at Calicut centre

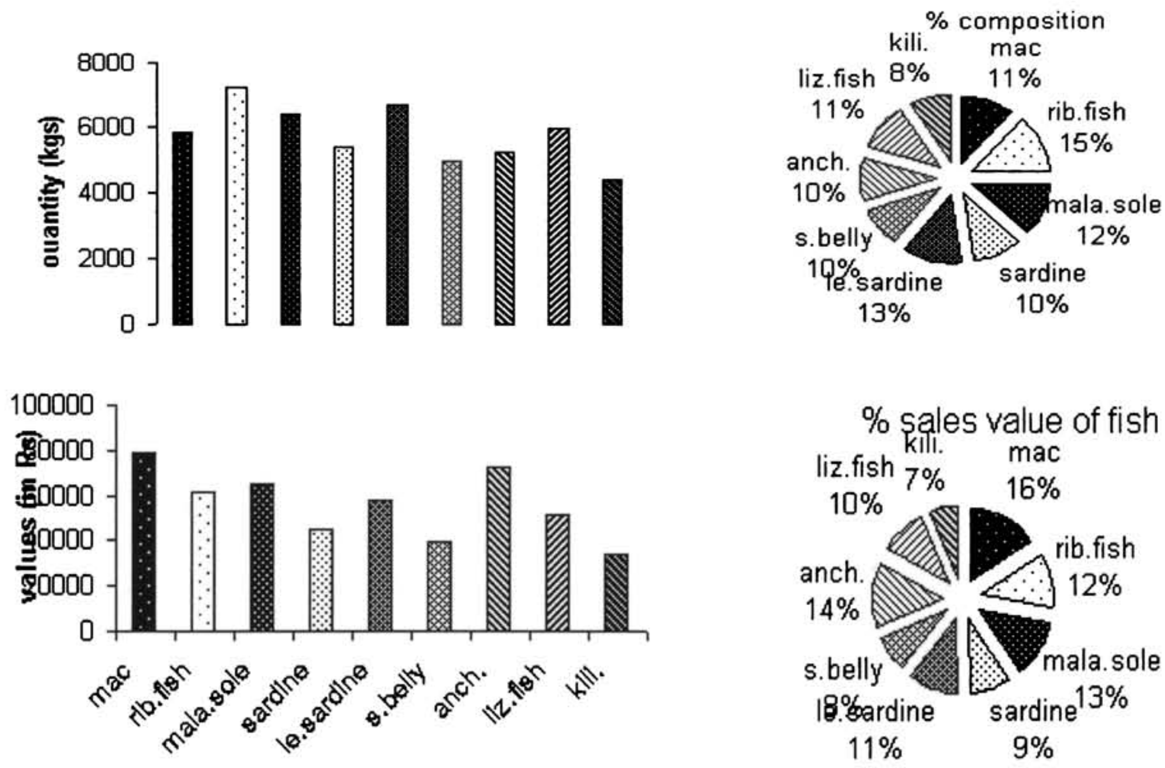


Figure – 2.12. Average sales and value and both in % composition of medium plants at Calicut centre

Chapter 3

MARKETING OF CURED / DRIED FISH

3.1. Introduction

The marketing of dried fish is not done in a defined structure as in the case of frozen fish. The field investigation showed that only small quantity of cured or dried fish is exported from India including accelerated freeze - dried prawns. The cured and dried fish are mainly covered in the internal marketing system and is not well structured. There is no clear chain of production, storage and distribution of cured and dried products in an organized manner (Anon., 1969). The curing of fish is seasonal and the storage and shelf life of these products are not studied well and pose problems. Producers are forced to sell the product as soon as the finished product is ready or as soon as the cured fish is taken out from the salt. The marketing people are the authority to fix the price to the product, depending on the demands of the products, the season and availability. They are well aware of consumer reaction to the products. The annual reports of the cargo movement shows that 1,44,570 kg of dried shrimp, shrimp shells and clam were exported during the year 2001 and 3,32,535 kg of dried shrimp and clam were exported during 2002 and during 2003 the export included clam, shrimp and shark with a total quantity of 4,24,426 kg (Anon., 2003b).

3.1.1. Marketing of dried fish

3.1.2. Marketing issue

Anon. (1969) reported that there were 7 important dry fish markets in kerala including Alwaye and Changanacherry. The products once accepted by public could be marketed and can be expected to fetch more revenue. Advanced technology to store the cured fish product is essential. But it is very difficult in this sector as this involves very complex system of production and marketing of fish. It also involves a complex series of interactions between fishermen, processors, wholesalers, transporters, and retailers. Anon. (1988a) reported that the dry fish marketing survey of Integrated Fisheries Project (IFP) was encouraging at High range region and Kottayam.

The economic condition of the society is a fundamental prerequisite for the successful adaptation of a new technology which is essential for profit making. The profitability in turn partly depends on the market demand of the products and the price per unit cost. The technological improvement increases the costs of production and the excess will be passed on to the consumer thereby discouraging purchase. The remaining part of increased cost must be born by the processing and marketing chain. The increase in unit price of the product can be brought down by large - scale production using modern technology. Further marketing of the product depends on the consumers taste and preference. Reducing loss and keeping high quality will be an added point (Anon., 1987).

3.1.3. Transportation and handling of dried fish

At present there is no better way of transportation of dried fish. The people like fresh fish better than dried fish. The main transportation is by road (Anon., 1984) and rail, waterways, bicycle, trucks and hand - carts (Gopakumar, 1996). Further it may be noted that people living at hilly places are not getting even dried fish for their daily needs. So it is considered to be a costly item. This may be due to non - availability of dried fish in the market.

3.1.4. Marketing factors and Socio – Economics of people

A clear survey is needed on the socio-economic condition and marketing relationship. This will give a clear picture of the needs, likes and dislikes, and other aspect of the product development in relation to the public and marketing factors. Extension assistance may be required to encourage both the development of required input and marketing of products. New source of credit may be needed to provide the initial finance for inputs for technical innovations and for subsequent marketing activities.

3.2. Aim

Most of the people in Kerala are fish consumers, so the fish has to be marketed in to the interior places. The cured fishes are marketed though some important markets and from outside states. So the study of flow of cured products is essential. Anon. (1969, 1984) reported that the important dry fish markets in Kerala are Kottayam, Changanacherry, Alwaye, Idukki, and Palghat. The important near by fish markets Alwaye and Changanacherry were selected for the present study.

This study is aimed to find:

- The important cured fish or dried fish available in domestic market and their rate at different seasons the better sold fish.
- To study the purchase and selling system of cured and dried fish.
- The arrival of varieties of fishes from out side states, their packing and consumer acceptance.
- Influence of out side market and fresh fish arrival in the market.
- The influence of festivals and other season on market of cured and dried fish.
- To find the approach of people towards smell of dry fish and cured fish.
- The storage strategy of cured and dried fish at different seasons and to increase the shelf life.
- The welfare of workers engaged in this trade.

3.3. Materials and Methods

The important cured fish markets in Kerala are Alwaye in Ernakulam district and Changanacherry in Kottayam district. Four wholesale stalls from Alwaye and three wholesale stalls from Changanacherry are selected and the required information were collected as per the questionnaire (in annexure B) used by Balasubramaniam & Kaul (1982). The data collected was tabulated for two years 1997 –1998 and 1998 – 1999. The purchase and sales quantity was calculated with the average monthly rate and the average purchase and sales value were also calculated. The problems in marketing of cured fish were noted with workers problem.

3.4. Results

3.4.1. Alwaye market

Whole sale merchants have 20 to 35 years experience and they are of the view that dried fishes were not preferred by people due to smell and their interest is towards fresh fish. There are seven wholesale fish dealers in the market. The wholesale dealers purchase the fish from here and transport to all interior places like Changanacherry, Kumuzhi and Malampuzha. Yet cured fish does not reach most of the remote places due to lack of transport facilities. The different varieties of fish include mackerel, ribbonfish, shark, sardines, anchovies, silver belly, malabar sole etc. At the very sight of the packing they are able to identify the place of origin of product. Usually palm tree leaf (Gopakumar, 1996) pack is from Tamilnadu / Pondicherry and coconut leaf pack is from local place, bamboo or gunny bag pack is from Orissa / Gujarat / vizag. The cured fish from Andrapradesh is prepared from rock salt and the saltiness is less and with more impurities. They identify the quality of fish by experience, appearance, colour and odour. They store for a maximum period of two weeks and with in the period they try to sell the product. During rainy season, due to high relative humidity the storage of cured fish and dry fish is very difficult and lead to spoilage and incur loss to them. So more salt is added to preserve the cured fish. The spoiled fish is used as manure. Their approximate turn over is Rs 1.5 to 2.0 lakh and attains a profit of 5 to 10% per annum.

The fish merchants have no guidelines about the purchase or sales of cured fish on quality either from Central or State Govts. Demand for dry fishes increase from April to August as the monsoon season starts. The merchants have strong preference for different product from different state, as shark, ray and dhoma are preferred from Gujarat. Ribbonfish, anchovies and silver belly are received from Tamilnadu and

Pondicherry. Shark, anchovies and ribbonfish are brought from Orissa and Andrapradesh. The average total quantity of fish purchase was 1,46,161 kg and value was Rs. 23,55,639/-. The total average sale of fish was 1,44,720 kg and value was Rs. 28,52,836/-. The percentage contribution of important fishes were mackerel, shark, ribbonfish, sardine, lesser sardine, silver belly, anchovies, lizardfish, dhoma and kilimeen (Figure – 3.1 & 3.2).

3.4.2. Workers

There are two groups of workers in the market namely, the workers under the direct control of merchants and loading and unloading workers. The office workers do not have any union and they carry out the works connected with office and sales. They are under the direct control of the owner or his agents. They are provided with monthly salary and other benefits. The loading and unloading workers are directly controlled by unions and are paid Rs 4/- per basket, and merchants do not grant them other benefits. The State govt. started a unit called "Fisherman welfare board" having its branches all over kerala to help these workers with certain rules. The loading and unloading workers have union affiliated to CITU. But no separate union to deal their purpose.

3.4.2.1. Changanacherry

This market is in high range region in Kottayam district. There are four wholesale merchants of which three are well functioning. They had more than 20 years experience in cured fish business. According to them, dry fish have good demand but it is not available. So the number of fish retail stalls reduced to 10 from 14. They usually get fish from different state enrouted through Alwaye or directly. The cured fish from Tamilnadu is always packed in palm leaf and in land cured fish were in coconut leaf. Andrapradesh people use gunny bags and Gujarat use bamboo baskets. The merchants identify the quality by appearance, colour and odour. They store fish for one or two weeks with out any quality difference and they add more salt to fish. The relative humidity of the market is usually more than Alwaye as it is a hilly place. The spoiled fish is used as manure to coconut trees. They reported that black insects may occur after one month and no other preservative except salt is added. The pink colour is an important problem and some time they rewash in salt solution and add more salt. Their annual expenditure is about Rs 80,000 to 90,000 and the profit is 5 to 9%. They have 4 to 6 casual workers and are paid Rs 2,000/- per month.

The merchants reported that the people prefer fresh fish but unlike at Alwaye, people have no shyness to carry cured fish. Festivals and other important days do not have any influence on sales of cured fish. Three to four months from April to August have high demand for all type of cured fishes. The products are sold on sell and pay basis. The fish is despatched to Malampuzha, Thekkady and other hilly areas. The total average purchase quantity was 69,345.5 kg and the value was Rs 13,45,171/- and the total sale was 67,799.65 kg and the value was Rs 15,33,248/-. The purchase contribution of fishes were mackerel, shark, ribbonfish, sardine, lesser sardine, silver belly, anchovies, lizardfish, dhoma and kilimeen (Figure – 3.3 & 3.4).

3.5. Discussion

The study in this field is limited. The results at Alwaye showed that the sale of fish was by 0.99% more than purchase of fish during the year and the value was more by 21.11%. This showed that the stock from previous year also sold. There is not much loss in product due to any reason except due to spoilage etc. The average percentage purchase quantity and sales quantity had equal effects and it showed that there was not much loss. The purchase and sales value show that there is a slight increase in mackerel and more in shark in the sales than purchase price. In all other varieties, the values are fluctuating. Shark is an important dried product and widely accepted by the people due to it's medicinal value. The data shows that the cured fish had high price during monsoon season.

The study at Changanacherry showed that the cured fish had high price than in Alwaye market. There was a decrease in sale of 2.23% than purchase quantity but the sales value increased by 13.96% than purchase value. The arrival of less quantity of cured fish had reduced the number of stalls. The cured fish marketing faces problem and there is no planned marketing due to the shorter shelf life. The Alwaye fish market is a centralized one to receive dry or cured fish from all part of India. Telephone helps to pass information on market trends and the rates are ascertained to the product and products are received. The market for cured or dried fish at Alwaye is always flexible and can't be assured. So the other local markets are affected due to the high fluctuations of the products. Further, the products from other States have lower cost than the local cost, which most often affects the local on auction and sales. So there is a need to ensure between demands and supply as noted by Gupta *et al.* (1983).

During Ester and Onam festivals and other fasting days of some religious functions people usually prefer only vegetarian food (Gupta *et al.*, 1983) and the demand for fish is reduced. So the cost of fish decreases and this affects on the curing units and market value of the products. The availability of fresh fish affects the cured fish market because people like fresh fish more than cured fish for the fresh taste. The fresh fish in the iced condition can have fresh taste for 3 to 5 days so the fresh fish in the iced condition is transported to interior places in vehicles. So the people go for the same and the demand for cured fish decreases.

The general trend of people is that they dislike the odour of cured / dried fish and they prefer to take fresh fish and to keep in refrigerator. So majority of the society ladies avoid the use of cured fish inspite of the fact that it is a nutritionally balanced food. Storage of cured fish is another important factor. Storing the cured fish in refrigerator (Gupta *et al.*, 1983) or in open condition also causes concern. If the temperature is high and relative humidity is low, the product will dry due to moisture loss and if the atmospheric temperature is low and relative humidity is high the product will absorb moisture and cause easy spoilage. This prevents the merchants and curers from storing cured fish for long period. Further, long storage at ordinary condition causes strong smell and discolouration and affecting the acceptability of product. Quality aspects of cured and dried fish are not properly cared neither by curers nor by the merchants. They only aim for high price based on the assumption that better appearance is the best quality.

So it is suggested that the Central (MPEDA) or State Govt. may provide technical guidelines to market cured fish and dried fish. Quality check is essential and must be carried out by qualified authorized agency for such purpose. The low quality cured fish are sold at a lower rate. Cured or dried fish marketing society is an essential one to help people in this sector. Cured or dried fish may be purchased through these societies. The quality check shall be done by the qualified technician in the society and marketed through them to the interior place in kerala. Dry or cured fish out lets may be opened in high range areas where sea fishes are not available. This can be a boost to people to get the good quality cured fish at a reasonable rate. So both govt. and people of high range can be benefited from the private vendors. The products can be sold on the "first come first out basis" as suggested by zugarramurdi *et al.*, (1993). This will be also a boost to the medium plant and lower class curers and the people in the hilly area as well.

The office workers and loading and unloading workers may be granted contributory provident fund benefit as in Govt. institutions after regularising the rules, so that it may be able to them to have a future in their work. They may have a membership in the fisherman welfare board.

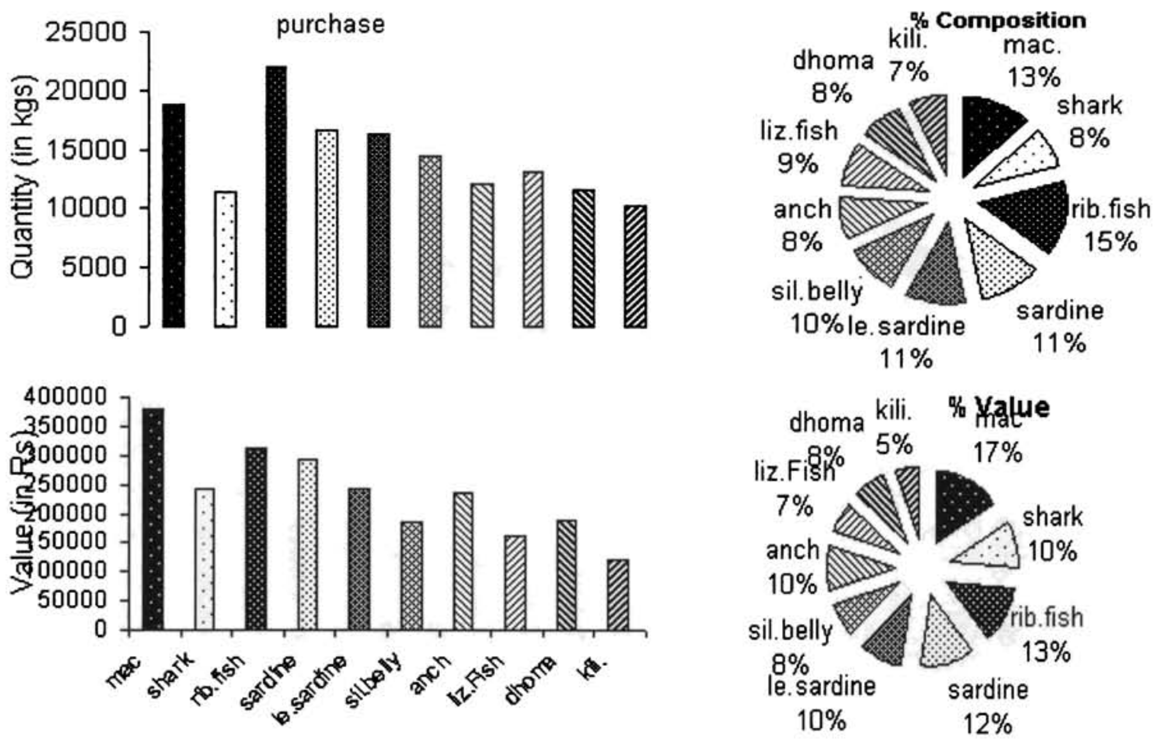


Figure – 3.1. Average fish purchase and value and both in % composition at Alwaye market

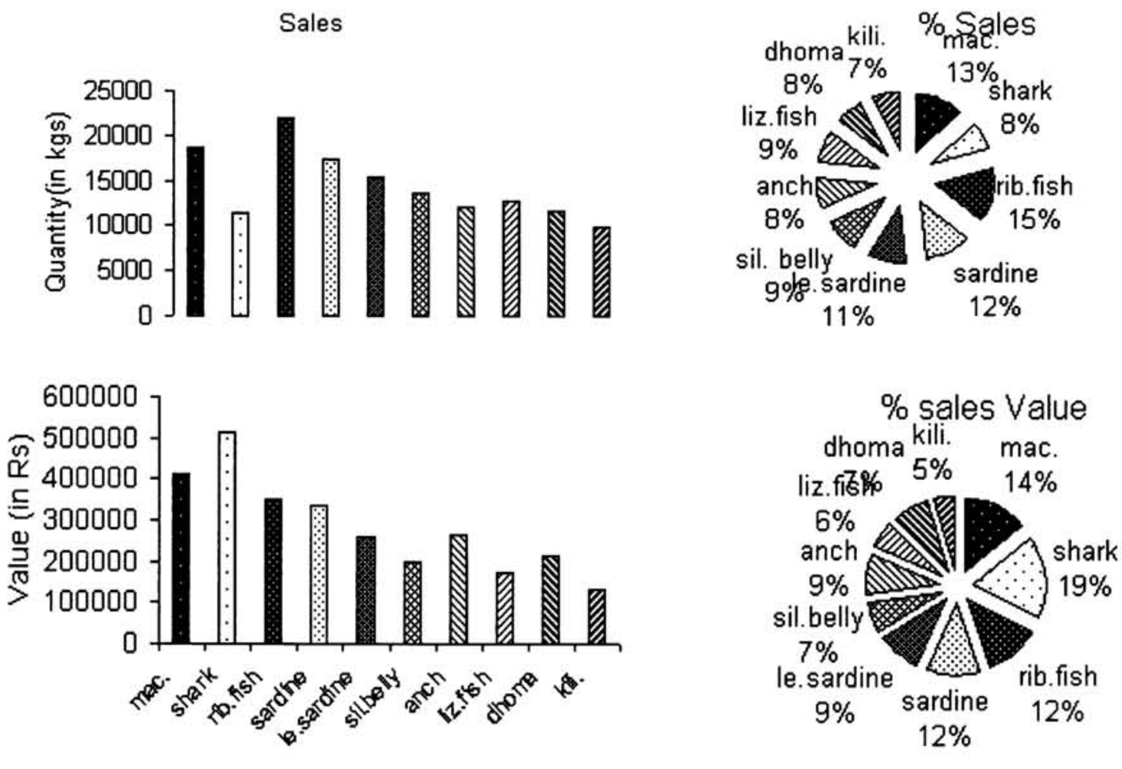


Figure – 3.2. Average sales and value and both in % composition at Alwaye market

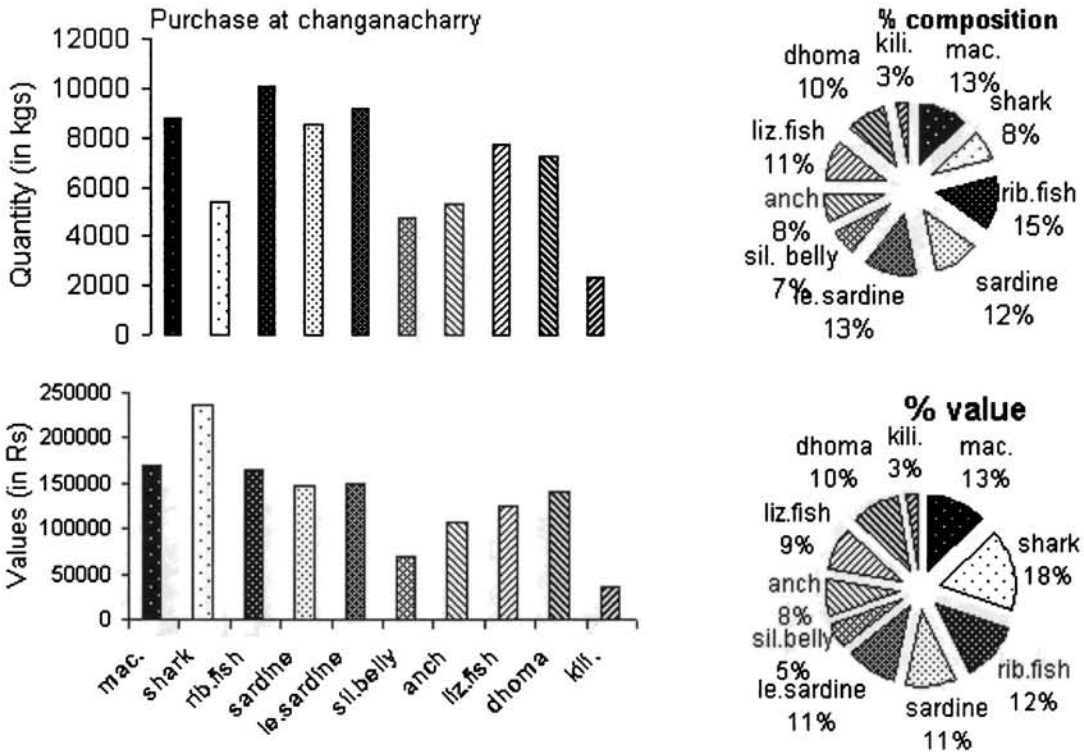


Figure – 3.3. Average purchase and value and both in % composition at Changanacherry market

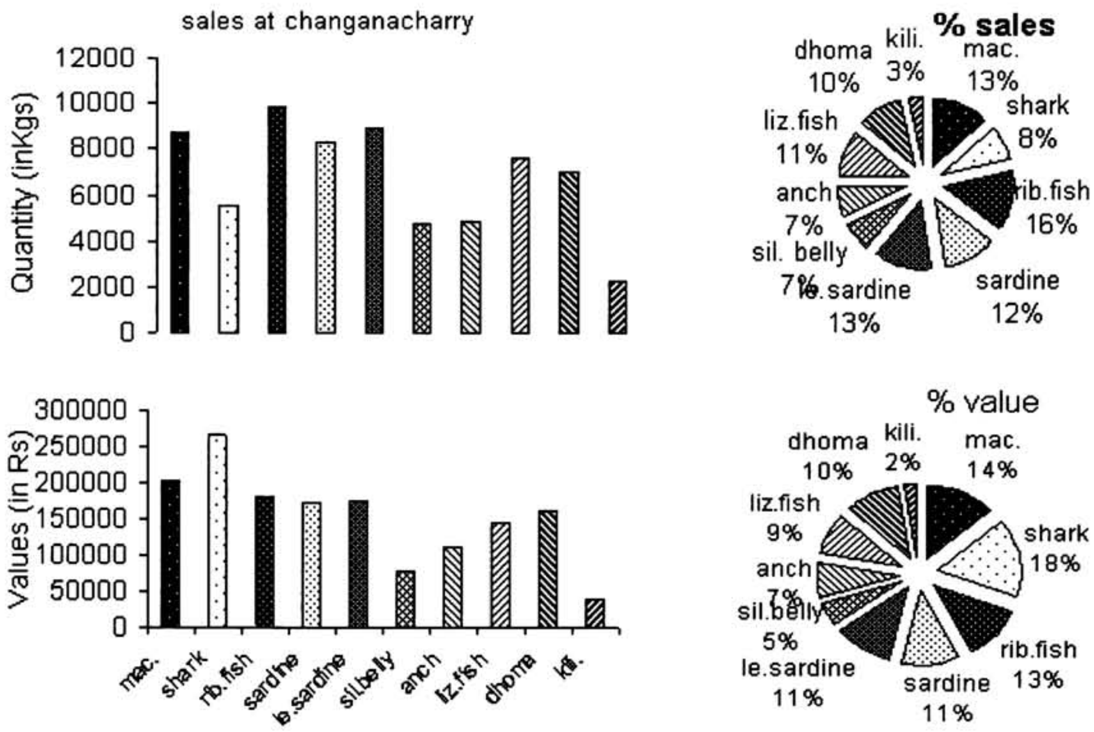


Figure – 3.4. Average sales and value and both in % composition at Changanacherry market

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 with out 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, pencillic 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^{0}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^{0}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 50C. 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^{0}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 10^0C to check the growth of red halophiles. Syme (1966) reported that the dry fish be stored at 41^0 F (5^0C) so that red halophiles do not grow. The maximum growth occurs during the storage at 77^0F (25^0C). Klaveren & Legendre (1965) suggested that the growth of red halophiles is due to the proteolytic action of the meat at 25^0C. Rubbi *et al.* (1983) reported that the fish stored at +13^0C 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 18^0C 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 + 5^0c.

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 elasmobranches 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 in to 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 1^{st} lot was stored without packing in room condition. The 2^{nd} 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 3^{rd} and 4^{th} lots were packed sealed in polyethane bags and stored in a refrigerator at $+13^0$c and cold store at -20^0c respectively to study the organoleptic and chemical changes during the storage periods using the standard methods. The 1^{st} and 2^{nd} lot's samples were removed at 10, 20 and 30 days interval and 3^{rd} and 4^{th} 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

$$X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$$

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

$$LSD = (2/r \times V_e) \times t_\alpha \text{ (error d.f.)}$$

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 48^{th} 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 $33.2^{0}c$ and 54% respectively. At four hours they were $36.1^{0}c$ and 45.1% and at eight hours 33.3^{0}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^{0}c and 57%. At four hours they were 36.2^{0}c and 51% and at eight hours they were 32.4^{0}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 32.50c and 64%, at four hours they were 36.4^{0}c and 49% and at 8 hours, 33.0^{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^{0}c and 60.0%, at four hours they were 36.6^{0}c and 51 and at 8 hours, 34.2^{0}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^{0}c and 45% relative humidity in the morning, 37.2^{0}c and 34.5% relative humidity at four hours and 34.8^{0}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^{0}c and 55 relative humidity in the morning, 34.1^{0}c and 45 relative humidity four hours and 32.2^{0}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.

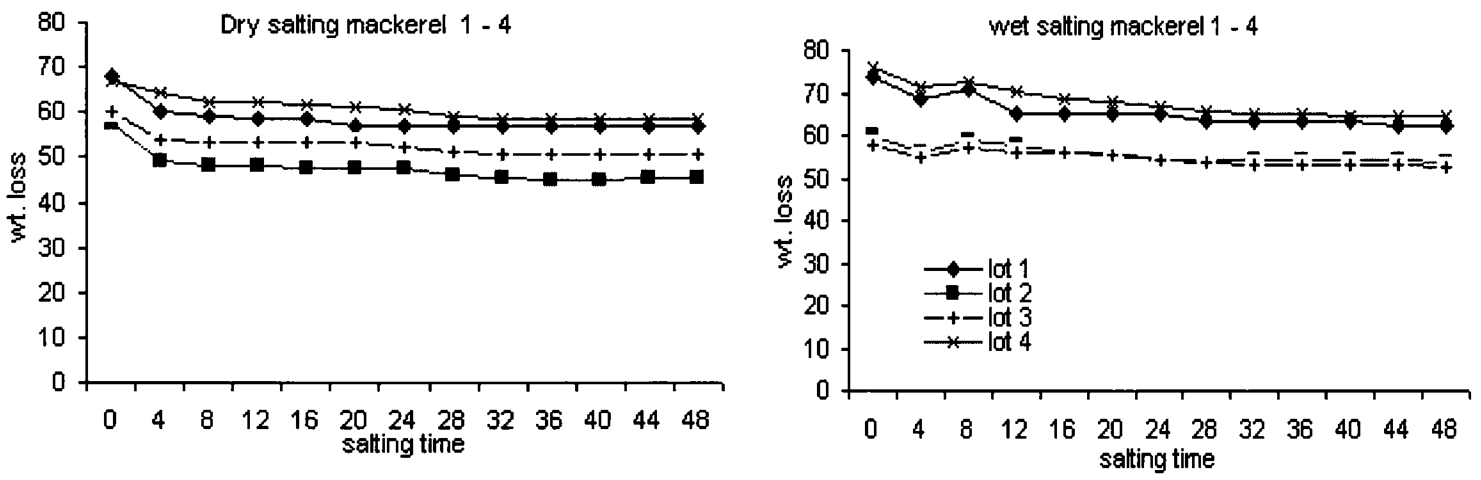
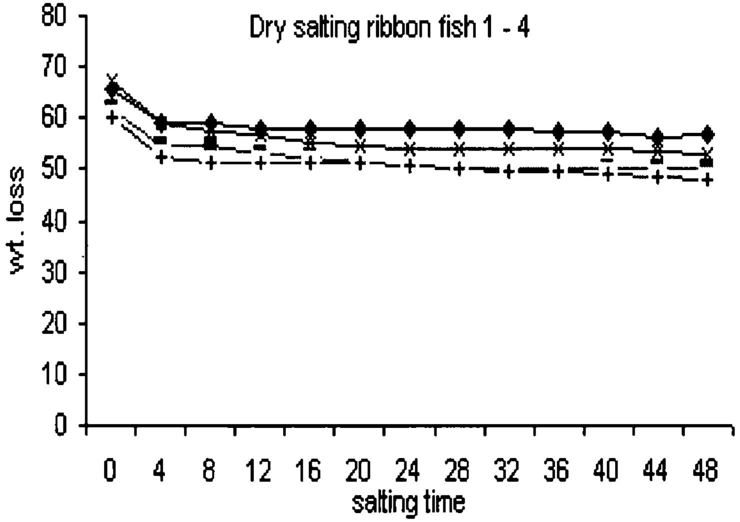


Figure - 4.1 Average weight loss in mackerel in different conc. of preservatives



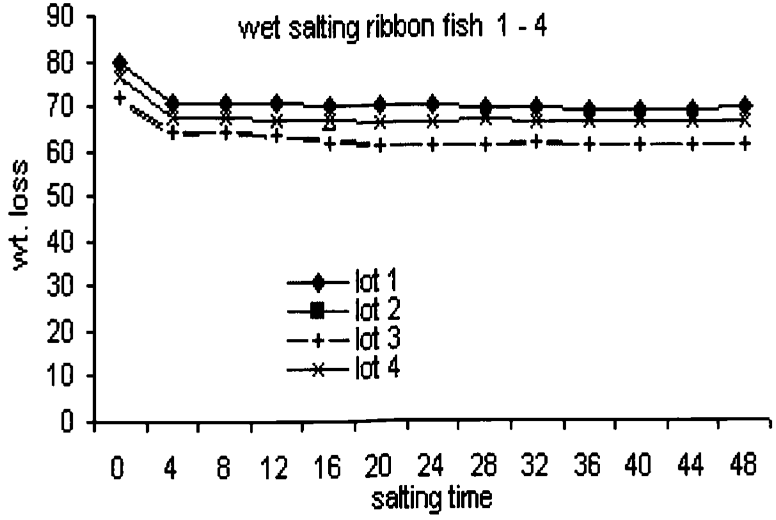


Figure - 4.2 Average weight loss in ribbonfish in different conc.of preservatives

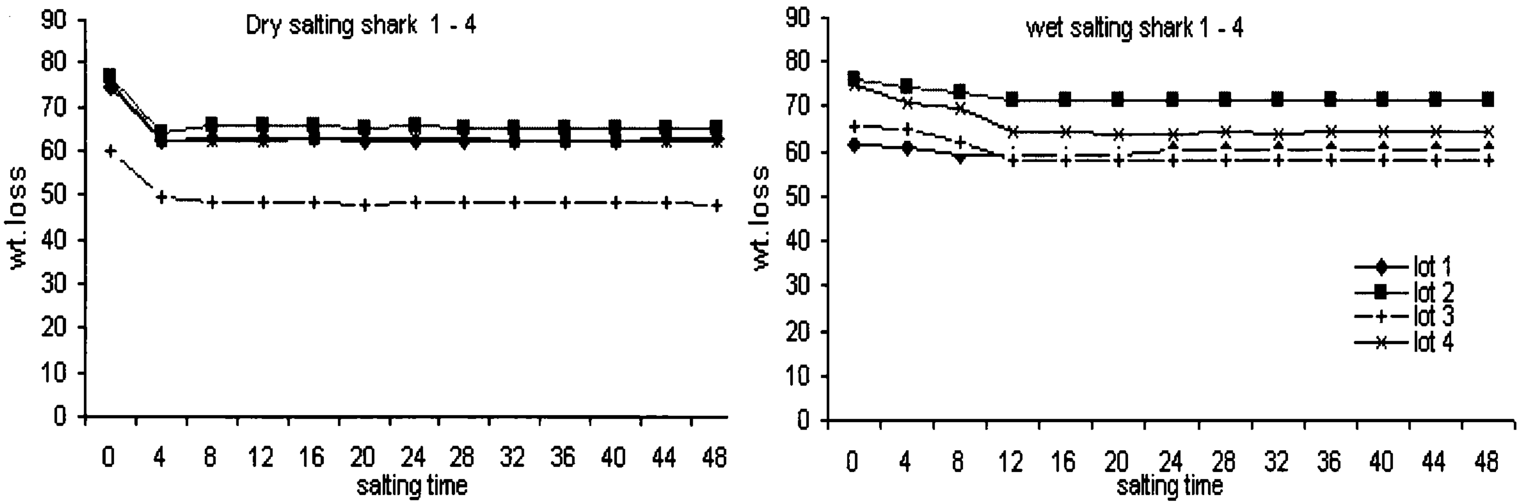


Figure - 4.3. Average weight loss in shark in different conc.of preservatives

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 salt & fish) (Lot – 1.)	1:4 + 1% Ca. Propionate (Lot – 2)	1:4 + 2% Ca. Propionate (Lot – 3)	1:4 + 3% Ca. Propionate (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)

Open air store (Without packing)	Open air store (Packed)	Refrigerator (Packed)	Cold storage (Packed)
Lot – 1	Lot – 2	Lot – 3	Lot – 4
↓	↓	↓	↓
10 days	10 days	one month	one month
↓	↓	↓	↓
20 days	20 days	2 months	2 months
↓	↓	↓	↓
30 days	30 days	3 months	3 months
	↓	↓	
	4 months	4 months	

Table – 4. 4. Average weight loss during Drying & Yield

Dry salted mackerel

	0 Hours drying	After 4 hrs drying	After 8 hrs drying	% Yield
Lot 1	57.2	56.25	54.75	80.51
Lot 2	45.6	44.2	43.8	76.04
Lot 3	50.8	49	47.4	78.74
Lot 4	58.4	56.4	53.2	79.4

Wet salted mackerel

Lot 1	62.3	61.2	59	80.16
Lot 2	53.8	47.8	45.2	75.25
Lot 3	52.8	46.4	45.1	77.85
Lot 4	64.8	57.2	55.4	73.09

Dry salted ribbonfish

Lot 1	56.8	49.5	42.4	64.83
Lot 2	50.2	39.4	36.6	59.42
Lot 3	47.8	38.2	35.4	58.8
Lot 4	53.2	43.2	40.4	61.42

Wet salted ribbonfish

Lot 1	69.5	59.5	57.5	72.1
Lot 2	60.8	50.6	47.8	67.32
Lot 3	60.8	49.2	45.8	63.43
Lot 4	66.2	51.6	49.01	61.98

Dry salted shark

Lot 1	62.8	50.2	48.5	63.02
Lot 2	65.3	57.75	55.56	69.28
Lot 3	48.1	44.5	43.2	74.92
Lot 4	62.5	54.25	51.5	69.63

Wet salted shark

Lot 1	60.2	55.25	53.1	86.02
Lot 2	71.5	65.5	62.4	81.31
Lot 3	58.2	52.25	49.52	75.29
Lot 4	64.2	57.51	53.52	71.33

Table 1 Results of two - way ANOVA on average weight loss of D.S. mackerel

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1383.696	3	461.2322	756.7008	1.47E-32	2.866265
Columns	381.9923	12	31.83269	52.22494	4.39E-19	2.032703
Error	21.9431	36	0.60953			
Total	1787.632	51				

Table 2 Results of two - way ANOVA on average weight loss of D..S mackerel on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	181.935	3	60.645	91.25266	0.00191	9.276619
Columns	5.61125	1	5.61125	8.44326	0.062212	10.12796
Error	1.99375	3	0.664583			
Total	189.54	7				

Table 3 Results of two - way ANOVA on average weight loss of w.s. mackerel

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1807.374	3	602.4579	410.8969	6.86E-28	2.866265
Columns	337.2752	12	28.10627	19.16944	3.93E-12	2.032703
Error	52.78327	36	1.466202			
Total	2197.432	51				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	306.6138	3	102.2046	661.1617	9.96E-05	9.276619
Columns	7.80125	1	7.80125	50.46631	0.005739	10.12796
Error	0.46375	3	0.154583			
Total	314.8788	7				

Table 5 Results of two - way ANOVA on average weight loss of D.S.ribbonfish

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	459.2375	3	153.0792	202.1959	1.41E-22	2.866265
Columns	448.6773	12	37.38978	49.38661	1.12E-18	2.032703
Error	27.255	36	0.757083			
Total	935.1698	51				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	102.5137	3	34.17125	14.78475	0.02655	9.276619
Columns	30.03125	1	30.03125	12.99351	0.036642	10.12796
Error	6.93375	3	2.31125			
Total	139.4787	7				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	589.4379	3	196.4793	647.4539	2.32E-31	2.866265
Columns	399.9009	12	33.32508	109.8154	1.31E-24	2.032703
Error	10.92472	36	0.303465			
Total	1000.263	51				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	143.3135	3	47.77118	286.0336	0.000349	9.276619
Columns	14.55301	1	14.55301	87.13727	0.002603	10.12796
Error	0.501037	3	0.167012			
Total	158.3676	7				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2262.974	3	754.3246	5049.233	2.74E-47	2.866265
Columns	539.2657	12	44.93881	300.8075	2.56E-32	2.032703
Error	5.378181	36	0.149394			
Total	2807.618	51				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	177.8729	3	59.29095	302.0682	0.000321	9.276619
Columns	7.88045	1	7.88045	40.14834	0.007949	10.12796
Error	0.58885	3	0.196283			
Total	186.3422	7				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1360.191	3	453.3971	221.9525	2.88E-23	2.866265
Columns	206.9593	12	17.24661	8.442775	2.77E-07	2.032703
Error	73.53957	36	2.042766			
Total	1640.69	51				

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

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	185.7253	3	61.90845	208.0636	0.000561	9.276619
Columns	17.91011	1	17.91011	60.19279	0.004454	10.12796
Error	0.892638	3	0.297546			
Total	204.5281	7				

Chapter 5

PHYSICAL AND ORGANOLEPTIC CHANGES IN DRIED FISH PRODUCTS

5.1 Introduction

The physical changes and organoleptic qualities are the important characteristics concerned directly with marketing of dried fish and cured fish. The appearance is one of the most important factors that attract consumers towards the product. The customers will not prefer poor appearance and other organoleptic characteristics in products. This leads to loss to the seller as well as the producer. So the study on physical changes is equally important with the chemical changes of the fish and fishery products (Prabhu & Kandoran, 1991).

Salting is reported to change the structural and mechanical feature of muscle tissue (Anon., 1982; Stansby, 1963 & Voskresensky, 1965). Due to the contraction of tissue and the electrostatic force of terminal end of protein molecule determining the structural lattices of proteins about 15 to 25% bound water is reverted to free state (Voskresensky, 1965). This leads to the shrinkage and structural variations in protein molecules. Drying is the removal of water. The products become hard, brittle and reduce in size (Anon., 1981; 1982). The salted fish reabsorbs moisture during storage period and causes damage to the fish. As the fish contain nutrients necessary to support the growth of microorganisms, water content in the fish increase the growth of mould. These are called as "dun", and cause objectionable flavour and texture. The pink discolouration on cured fish and dried fish cause proteolytic attack to soften and break up the flesh and produce off-flavours (Anon., 1982).

5. 1. 2. Storage temperature

Like any other product, proper storage is an important factor in case of dry fish too. The dried fishes are usually stored at room temperature 28^{0}C (Antony, 1990). Further, the stored dried fish absorbs moisture from the surrounding atmosphere or it may lose moisture due to dry atmosphere. This is because the moisture content of the atmosphere has greater influence on the relative humidity and temperature. Keeping fish at the low temperature of 10^0C check the growth of red halophiles (Anon., 1982; 1981). Syme (1966) reported that the dry fish be stored at 41^0 F (5^0C) so that the red halophiles do not grow. The maximum growth occurs during the storage at 77^0 F (25^0C). Klaveren & Legendre (1965) suggested that the proteolytic action of the meat at 25^0C helps the growth of red halophiles. FAO. (1957) suggested that the salted dry fish stored at low temperature did not encourage the growth of red halophiles. Rubbi *et al.* (1983) reported that the fish stored at 13^0C 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 18^0C is acceptable for 12 week. Tressler & Lemon (1951) recommended low temperature for fatty fishes.

5. 1. 3. Fish spoilage

5. 1. 3. 1. Microbiological spoilage

In cured / dried fish the salt loving bacteria or other bacteria or yeast help the spoilage (Anon., 1982). The dominating bacteria are gram positive, halophilic or halotolerant micrococci, yeasts, spore formers, lactic acid, bacteria and moulds. A number of specific spoilage organisms have been reported (Anon., 1981, 1982). Some are extremely halophilic, anaerobic gram-negative rods and halophilic yeasts as causing off odour and flavours (sulphidy, fruity) in wet salted herring and cause 'pink'. The bacteria (Halococcus and Halobacterium) also cause pink discolouration of salt, brine and salted fish as well as off odours and off flavours normally associated with spoilage (hydrogen sulphide and indole). Some halophilic moulds cause spoilage, not produce off odours but reduce the value of the product.

5. 1. 3. 2. Chemical spoilage

The most important chemical spoilage process was the changes taking place in lipid fraction of the fish. Oxidative process, autoxidation, is a reaction involving only oxygen and unsaturated lipid. The first step leads to formation of hydroperoxide, a tasteless compound but causes brown and yellow discolouration to the fish tissue. The degradation of hydroperoxide give rise to formation of aldehydes and ketones. These compounds have a strong rancid flavour. Oxidation are initiated and accelerated by heat, light and several organic, inorganic substances. The signs of spoilage include detention of off-odours and off-flavours, gas production, discolouration and changes in texture. These changes are due to the combined effect of microbiological, chemical and autolytic phenomena (Anon., 1981, 1982).

5.1.3.3. Autolytic spoilage

The autolytic changes are responsible for early quality loss in fresh fish and contribute to the spoilage of chilled fish and fish products. Rapid development of off odour and discolouration are due the action of gut enzyme in ungutted fish.

According to Sikorski *et al.* (1995) the sensory characteristics of salted fish is resulting from enzymatic changes in protein, lipids and carbohydrates and undergoes various partial proteolysis and depends on temperature. So the salted fish should be stored at low temperature. The product needs good colour and appearance for effective selling. If the product is accepted, the consumer will always tend to buy the product even at a higher rate. The freshly prepared dried fish will always have a good colour subject to good handling of fish. Colour, appearance, flavour and textural changes are the important physical and organoleptic observations and are normally made on the point to check the quality of dried fish. Colour is an important factor to attract the customer to buy the product than quality. All are interconnected factors while the texture of fresh salted fish is always good, hard with less moisture content.

Anon. (1956) reported organoleptic changes of dehydrated fish. Firmness of fish increases (Anon., 1982, 1981) and textural change is due to the extraction of the moisture content from the fish flesh during salting. The appearance of the fish product is an added quality for a customer. Really the appearance and colour attracts the increase of the price of product and also the customer will eagerly spent more money for the same. The packets also need good appearance. The dried fish always have the fishy odour due to its nature and the oxidative nature of the fish oils contained in flesh. The organoleptic qualities of dry fish were studied by (Antony *et al.*, 1988) in bulk packing and market samples by Joseph *et al.* (1983; 1986; 1988a). Since, the unsaturated fatty oil content of fish reacts with oxygen in the surrounding air in presence of the salt, the fishy odour is unavoidable. Sodium chloride accelerates the reaction and affects the appearance of the products.

5.2. Aim

This study was aimed at,

- Organoleptic and physical changes of fresh fish during salting that affect the quality of dried products.
- Physical and organoleptic changes during different intervals of salting that affect the quality of dried products.
- To observe, physical and organoleptic changes during different intervals of storage at different conditions that has different effect on the quality of dried products.

5.3. Materials and Methods

For storage studies, the fishes used were mackerel, ribbonfish and shark. The observations were made during salting and storage to study the physical and organoleptic changes of the products from initial to final storage periods by following the materials and methods described in Chapter 4 and flow sheet tables 1, 2 and 3 in order to find out the limitations of storage period at different temperature and storage conditions. Only general observations were made during salting. Rating method was used to assess the quality, as 1- Very good, 2. Good, 3. Fair, 4. Bad, and 5. Very bad

(Ramachandran & Solanki, 1991) in different products. The parameters were tabulated and compared.

5.4. Results

5.4.1. General observations

The fish were salted at fresh condition after cleaning. The fish became firm in dry and wet salted fish and water came out only in dry salted fish. The colour and appearance were good during the course of salting and drying.

5.4.2. Initial Quality of Salted Fish

Dry salted mackerel. The selected lot was good in colour and appearance, with firm texture and fishy odour. In wet salted mackerel the selected lot was good in appearance, semi-firm texture, fishy odour and lightly oily yellowish colour. In dry salted ribbonfish the selected lot was having good appearance, colour, hard texture and fishy odour. In wet salted ribbonfish the selected lot was good in appearance, colour, semi-firm texture and slightly yellowish at belly portions. In dry salted shark the selected lot was good in appearance, colour, firm texture and ammonia odour. In wet salted shark the selected lot was good in appearance, semi - hard texture, ammonia odour and very light yellowish colour. No wet salted fish from *T. Indicus* had dark colour as noted in the products from gorukha puli (Rao *et al.*, 1958; Balachandran & Muraleedharan, 1975) but was palatable and semi - firm.

5.4.3. Products

5.4.3.1. Unpacked Sample stored in open air

The dry salted mackerel after 10 days showed that the oily yellow colour and hard texture increased and with good appearance but fishy odour decreased. After 20 days, it had less appearance with dark yellowish colour, hard texture and less fishy odour. After 30 days, it had increased harder texture and brittle, yellowish colour with salt crystal and moderate appearance and less fishy odour (Figure – 5.1). The wet salted cts after 10 days showed yellowish colour increased at the belly portion, firm and fishy odour with good appearance. After 20 days the yellowish colour increased further with less fishy odour and hardened texture and moderate appearance. After 30 days the fish hardened and the tail side portion broken with less fishy odour with moderate appearance and yellowish colour as observed by Nair & Gopakumar (1986) with salt crystals on surface and brittle (Figure – 5.2). The dry and wet salted fish were acceptable up to 20 days only.

The dry salted ribbonfish had good appearance, colour, fishy odour and firm texture initially. After 10 days, fishy odour slightly decreased with little hard texture and good appearance and colour. After 20 days, they were yellowish or grey colour at belly with moderate appearance, less fishy odour and little hard texture. After 30 days they were yellowish colour and the colour was dense at belly portion, fair appearance, hard texture, and brittle and very less fishy odour (Figure – 5.3). The wet salted ribbonfish had soft texture which increased to hard, fishy odour decreased with good appearance and colour after 10 days. The colour of the fish turned to whitish yellow with moderate appearance, hard texture and fishy odour decreased after 20 days. After 30 days, colour changed to yellowish with fair appearance and very hard texture with no fishy odour and brittle (Figure – 5.4). The dry and wet salted samples were acceptable only for 10 days.

The dry salted shark was good in appearance, colour with ammonia odour and hardness increased in texture after 10 days. After 20 days, there was no change in appearance and colour but hardness in texture increased with ammonia odour. After 30 days, ammonia odour decreased and colour and appearance were dim with harder and brittle texture with salt crystals (Figure – 5.5). The wet salted shark, after 10 days showed that colour and appearance are decreasing with ammonia odour and hardness slightly increased. After 20 days, colour, ammonia odour and appearance are further decreased with increase of hardness in texture. After 30 days the appearance and colour got faded with very less ammonia smell with hard texture and brittle (Figure – 5.6). The products seemed to be good and acceptable for 20 days.

5.4.3.2. Packed and Stored sample in open air

The Dry salted mackerel had good appearance, colour and fishy odour and hard texture after 10 days. But after 20 days, the appearance and colour decreased with decrease of hardness in texture and fishy odour. After 30 days, the samples had fouling smell and were almost spoiled (Figure – 5.1). The wet salted samples were with fade appearance, colour, less fishy odour and with softened texture after 10 days. After 20 days, the samples had pale yellow colour and appearance was dim, with semi-hard texture and less fishy odour. After 30 days, the samples were with colour fadedness and appearance with spoiled smell and lousy texture (Figure – 5.2). The former product seems to be good for 20 days and latter only for 10 days.

The dry salted ribbonfish after 10 days storage was good in appearance, whitish grey in colour with fishy odour and hard texture. After 20 days, colour and appearance are faded with texture and fishy odour decreased. After 30 days, the colour turned to grey with faded appearance, soft texture and little fishy odour (Figure – 5.3. The wet salted samples were good in appearance, colour fishy odour and hard texture after 10 days storage. After 20 days, colour turned to pale with loss of good appearance, less fishy odour and light soft texture. After 30 days, the colour turned to grey with further loss of good appearance and soft texture with very little fishy odour (Figure – 5.4). The dry salted fish was better than wet salted fish and the former was acceptable for 20 days and the latter for 10 days.

The dry salted shark after 10 days, were good in appearance, colour, with firm texture and ammonia odour. After 20 days, the ammonia odour increased with less colour, texture and appearance. After 30 days the samples showed very fair appearance and colour, soft texture with strong ammonia odour (Figure – 5.5). The wet salted samples showed good appearance, texture and colour with ammonia odour after 10 days. After 20 days the samples showed high ammoniacal odour, mild soft texture with less appearance and yellowish colour. After 30 days the samples were with inferior appearance, colour and odour with soft texture with strong ammonia smell with indication of spoilage (Figure – 5.6). The dry products were acceptable for 20 days and wet salted for 10 days.

5.4.3.3. Refrigerator Stored Sample

Dry salted mackerel samples had no identifiable organoleptic change even after one month storage. During the second month also not much change was noticed except the change in colour to light yellow. In the 3rd month there was no change in appearance but the yellowish colour increased with decrease of hardness and fishy odour. In 4th month the sample had only a slight change in appearance but the colour and texture were decreased (Figure – 5.1). The wet salted samples showed not much change in 1st month. In the 2nd month the samples showed moderate change in appearance, fishy odour and yellowish colour with hard texture. In the 3rd month, colour turns to yellow and with reduction in the initial appearance with soft texture with less fishy odour. In the 4th month the appearance was further decreased, yellow colour turn to dark with soft texture and with very less fishy odour (Figure – 5.2). The dry salted fish is better than the wet salted fish. The yellowish colour formation is fast in wet salted fish than dry salted fish even during storage. Dry salted fish is acceptable for four months and wet salted fish for three months.

The dry salted ribbonfish samples showed no organoleptic changes in the 1st and 2nd months. In the 3rd month, the samples had slightly yellowish colour with fair appearance, soft and fishy odour. In the 4th month, the samples had yellowish colour and appearance was dim with soft texture and fishy odour decreased (Figure – 5.3). The wet salted samples showed no difference in the 1st and 2nd month except the starting of yellowish colour. In the 3rd month the colour and appearance decreased slightly with soft texture and lightly fishy odour. In 4th month, the appearance and colour further decreased with soft texture and less fishy odour (Figure – 5.4). The dry salted fish was better than the wet salted fish and the acceptance was four months and three months respectively.

The dry and wet salted shark had no changes in the 1st month. In the 2nd month the appearance and colour were good with slight change in texture and ammonia odour. In the 3rd month, samples had high ammonia odour with less appearance and colour with soft texture. The meat was white in colour and without any discolouration (Figure – 5.5). The wet salted samples had same characters as fresh dried fish in the 1st and 2nd month except in high ammonia odour. In the 3rd month the appearance was less and the colour turned to brownish and softness of texture increased with more ammonia odour. The meat was pink or reddish colour and this may be due to the oxidized body oil (Figure – 5.6). The dry salted shark was better than wet salted fish in all quality parameters. The dry and wet salted shark was acceptable up to three months.

5.4.3.4. Packed Sample stored in cold storage

The dry salted mackerel samples showed no changes in the 1st month. In the 2nd month the samples had slight yellow colour with out any change in texture, odour and appearance. In the 3rd month the samples showed hard texture and the yellowish colour widen to other places with fishy odour. In the 4th month, it was noticed that appearance was fair with less fishy odour and less hardness with yellowish colour (Figure – 5.1). The wet salted samples had no difference from that of freshly salted fish product up to 2nd month except that slight change in colour. In 3rd month, sample had light yellowish colour, lightly hard with less fishy odour with less appearance. In 4th month the appearance was dim with yellowish colour, soft texture with slight fishy odour (Figure –

The dry salted fish was better than wet salted and the dry salted fish was acceptable for three months and wet salted less than three months.

The dry salted ribbonfish samples had no change for the 1^{st} and 2^{nd} months. The samples in 3^{rd} month, had slight yellow colour at white meat with less appearance, soft texture and fishy odour. In 4^{th} month, the colour was yellowish, the appearance decreased with slight soft texture and fishy odour (Figure – 5.3). The wet salted samples had no significant change in first month. In the 2^{nd} month, only slight change in colour was noticed. In the 3^{rd} month, colour changed to yellowish with slightly soft texture and fishy odour and slight loss of appearance. In the 4^{th} month, the appearance and colour were dim and soft texture increased with less fishy odour (Figure – 5.4). The dry salted fish was better than the wet salted fish and the dry salted fish was acceptable for three months and the wet salted between two to three months.

The dry salted shark samples had no specific change in the 1^{st} month. In the 2^{nd} month it had slight change in appearance with ammonia odour and hard texture with out any colour change. In the 3^{rd} month, the appearance and colour were reduced, and soft texture increased with ammonia odour. The meat was white in colour and without any discolouration (Figure – 5.5). The wet salted samples had no specific change in the 1^{st} month. In the 2^{nd} month, the samples had less appearance and colour, hard texture with ammoniacal odour. In the 3rd month, the samples had less appearance and colour, softness of the texture increased with strong ammonia odour. The meat was pink or reddish may be due to the oxidized body oil (Figure – 5.6). The dry salted fish was better than wet salted shark and the dry salted shark was acceptable for three months and the wet salted shark for two months.

5.5. Discussion

As fresh fish was used for the present study, quality of the raw fish was good and only minor changes were noted. The firmness of the meat increased as observed by

Solanki *et al.* (1970). The shrinkage and deformations were more in dry salted fish than wet salted. The pressure on the fish was less due to less quantity used for salting purpose. Sikorski *et al.* (1995) reported that the quality depends on the property of the raw material and the condition at the time of packaging.

Unpacked stored lots had almost same condition that they decreased the softness and moisture and increased hardness and become brittle and agrees as reported by Anon (1981), Zain and Yusof (1983). The dried fishes are usually stored at room temperature 28^{0}C (Antony, 1990). Nair *et al.* (1994) reported the yellowish discolouration on dried stored fish but no red or dun formation was observed during 30 days of storage in this experiment as sterilized salt was used. Prasad & Rao (1994) reported that the discolouration is due to the increase in moisture from initial to final stage. This may be due to wet humidity condition. Prabhu & Kandoran (1991) reported the organoleptic changes of dried anchovies and studied the colour changes as pale yellow, browning and rancid. This may be due to dry humidity condition. Since the samples were stored in room condition the possibility of dust fall on samples were less. As the lots lose moisture due to dry atmospheric temperature and relative humidity (Figure – 9.1), the texture become hard and brittle. The yellowish colour on the fishes showed the oxidation of fatty acids of the fish body. The yellowish colour was more on the wet salted lots than the dry salted lots. So it is assessed that the dry salted lots are good for 20 days on the basis of appearance. This is the same in ribbonfish and shark. Dried shark has unpleasant ammonia odour as reported by (Anon., 1956).

The packed open air stored lot showed the fish was useful only for 20 days as observed by Ramachandran *et al.* (1990) in storage of semi-dried dhoma. The fish was initially firm for 10 days then the moisture accumulated in the sealed cover might have been reabsorbed in the flesh and cause the spoilage of fish. The moisture content was not affected in any lots and spoilage was easy as reported by Hanumanthappa &

Chandrasekhar (1987) in hot smoked mackerel. Anon (1956) reported the same observation on packed and stored fish which loss fishy odour in fatty fish which cause unpleasant bitter product. Klaveren & Legendre (1965) suggested that the meat at 25^{0}C keeps the proteolytic action.

The lot stored in refrigerator showed that fish can be used for two to three months and there is not much textural and colour change. But further storage gradually reduces the organoleptic qualities of the products. FAO. (1957) suggested that the salted dry fish be stored at low temperature. Rubbi *et al.* (1983) reported that the fish stored at 13^{0}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^{0}C is acceptable for 12 weeks. This observation agrees with above report. Cold storage stored lot showed that there is no much change in colour and texture for three months and this also can be used for more than three months. Only little dryness was observed during storage period. Anon., (1981; 1982) suggested to keep the dry fish at low temperature of 10^0 C and Syme (1966) reported that the dry fish be stored at 41^0 F (5.^{0}C). Tressler & Lemon (1951) recommended low temperature for fatty fish. This study shows that the cured or dried fish can be stored in the refrigerator or in cold storage to increase shelf life substantially. This can also avoid the easy spoilage of dry or wet salted fish at ordinary condition.

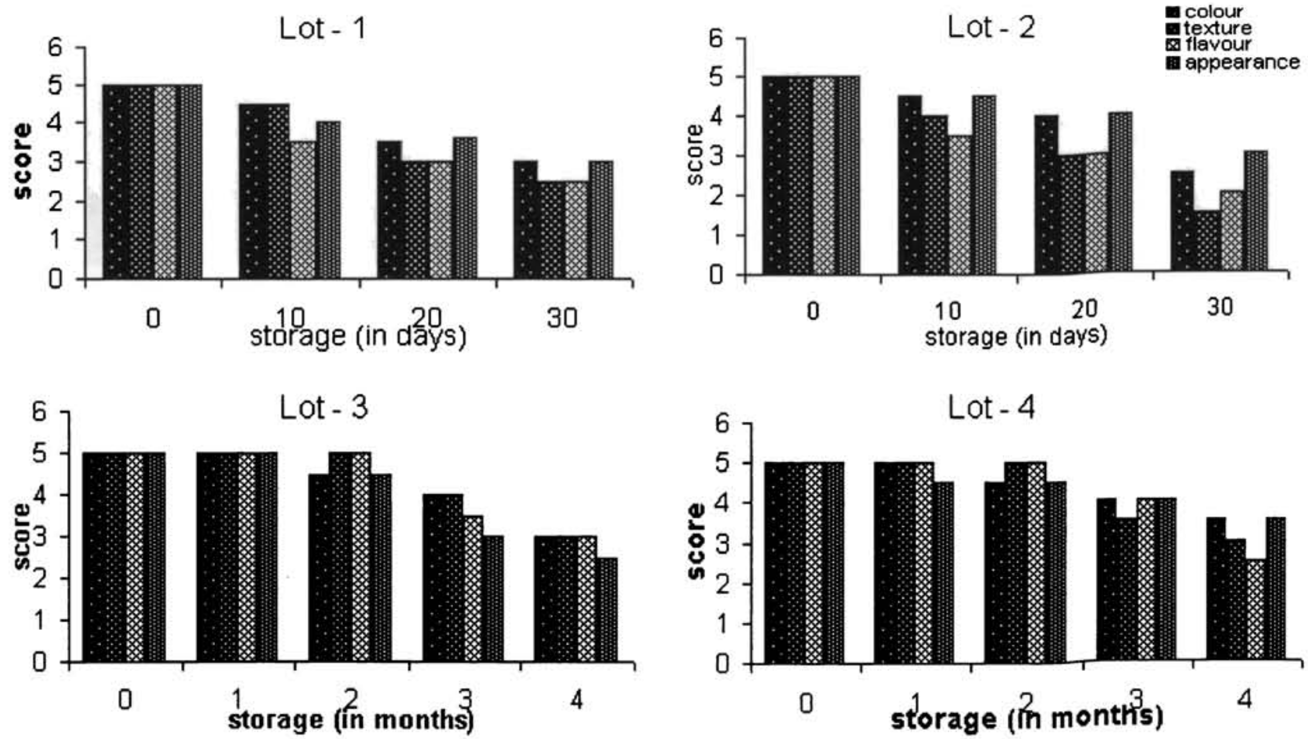


Figure – 5.1. Organoleptic changes on dry salted Mackerel

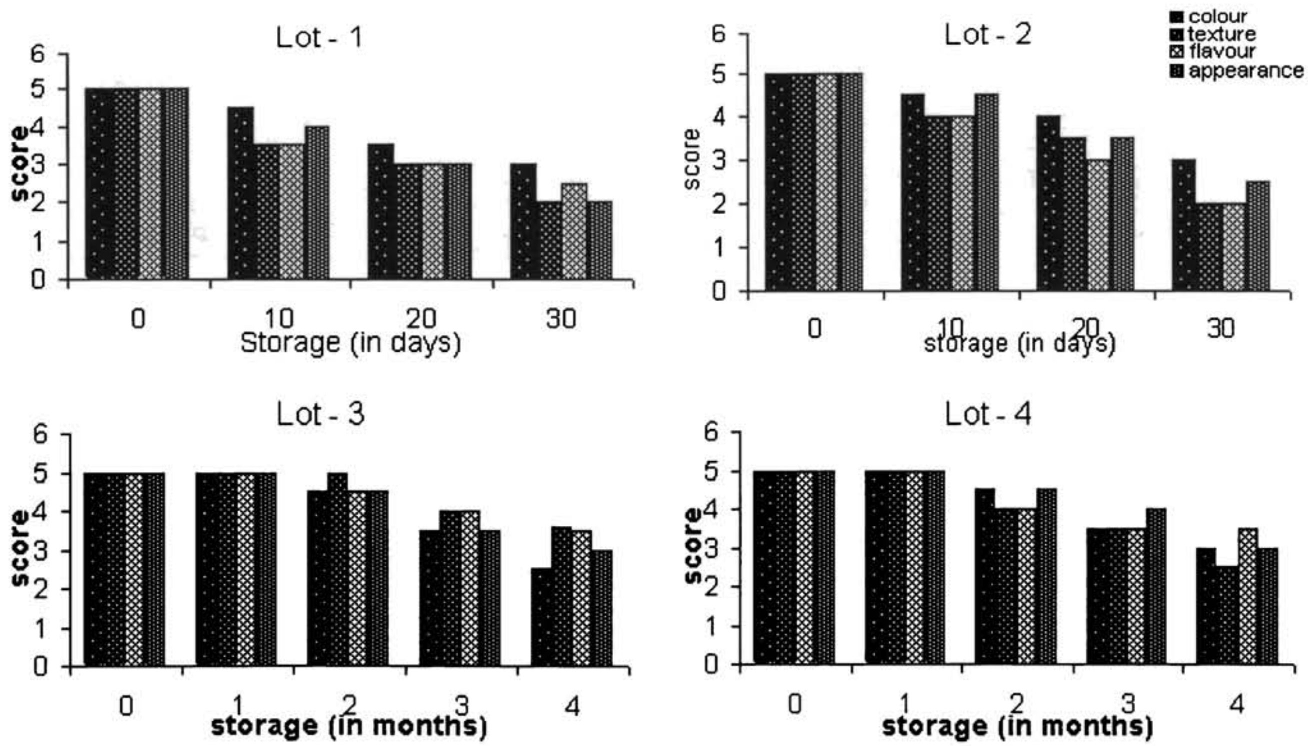


Figure – 5.2. Organoleptic changes on wet salted Mackerel

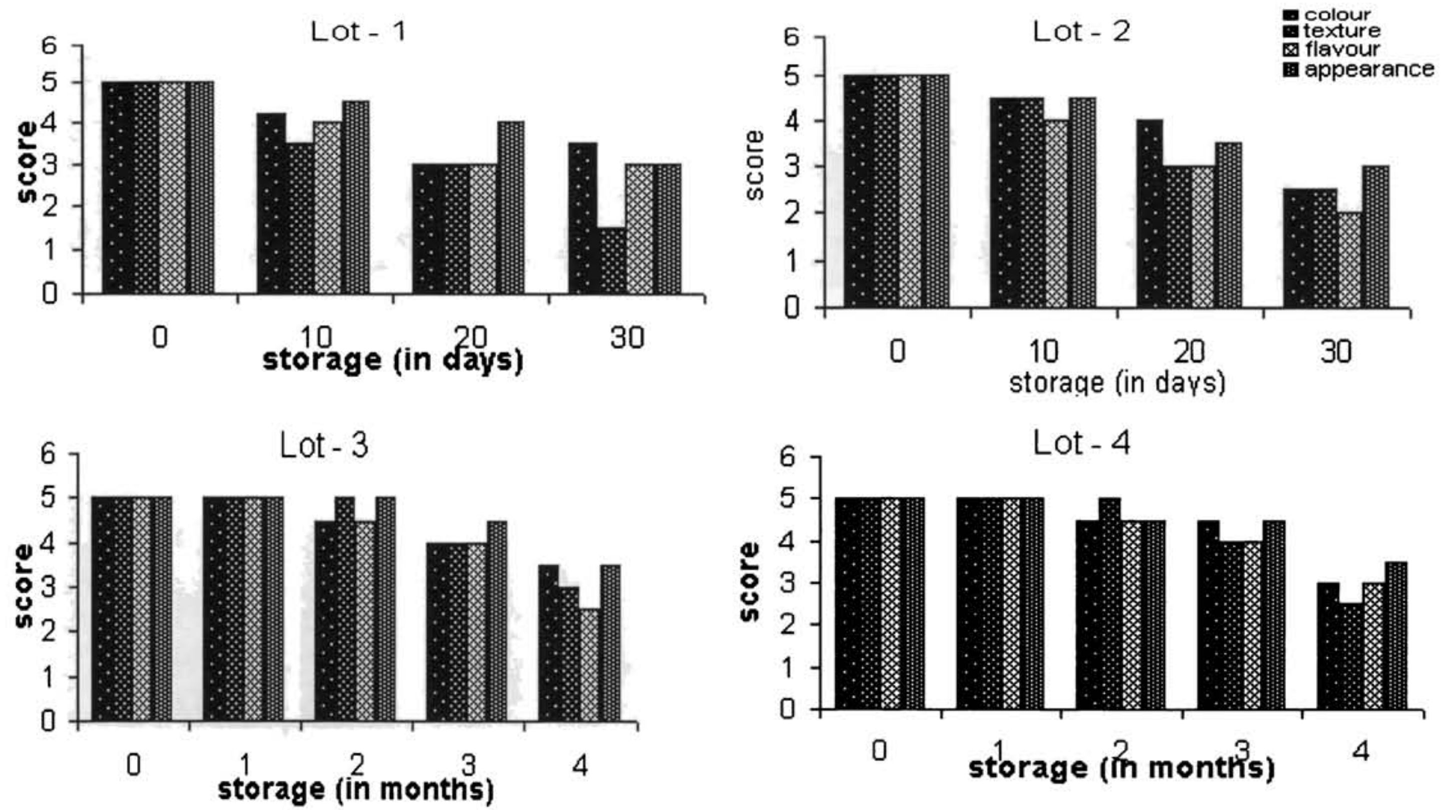


Figure – 5.3.Organoleptic changes on dry salted Ribbonfish

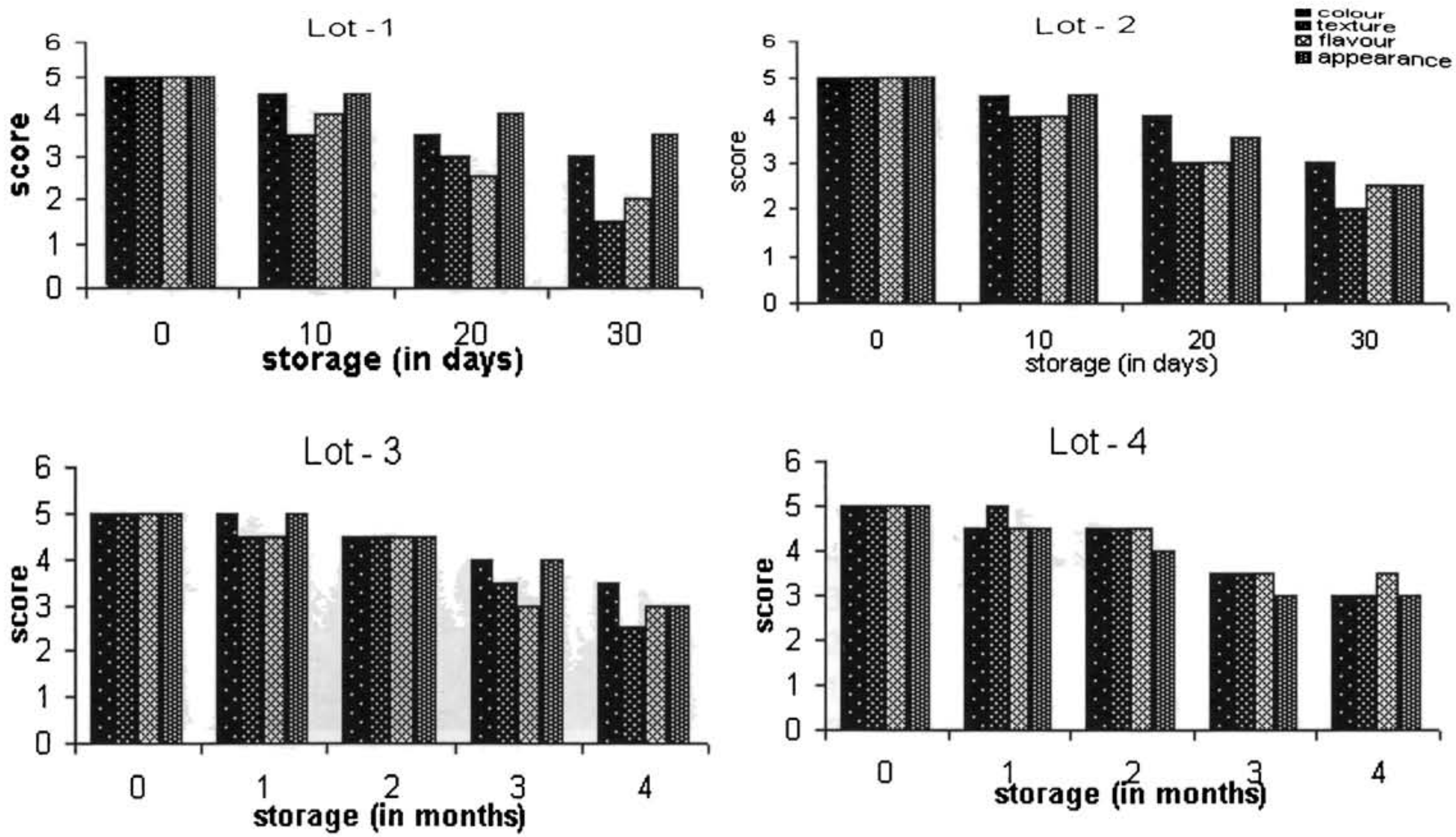


Figure – 5.4. Organoleptic changes on wet salted Ribbonfish.

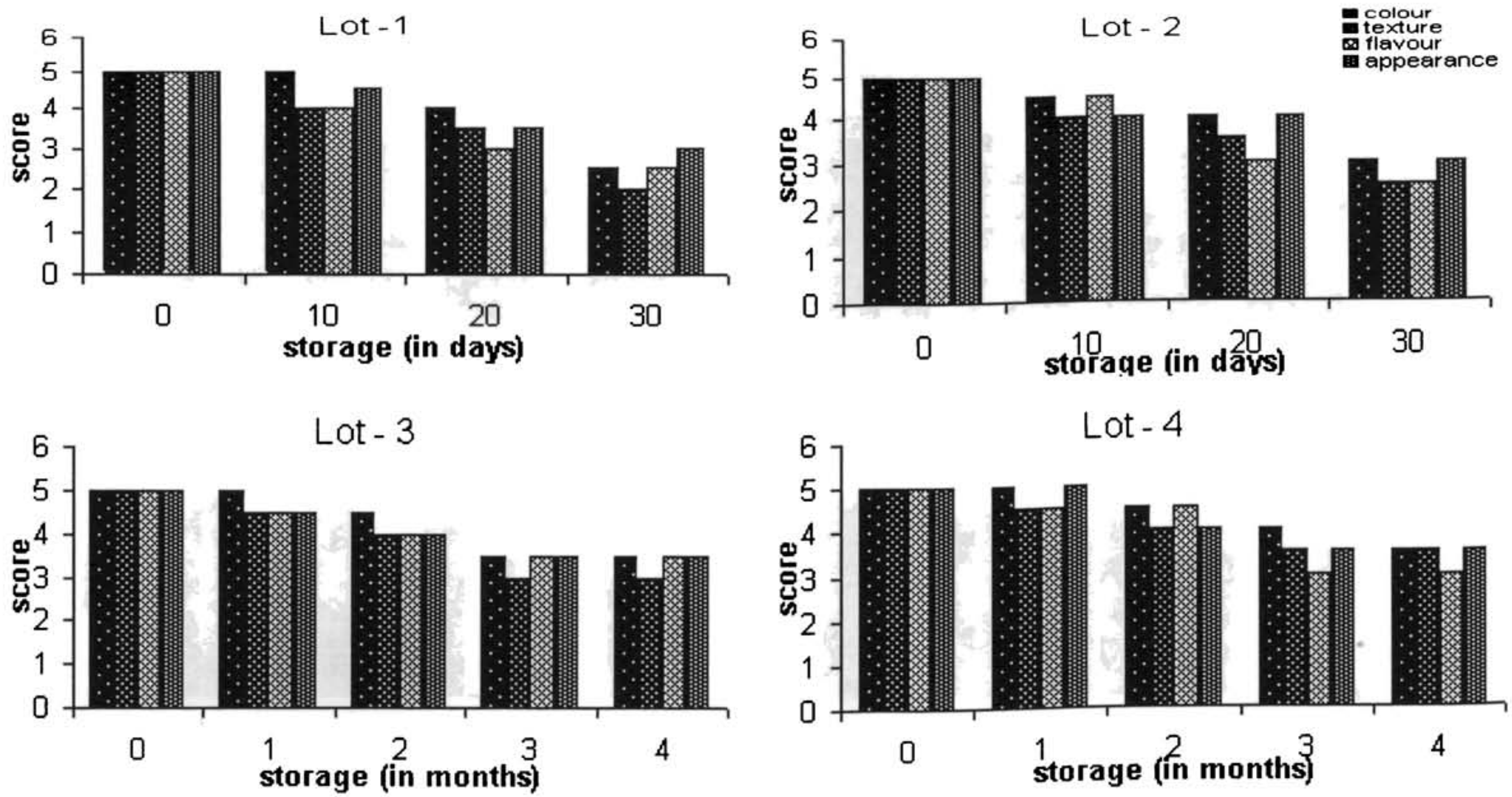


Figure – 5.5. Organoleptic changes on dry salted Shark

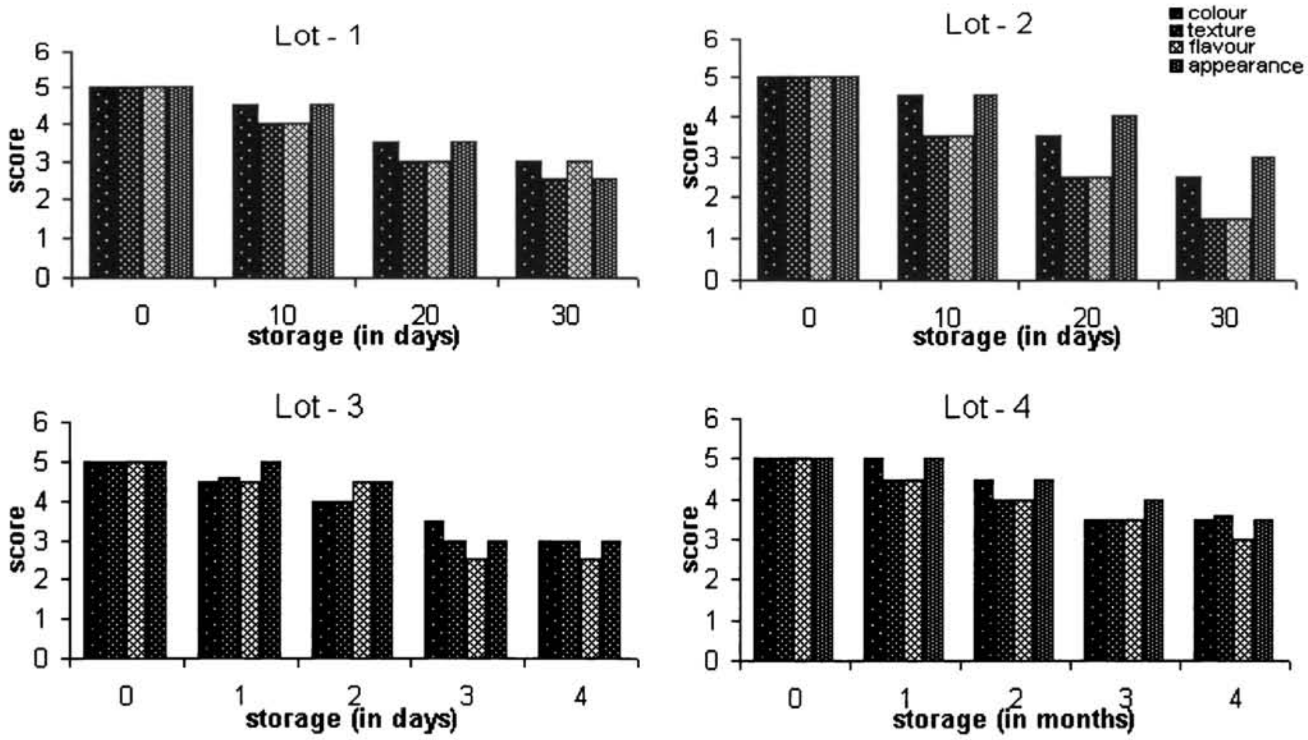


Figure – 5.6. Organoleptic changes on wet salted Shark

Chapter 6

CHEMICAL CHANGES OF FISH DURING SALTING, DRYING AND STORAGE

Introduction

The chemical aspects are grouped under two heads as nutritive and non-nutritive value components. The nutritive components are further divided into two major factors as nitrogen factors and lipid factors. The non-nutritive component consists of moisture, pH, ash, calorific value and salt. According to Nettleton (1985) nutrients like protein, fat and carbohydrate are converted into energy and the carbohydrate content in fish is less. Calorific value was calculated for the fish or fish products from the chemical composition. Water activity is a mixed property as the food material is concerned. Fish has very high water activity. Higher the water activity higher is the rate of spoilage. The deterioration can be expected at a_w 0.75 from normal putrefactive bacteria and salted fish can be spoiled by halophilic bacteria. Further it also related to toxin production, sporulation and germination. The above action of bacteria differs and depends on many factors like temperature, relative humidity, etc.

Moisture is an important factor in all stages of processing and storage of fish and fishery products. Salt is an essential component of cured fish products and provided environment to prevent spoilage by reduction of water. The powder salt has more penetrative power than crystal salt (Sikorski *et al.*, 1995). Finely grained salt rapidly dissolve in fish muscle fluid causing a too rapid withdrawal of moisture. 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). Sikorski *et al.* (1995) stated that salt penetration during dry salting is critical and fast and 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. Live fish has an optimum pH of 6.5 to 7.0 upon death and due to post mortem changes pH drops.

As spoilage proceeds the pH affects spoilage. The decline in pH affects the quality of fish texture and easy microbiological spoilage. The lowering of pH, in sardine in brine was reported by Krishnakumar *et al.* (1986), and in mackerel and in sardine (Balachandran & Muraleedharan; 1975 and Rao *et al.,* 1958). The insoluble ash content is useful to determine the purity of fish and the place from where it is processed. The water activity (a_w) study is essential to improve the storage life of the cured fish. Anon. (1981) reported a_w of the microorganisms. The water activity of bacteria – 0.91, yeasts - 0.85, moulds – 0.80, halophilic bacteria - 0.75, xerophilic moulds – 0.65 and osmophilic yeasts - 0.6. Doe *et al.* (1983) suggested that spoilage bacteria cease to grow at a_w below - 0.90 and growth of most moulds is inhibited below – 0.80. A_w of fish cake on brining decreased from 0.96 to 0.82 and 0.80 to 0.79 a_w in brine salted anchovies (Chakrabarti *et al.*, 1991; Reddy *et al.*, 1991 & Balachandran, 2001).

6.2. Aim

Fish meat undergoes various changes during salting, drying and storage. This study is aimed

- To observe the changes on moisture during dry and wet salting with different preservatives, drying and storage at different storage condition
- To observe the changes on salt intake in the meat during wet and dry salting with different preservatives and changes during drying and storage at different storage condition
- To observe the changes on pH in the meat during dry and wet salting with different preservatives, drying and storage at different storage condition.
- To observe the changes on a_w of fish flesh during dry and wet salting with different preservatives, drying and storage at different storage condition
- This is in turn aimed at assessing the impact of these components on the shelf life and storage behaviour of salted and dried products

6.3. Materials and Methods

6.3.1. Preparation of sample

The processed fish prepared as in M.M in the chapter 4 and flow sheet Table no 4.1, 4.2 and 4.3 were used to find the moisture, salt, pH and a_w. The fresh fish before and during salting or dried fish were cleaned without bone or skin and chopped into small pieces on a dried plastic board or wooden piece and then kept in a dried grinder. The meat was ground and this meat was used for various experiments. The prepared sample was kept in a refrigerator until further use. The graphs of the 4 lots during salting were grouped as one with serial numbers.

6.3.2. Moisture

The moisture content of the sample was determined as per standard method by AOAC. (1980).

6.3.3. pH

1gm of the minced meat was taken in a test tube and shacked with10 ml of distilled water. The pH was measured by using a standard pH meter as Obanu (1987).

6.3.4. Total ash, and acid insoluble ash

The total ash and insoluble ash were determined as AOAC. (1980)

6.3.5. Salt content

The salt content of the sample was determined as Anon. (1981). A known quantity of the dried sample was mixed well in a mortar with distilled water and made up to 250 ml in a standard flask. 25 ml of the sample was titrated against 0.1 N Silver Nitrate using Potassium Dichromate as indicator. The end point is the yellow colour just turn to red.

$$\text{Salt (\%) as sodium chloride} = \frac{\text{Titration value} \times 5.8}{\text{Weight of sample}}$$

esults were plotted in wet wt. basis.

3.16 Water Activity (a_w)

The water activity of the salted fish was calculated as per the method suggested Lupin (1993). The moisture and salt of the cured fish is determined using standard method and calculated water activity was determined.

$$m = \frac{17.111 \times \text{ \% of sodium chloride (ms)}}{\text{\% of moisture (mw)}}$$

a_w = 1.007 – 0.040m

Where, ms = mass of Nacl (g) and mw = mass of water (g)

The Nacl molality (m) is calculated considering it to be in true solution in the total water content of the product.

The water activity of dried fish was calculated on salt free, fat-free dry mass (mb) and mass of water (mw). The water activity is lowered by the drying action of the muscle. In drying, lowering of a_w normally begins in the first stage, during brining of fish as fish react with salt.

$$a_w \text{ for salted /dried fish} = \frac{\{1.007 - 0.684 \text{ (ms) X } 1.160 - 0.060 \text{ (mb)}\}}{\text{(mw)} \qquad\qquad \text{(mw)}}$$

Mb = SFDM = DM – SD. (OR) DM = 100 – Moisture. SD = -------- $\frac{x\,S}{DM}$

So a_w = mb / mw. mb = salt-free, fat- free dry mass. mw = mass of water. a_w = 1.084 - 0.077 (mb / mw). SFDM = salt free dry matter. Doe *et al.* (1983) stated that a_w of fat is hydrophobic and has no part in calculation of a_w provided water and salt ressed in fat free dry matter basis and find that a_w measured and calculated have d agreements.

.7. Calorific Value

The k.calorific values per 100 gm of the fish were determined from total nitrogen d total lipid using the standard method as Burton (1980) and Kleimannov (1982) and ltiplying with standard factor 4 for nitrogen and 9 for lipids.

4. Results

4.1. Calorific value, ash and insoluble ash

The fresh fishes had the following k.cal. value for mackerel 166.64, ribbonfish 39.75 and shark 107.23. The Ash content in fresh fish was mackerel 5.41, ribbonfish 13, and shark 2.09 gm / 100 gm of fish. The insoluble ash at fresh condition was nil.

.4.1.1. Moisture and salt changes during salting, drying and storage

.4.1.2. Dry salted Mackerel

The moisture and salt contents of raw mackerel were 69.71 gm and 1.23 gm 100 gm. In lot 1, the moisture content, increased by 0.75% initially and decreased subsequently by 3.56, 12.21 and 10.36% during 4, 8, 24 and 48 hours of salting respectively. Salt was 18.16, 20.52, 20.31 and 20.09% respectively than raw fish at 4, 8, 24 and 48 hours of salting. In lot 2, the moisture loss was 2.38, 3.59, 20.30 and 21.16% and salt was 19.66, 20.23, 21.04 and 20.09 in the same hours. In the lot 3, the moisture decreased by 2.68, 3.59, 13.57 and18.49% and salt was 20.07, 20.10, 21.55 and 21.13 n the same hours. In the lot four, moisture decreased by 0.09, 3.21, 22.15 and 26.41% and salt was 21.81, 22.80, 22.03 and 21.86 after 4, 8, 24 and 48 hours of salting than fresh fish (Figure – 6.1). The ANOVA results show high significance ($p < 0.001$) in moisture and salt and is less significant in column as the salting time increases (Table 1 - 4).

During drying, the moisture further decreased in lot 1, 12.62 and 19.89% and at was 21.03 and 21.33% after four hours at noon and after eight hours at evening than ated fish. In lot two, the moisture decreased by 8.22 and 13.0% and salt was 20.63 and :42% in the same period. In the lot three, the moisture decreased by 10.42 and :93% and salt was 21.48 and 21.35% in the same period. In the lot 4, the moisture ecreased by 4.60 and 8.24% and salt was 22.28 and 22.76% at noon and evening able - 6.1). There is significance between moisture and salt during drying ($p < 0.01$) ut no significance between drying hours (Table 5 - 8).

The moisture content in unpacked lot 1, of dry salted mackerel showed ecrease by 17.95, 27.34 and 35.04% and salt was 13.16, 11.70 and 10.86% after 10, 20 and 30 days of storage than dried fish. ANOVA results showed that there is significant difference in moisture and salt ($p < 0.01$) and no significance was observed etween storage hours (Table 9). The packed lots 2 showed that the moisture ecreased by 1.30, 2.65 and 5.48% and salt was 18.76, 19.42 and 17.05 during the same period. There is significance between moisture and salt ($p < 0.001$) but no significance between storage hours (Table 10). The refrigerator stored lots three had moisture loss of 5.35, 7.69, 4.58% and 7.17% and salt was 21.50, 21.54, 21.41 and 19.09% during one to four months. There is significance between moisture and salt ($p < 0.001$) but no significance between storage hours (Table 11). The cold storage stored ots four, had a loss of moisture of 3.15, 7.65, 6.49% and 2.63% and salt was 21.68, 21.82, 21.06 and 20.90% in 1 to 4 months (Figure – 6.2). There is significance between moisture and salt ($p < 0.001$) but no significance between storage period (Table 12).

6.4.1.3. Wet salted Mackerel

The moisture content in lot 1 decreased by 7.13, 14.27, 6.84 and 8.16% and salt was 16.43, 21.86, 21.03 and 20.89% more than in raw fish after 4, 8, 24 and 48 hours salting. In lot two, the moisture content decreased by 10.37, 15.99, 8.49 and 11.02% and he salt was 16.96, 18.86, 21.72 and 21.03% during the same salting period. In the 3rd lot moisture content decreased by 7.79, 10.77, 8.55 and 10.54% and salt was 18.41, 19.10, 2.22 and 19.19% during the same salting periods. In lot 4, the moisture content decreased by 10.75, 15.23, 9.04 and 10.51% and salt was 17.92, 21.14, 21.92 and 20.91% in the same salting period (Figure – 6.3). There is significant difference ($p < 0.001$) in water and salt but no significance in salting time (Table 13 - 16)

The moisture in lot 1, during drying further decreased by 11.15 and 13.71% and salt was 22.34 and 22.80% respectively after four hours at noon and after eight hours at evening than salted fish. There is significance between moisture and salt ($p < 0.05$) and no significance in drying hours (Table 17). In lot 2, the moisture decreased by 12.75 and 16.06% and salt was 22.26 and 22.40% respectively in the same period. There is significance between moisture and salt ($p < 0.01$) and no significance in drying hours Table 18). In lot 3, the moisture decreased by 11.93 and 15.57% and salt was 20.62 and 21.10% in the same period. There is significance between moisture and salt ($p < 0.05$) and no significance between drying hours (Table 19). In lot four, the moisture decreased by 12.54 and 12.45% and salt was 21.64 and 21.83% at noon and evening than salted fish (Table – 6.1). There is significance between moisture and salt ($p < 0.01$) and no significance in drying hours (Table 20).

The moisture decreased in unpacked lot one by 23.45, 48.55 and 78.61% and salt was 15.08, 10.50 and 3.14% than dried fish after 10, 20 and 30 days. There is significance between moisture and salt ($p < 0.05$) but no significance difference between storage hours (Table 21). The packed lot two had 9.93, 10.20 and 16.59% moisture decrease and salt was 18.93, 19.12 and 17.62% in the same period. There is significance between moisture and salt ($p < 0.001$) and no significance between storage hours (Table 22). The refrigerator stored lots three, had a decrease of moisture was 9.70, 15.46, 12.91 and 10.95% in one to four months and salt was 21.46, 21.01, 19.69

and 20.17% in the same periods. There is significance between moisture and salt ($p < 0.001$) but no significance in storage hours (Table 23) The cold storage stored lots four, and a decrease in moisture was 8.08 and 16.66,11.87 and 9.35% and salt was 19.16, …82, 19.14 and 20.01% after 1, 2, 3 and 4 months of respective storages than dried fish (Figure – 6.4). There is significance between moisture and salt ($p < 0.001$) but no significance in storage time (Table 24).

6.4.1.4. Dry salted Ribbonfish

The moisture and salt of raw fish were 76.56 gm and 1.02 mg / 100gm. In four lots, the moisture decrease and salt uptake in the meat are in similar trends as in mackerel in the said time as noted in (Figure – 6.5). All lots have significance between moisture and salt ($p < 0.001$) and no significance in salting hours (Table 25 – 28).

During drying, in lot 1, moisture content further decreased by 13.46 and 19.37% and salt was 22.01 and 23.12% during drying than salted fish. There is significance in moisture and salt ($p < 0.01$) but significance in drying hours (Table 29). In lot 2, moisture decreased by 18.63% and 19.88% after 8 hours of drying and salt was 23.37 and 24.44% in the same period. There is significance in moisture and salt ($p < 0.001$) and no significance in drying hours (Table 30). In lot 3, moisture decreased by 8.54 and 12.42% and salt was 24.05 and 21.98% in the same period. In lot 4, moisture decreased by 9.35 and 11.57% and salt was 23.35 and 23.98% after 4 hours at noon and after 8 hours at evening (Table – 6.2). There is significance between moisture and salt ($p < 0.01$) but no significance in drying hours (Table 31and 32).

The unpacked lots 1 had similar results as dry salted in mackerel. There is significance in moisture and salt ($p < 0.01$) and in column ($p < 0.05$) as storage period increases (Table 33). The packed lots 2, had similar results as in mackerel on moisture and salt. There is significance between moisture and salt ($p < 0.001$) and no significant difference between storage hours (Table 34). In refrigerator stored lots 3, the moisture and salt have similar results as in dry salted mackerel. There is significance between moisture and salt ($p < 0.001$) but no significance in storage hours (Table 35). The cold storage stored lots 4 had similar results as in dry salted mackerel (Figure – 6.6). There is significance between moisture and salt ($p < 0.001$) but no significance in storage period (Table 36).

6.4.1.5. Wet salted Ribbonfish

Moisture content decreased and salt increased in all 4 lots, as observed in wet salted mackerel. The decrease in moisture and increase in salt are slightly influenced by concentration of the preservative also (Figure – 6.7). The ANOVA results in four lots shows that there is significance in moisture and salt ($p < 0.001$) and no significant difference in salting hours (Table 37 – 40).

In all four lots, drying had similar effect on moisture and salt as in wet salted mackerel. There is significance between moisture and salt ($p < 0.05$) but no significance in drying time (Table 41). Slight variations were found In ANOVA results in lot two; there is significance in moisture and salt ($p < 0.01$) but no significance in drying time (Table 42). In lot three, there is significance between moisture and salt ($p < 0.01$) but no significance between drying time (Table 43). In lot four, (Table – 6.2). There is significance between moisture and salt ($p < 0.01$) and no significance between drying time (Table 44).

In unpacked lots one, the moisture and salt had similar effects as in wet salted mackerel. There is significance between moisture and salt ($p < 0.05$) and in storage period ($p < 0.05$) (Table 45). In packed lot two, in refrigerator stored lots three and in cold storage stored lots four, the moisture and salt had similar effects as in wet salted mackerel, only slight variations observed. There is significance between moisture and salt ($p < 0.001$) and storage period ($p < 0.05$) (Table 46). In lot three, There is significance in moisture and salt ($p < 0.001$) but no significant different between storage period (Table 47) (Figure – 6.8). In lot 4, there is significance in moisture and salt ($p < 0.001$) and in storage period ($p < 0.05$) (Table 48).

6.4.1.6. Dry salted Shark

The initial moisture and salt were 73.51gm and 1.35 gm / 100gm in raw shark. In four lots, the moisture decrease and salt uptake in the meat are in similar trends as in dry salted mackerel in the said time as noted in (Figure – 6.9). However, the salt uptake was faster due to more cut surface. There is significant difference between moisture and salt ($p < 0.001$) but no significance between salting hours in all four lots during salting (Table 49 – 52).

The change during drying in four lots had similar effects as in dry salted mackerel on moisture and salt in the above drying hours (Table – 6.3). The ANOVA results are similar in all four lots. There is significance between moisture and salt ($p < 0.05$) but no significance between the drying time (Table 53 - 56).

In unpacked lots one, the moisture and salt had similar effect as in dry salted mackerel. There is significance between moisture and salt ($p < 0.01$) and no significant difference between storage period (Table 57). In packed lots two, moisture initially increased by 0.29% and then decreased by 6.53 and 12.54% and salt was 23.21, 21.22 and 20.28% in the same period. There is significance between moisture and salt ($p < 0.001$) but no significance in storage period (Table 58). In refrigerator-stored lots three, and in cold storage stored lots four, moisture and salt had similar effect as in mackerel (Figure – 6.10). The lots three and four had ANOVA results, as there is significance between moisture and salt ($p < 0.001$) and no significance in storage period (Table 59 - 60).

6.4.1.7. Wet salted Shark

In four lots, the moisture decrease and salt uptake in the meat have shown similar trends as in wet salted mackerel in the said time as noted in (Figure – 6.11). In all

:/lots there is significance between moisture and salt ($p < 0.001$) but no significance ·salting hours (Table 61 - 64).

During drying, moisture and salt had similar results as in wet salted mackerel in ad drying hours. in all four lots. The ANOVA results are similar for lots one to three. 'ere is significance between moisture and salt ($p < 0.05$) but no significance in drying me (Table 65 - 67). In lot four, moisture decreased by 8.53 and 14.40% and salt was :.33 and 26.65% after noon and evening (Table – 6.3). There is no significance :etween moisture and salt and drying time (Table 68).

In unpacked lots one and in packed lots two, moisture and salt had similar effect as in wet salted mackerel in the said storage period. There is significance between moisture and salt ($p < 0.01$) and no significance in storage period (Table 69). In lot two, :here is significance between moisture and salt ($p < 0.001$) and no significance in storage period (Table 70). In refrigerator-stored lots three, moisture content increased nitially by 0.41% and then decreased by 4.09, 1.04 and 2.54% and salt was 23.52, 25.35 and 24.13% in one to three months. There is significance between moisture and salt ($p < 0.001$) and no significance in storage period (Table 71). In cold storage stored ot four, moisture and salt had similar effect as in wet salted mackerel (Figure – 6.12). There is significance between moisture and salt ($p < 0.001$) and no significance in storage period (Table 72).

6.4.2. Change in pH and a_w (Cal) during salting, drying and storage

6.4.2.1. Dry salted Mackerel

The pH and a_w of raw mackerel were 6.83 and 0.99. In lot one, pH decreased to 6.39 initially after four hours and further decreased to 6.51 during 48 hours and a_w decreased to 0.74 at 8 hours and slightly increased to 0.79 at 48 hours than fresh fish. In lot 2, pH was initially 6.37 but decreased to 5.92 and increased to 6.27 and a_w was 0.74 in 4 hours and 0.77, 0.75 and 0.73 at 8, 24 and 48 hours. In lot 3, pH decreased to 5.78

ially and then increased to 6.19 at 48 hours and a_w was 0.78, 0.77, 0.74 and 0.73 after 4, 8, 24 and 48 hours of salting. In lot 4, pH decreased to 6.64, 6.40 and 5.92 and a_w 0.78, 0.73 and 0.80 at 8, 24 and 48 hours (Figure – 6.13). The 4 lots show that there is significant difference between pH and a_w ($p < 0.001$) initially but it decreases as salting time increases. There is no significance between salting hours (Table 73 – 76)

The change in pH and a_w during drying, in lot one, pH increased to 6.40 and 6.41 and a_w to 0.77 and 0.74 after 4 hours at noon and after 8 hours at evening than salted fish. The pH and a_w are significant ($P < 0.01$) but no significance in drying hours (Table 77). In lot 2, pH increased to 6.16 and 6.24 and a_w was 0.75 and 0.72 in the same period. pH and a_w have showed significant difference ($p < 0.01$) and not significant in drying hours (Table 78) In lot 3, pH increased to 6.14 and 6.19 and a_w decreased to 0.77 and 0.76 in the same period. There is significance between pH and a_w ($P < 0.01$) but no significant difference between drying hours (Table 79). In lot 4, pH increases to 6.09 and 6.10 and a_w decreased to 0.76 and 0.74 after noon and evening (Table – 6.4). There is significance between pH and a_w ($p < 0.01$) but no significance in drying hours (Table 80).

In unpacked lots 1, pH increased initially to 6.21 and then decreased 5.67. A_w decreased to 0.76 to 0.75 in 30 days than dried fish. In packed lots 2, pH decreased to 6.19 and 5.48 and a_w was 0.75 during the same period. In refrigerator-stored lots 3, pH decreased to 6.19 and 5.48. A_w remained 0.75 in 4 months. In cold storage stored lots 4, pH decreased to 6.19 and 5.66. A_w remained 0.75 during the same period (Figure – 6.14). There is significance between pH and a_w ($p < 0.001$) and no significance in storage period in all four lots stored in the above conditions. (Table 81 - 84).

6.4.2.2. Wet salted Mackerel

The pH increased initially to 6.86 and then decreased to 6.19 and 6.73 at 8 and 48 hours in lot 1, and a_w decreased to 0.83, 0.74, 0.73, 0.77, and 0.77 respectively at 4, 8, 12, 24 and 48 hour salting than fresh fish. In lot 2, pH decreased to 5.98 at 8th

urs but increased to 6.05 at 24 hours then decreased to 5.94 at 48 hours. A_w reduced to 0.82 and 0.73 at 4 hours to 48 hours. In lot three, pH decreased to 6.46 at 4 hours and 5.64 at 48 hours. A_w reduced to 0.81 in four hours and again decreased to 0.77 in 48 hours. In lot four, pH was 6.39 at 4 hours and reduced to 5.30 at 48 hours. A_w decreased 0.81 and 0.76 in four and eight hours and maintained at 0.76 in 48 hours (Figure - 6.15). There is significance between pH and a_w ($p < 0.001$) and no significance in salting hours (Table 85 – 88).

During drying, pH in lot one decreased from 7.00 to 6.35 and a_w decreased to 0.74 after 4 hours at noon and maintained at that level after 8 hours also than salted fish. In lot two, pH reduced to 6.26 and 6.06 and a_w decreased to 0.77 and 0.74 in the same period. In lot three, pH increased to 5.62 and 5.84 and a_w decreased to 0.75 and 0.73 in the same period. In lot four, pH decreased to 5.45 and 5.42 and a_w decreased to 0.74 and 0.73 during four hours at noon and after 8 hours at evening (Table – 6.4). There is significance between pH and a_w and no significant difference between drying hours in 4 lots (Table 89 - 92).

The pH in unpacked lots one reduced to 4.78 and a_w to 0.46 at 30th day than dried fish. In packed lots two, pH reduced to 5.73 to 4.94% and a_w maintained at 0.75 for 30 days. In refrigerator stored lots three and cold storage stored lots four, the pH reduced to 5.81, 5.52 to 4.96 and a_w maintained at 0.75 in one to four months (Figure – 6.16). There is significance between pH and a_w ($p < 0.001$) but no significance in storage period in four lots during storage in the above conditions (Table 93 – 96).

6.4.2.3. Dry salted Ribbonfish

The pH and a_w of raw fish was 7.01 and 0.99. In lot one, pH increased to 7.3 initially at four hours and the remaining results are similar as in dry salted mackerel (Figure - 6.17). There is significance between pH and a_w ($p < 0.001$) but no significance between salting hours in four lots (Table 97 – 100)

During drying similar results were observed as in dry salted mackerel in all four ɛs (Table – 6.5). There is significance between pH and a_w and there is no significance ɛtween drying hours in four lots during drying (Table 101 – 104).

The pH and a_w change in unpacked lots one, packed lots two, Refrigerator ɛred lots three, and cold storage stored lots four similar in results with dry salted ackerel as in (Figure – 6.18). There is significance between pH and a_w ($p < 0.001$) but o significance in storage period (Table 105 – 108).

6.4.2.4. Wet salted Ribbonfish

Similar trend was seen in the case of pH and a_w in wet salted ribbonfish during salting, drying and during storage at different condition (Figure – 6.19, 6.20 and Table 6.5). There is significance between pH and a_w ($p < 0.001$) but there is no significant difference between salting, drying and storage periods in 4 lots (Table 109 – 120).

6.4.2.5. Dry salted Shark

The initial pH and a_w of fresh shark were 7.09 and 0.99. In lot one, pH decreased to 6.24 and then increased to 7.02 at 4 and 48 hours respectively than fresh fish. In lots two, pH decreased to 5.84 at four hours but increased to 8.27 at 48 hours. In lot three, pH decreased to 5.80 at four hours and increased to 5.99 and decreased subsequently to 5.09. Lot four also showed similar trends in the case of pH. The results of a_w are similar with dry salted mackerel (Figure – 6.21). There is significance between pH and a_w ($P < 0.001$) but no significance between salting hours in four lots (Table 121 – 124).

The lot one, during drying the pH increased to 8.54 and then decreased to 6.96. A_w reduced in all four lots as observed in dry salted mackerel. There is no significance between pH and a_w and in drying hours (Table 125). In lot two, pH decreased from 8.17 to 8.07. There is significance between pH and aw ($p < 0.001$) and significance between drying hours ($p < 0.05$) (Table 126). In lot three and lot four, pH increased from 6.07 to

:20 and 6.69 and 7.04 (Table – 6.6). There is significance between pH and a_w ($p <$ .001) but no significance between drying hours (Table 127 - 128). The storage pattern s given in figure – 6.22 and ANOVA in Table 129 – 132.

6.4.2.6. Wet salted Shark

The pattern of behaviour of pH and a_w in wet salted shark is reflected in Figure – 6.23 and is similar with wet salted mackerel. There is significance between pH and a_w ($P < 0.001$) but no significance between salting hours in all four lots (Table 133 – 136).

During drying in lot one, pH increased 7.99 and 8.07 and a_w reduced 0.76 and 0.75 after four hours at noon and after eight hours at evening than salted fish. In lot two, pH increased 6.20 and 6.24 and a_w decreased 0.73 and 0.71 in the same period. In lot three, pH increased 5.00 and 5.09 and a_w decreased 0.68 and 0.68 in the same period. In lot four, pH increased 5.43 and 5.68 and a_w decreased 0.74 and 0.69 in same period (Table – 6.6). There is significance difference between pH and aw ($p < 0.01$) in lots 1 – 3 and ($p < 0.05$) in lot 4 but no significance between the drying hours (Table 137 – 140)

In unpacked lots one, pH increased 6.31, 6.40 and decreased 6.07 than dried fish. In packed lots two, pH increased initially 6.94 and decreased 6.76 in 20 days and increased 7.64 in 30 days. In refrigerator-stored lots three, pH increased initially 7.56, then decreased 6.8 and increased 7.2. In cold storage stored lots four, pH increased initially 6.64, decreased to 6.51 and a_w in all four lots was 0.75 (Figure – 6.24). There is significance difference between pH and a_w ($p < 0.001$) in four lots but no significance between storage period (Table 141 – 144).

6.5. Discussion

Gopakumar & Devadasan (1983) reported the moisture content of fresh mackerel as 73 to 75%, ribbonfish 74 to 76% and shark 73 – 75%. The result of moisture content agrees with and slight variations in results are due to season. In lot one, result shows that it contains more moisture initially and then decreases at eight hours. The oisture loss was little initially but increased as salting time increased, as noted by utting (1961) up to 28 hours and further loss was less as observed by Sanjeev & urendran (1993). The 1st lot reabsorbs moisture from medium after 24 hours as noted y Ragulin (1958) in Anchovies. The remaining dry salted mackerel showed moisture ss as the salting time increased. The results showed that moisture loss slightly epends on preservative and agrees with Kandoran *et al.* (1969). Decrease of moisture ontent later was due to uptake of salt in meat and this action was lowered as salting me increased. The wet salted mackerel showed that the moisture loss was high from itial period of salting and little after 8 hours (Ramachandran *et al.*, 1990). The freshly dded brine had very little effect on moisture. The results showed that the sample bsorbed moisture from the medium after 24 hours of salting as reported by Ragulin 958) in anchovies. The moisture loss was fast in wet salted lots during initial stage of alting and agrees with Sankar & Solanki (1992) in shark in control lot 1. But slow down s salting time increased.

The dry and wet salted ribbonfish showed that the moisture content in all lots ecreased as the salting period increased. High moisture loss was observed in lot three f the dry salted ribbonfish. The moisture loss was more in dry salted lots than wet alted lots. The dry and wet salted shark lots showed the moisture loss was high during he initial period in all cases as reported by Ramachandran & Solanki (1991) but it was ess during the subsequent salting period as noted by Kandoran *et al.* (1965) in shark. The difference in uptake of salt depends on the osmotic pressure and the concentration f mixture during dry and wet salting.

All lots lost moisture during sun drying. Moisture loss during drying was more in wet salted lot than dry salted lots. Valsan (1976) noted that moisture loss of dried ackerel as 18%. The moisture loss was more in control lot than the preservative added ots. Moisture content of cured mackerel 35 – 40%, ribbonfish 35 – 45% and shark 40 –

18% (Gopakumar & Devadasan, 1983) and requirement as ISI to mackerel is 35 and shark is 40%. The moisture content of 8 hours dried fish is high than above report and ISI standards. It is important that fish curing people not expects more weight loss. Above reports can only apply to dried fish.

All unpacked lots showed loss in moisture as reported by Daniel & Etoh (1983). But this depended on the relative humidity and atmospheric temperature. The packed lot two, had no much moisture loss and the results agree with reports of Nair & Gopakumar (1986) and Nair *et al.* (1994) in packed silver belly and shark stored at ambient temperature. Gupta & Chakrabarti (1994) reported that moisture loss occurred in packed dried sample during storage at ambient temp. In refrigerator-stored lot three, moisture decreased initially but increased subsequently. The cold storage stored four lots, had similar observation.

According to Cutting (1961) salting do not reduce any nutritive value but acts as a bactericide to reduce the bacteria. The results showed that the in take of salt was high at the initial period of salting at four hours in both dry and wet salting. Sikorski *et al.* (1995) stated that the finely grained salt rapidly dissolves in fish muscle fluid causing a too rapid withdrawal of moisture. Klaveren & Legendre (1965) stated that fine salt has the advantage of dissolving rapidly than crystal salt. So it readily dissolves on the surface of fish and contact of salt with fish is faster than brine. So the salt content is high in dry salted fish in four hours of salting than wet salting. According to Daun (1975) during salting mass transfer of elements and fish constituents take place in both direction and the effect of salting will be faster. It is observed that the salt penetration is faster in dry salted mackerel than wet salted mackerel. Salt uptake is faster in wet salted ribbonfish than dry salted ribbonfish and almost equal in dry and wet salted shark. Yet faster in dry salted shark. The fast action of the salt in wet salted fish was due to the dissolved brine (Ragulin, 1958). The concentration of preservatives had some effect in and dry salting process. The maximum salt penetration is possible in dry and wet salting during first four hours. Solanki *et al.* (1970) and Ramachandran & Solanki (1991) reported that the salt intake and salt penetration are quick in wet salting than dry salting. Sankar & Solanki (1992) reported that salt uptake is rapid in wet salting and is temperature dependent (Levendov, 1958).

According to Daun (1975) the salt or mixture or solution outside the flesh has to interact fastly with protein to absorb moisture and penetrate in the flesh. According to Ragulin (1958) the fish flesh cannot absorb solid salt directly. So, in the case of dry salting the salt has to absorb the moisture from flesh and the salt has to dissolve in it to form salt mixture out side. Dissolved ionic sodium chloride was absorbed in the flesh (Sikorski *et al.*, 1995) due to osmotic difference between fish flesh and brine. The salt uptake is faster during the initial period of wet salting than dry salting and was reported by Ragulin (1958) in anchovies, Krishnakumar *et al.* (1986) in sardine and Perigreen *et al.* (1975). In wet salting, the sodium chloride is in ionic form so the time for penetration of sodium chloride in fish is nil. The results show that the finely grind salt penetrates faster in the fish flesh than salt in brine. The powder salt has more penetrative power than crystal salt (Sikorski *et al.*, 1995 & Balachandran, 2001).

The same observations were made in dry and wet salted ribbonfish. The wet salted shark had little faster uptake of salt than dry salted fish. This was due to the scoring of fish flesh and more area of cut portion to easy direct contact of salt with fish flesh as reported by Kandoran *et al.* (1965). The increase of salt content in wet salted shark agrees with observations of Ramachandran & Solanki (1991) and Sankar & Solanki (1992).

The sun drying causes to increase salt content due to evaporation of moisture and salt content increased in all cases irrespective of lots. The dry and wet salted mackerel had 21.33 to 22.78 and 19.8 to 22.47%. Dry and wet salted ribbonfish had

3 to 24.98 and 21.51 to 25.83%. Dry and wet salted shark had 25.2 to 26.2 and 38 to 26.25% after drying Gopakumar & Devadasan (1983) reported salt in cured ackerel 15 – 25, ribbonfish 30 –35 and shark 15 – 35%. The requirement of salt as ISI o dried mackerel – 25 and shark – 30%. Joseph *et al.* (1986 & 1988a) studied salt ntent of various dried product and salt content had different range.

The unpacked lots one, in all cases showed that the moisture decreased and e salt increased as reported by Daniel & Etoh (1983). The white salt crystals are ailable during storage on dry and wet salted lots. The quantity was more on the wet ated lot than dry salted lot. Zain & Yusof (1983) reported moisture and salt in salted red fish as 32.9% and 20.0% and in hard dried and brittle fish was 25 and 11% in und dried Herring. This may be due the fact that as drying continues, the water and alt may penetrate to the surface and salt deposits on the surface (skin) of fish while oisture evaporate. On preparation of sample for tests as the skin was separated and alt crystals formed on surface (skin) was discarded. So the salt content in the flesh eems to be less and decreasing in flesh as the storage period increases. According to uss (1942)* cited in Huss (1988) the minute salt crystal appearing on the skin after uring causes red discoloration. But this depends on relative humidity and temperature f the atmosphere. The packed and stored lots two had no much difference except at nal storage time. Salt content in wet salted fish increased initially but decreased latter ue to the moisture difference at the storage time. Nair & Gopakumar (1986) reported at salt content have minor effect during storage. The salt content in refrigerator lot ree, and cold storage stored four lots, had more salt initially but decreased ubsequently; this may be due to moisture loss initially by the product as stated above.

Huss (1988) reported that pH has greater technological importance and even nor change drastically affects the property of connective tissue. The pH of the living sh muscle is neutral in reaction (Anon, 1956). The control lots without preservative in and wet salted fish had only slight decline in pH to acidity. pH lowered in mackerel ees with Krishnakumar *et al.* (1986) in chilled sardine in brine. The pH decreased to 3 and 5.38 in dry and wet salted mackerel. This shows that the natural preservative s on the fish muscle in presence of salt. Natural preservative is more effective on ering pH. The pH decreased during dry and wet salting of ribbonfish was 5.7 and 5. The results agree with Rao *et al.* (1958) and Balachandran & Muraleedharan 975). The pH of shark was not lower than 7.00. pH reached in dry and wet salted ark were 5.71 and 4.04 respectively during 48 hours of salting. The lowest pH was ained from natural preservative.

The drying caused to decrease the acidity and the alkaline nature increased. is may be due to the moisture loss and increase of salt content in meat. The packed lots one showed that in dry or wet salted lots, the alkalinity increased initially llowed by an increase in acidity during storage. The dry salted shark showed that the kaline nature increased as the storage period increased. The wet salted shark showed at alkalinity was more initially and acidity increased subsequently. This may be due to e high content of moisture available in wet salted shark.

The packed lot two, showed that the pH decreased to acidity as the storage period increased in dry and wet salted mackerel. The alkalinity increased initially but eclined subsequently to acidity as the storage period increased in dry and wet salted ibbonfish. In shark, the alkalinity increased initially and decreased in dry salted but alkalinity increased in wet salted one. The refrigerator stored lots three, showed that the pH value declined from alkaline to acidic in dry and wet salted mackerel. In dry salted ibbonfish pH declined to acidity but the wet salted fish pH increased to alkalinity. In dry salted shark, the alkaline nature increased initially then decreased to acidity. The wet salted shark was initially alkaline in nature then declined to acidity and subsequently alkalinity increased. The cold storage lots four, showed that the pH increased to alkalinity followed by a decrease to acidity in dry salted mackerel, wet and dry salted ... fish and dry and wet salted shark. The results showed that some reactions are going on in the products after packing and storage.

The results showed that lower a_w was reached at 24 hours of dry salting and lowering of a_w after this was very less. According to Sikorski *et al.* (1995) 0.7 a_w was reached during salting and most bacteria do not grow and multiply at this level of a_w. ...pott & Tucker (1990) observed that a_w reached 0.75 to 0.85 during hard curing and the present results agree the same. During wet salting lower a_w was attained in four to eight hours salting. So during the remaining hours, fish reabsorbs moisture slightly and a_w increased. But this depends on the concentration of the solution. The action performed by the preservative is also important. The reabsorption of moisture was noted in all dry and wet salted control lots. Here the salt and fish ratio was 1: 4 in dry salting and saturated solution was used at high temperature. The concentration of preservative has some effect on pH. Chakrabarti *et al.* (1991) reported that brine salting reduced a_w from 0.96 to 0.82. Reddy *et al.* (1991) reported that a_w reached 0.80 to 0.79 in brined anchovies. Gupta & Chakrabarti, (1994) noted a_w of salted pressed fish in brine and it reached 0.85 on 6th day of salting. Olley *et al.* (1988) stated that salting reduce a_w to 0.75 and further added that a reduction in a_w and unfavorable pH and temperature prevent growth of micro – organism. The lower pH attained was 0.72 to 0.75 in almost all lots than above findings.

A_w of dried lots are lowered from 0.75 to 0.63 and depends on the size of fish. According to Curran & Trim (1983) salting and drying will cause the reduction in growth of bacteria and mould, the solar dried products reached 0.65 a_w and have 100 to 450 days self life. The drying causes loss of moisture and increases of salt and a_w and the bacterial activities are reduced. Kalaimani *et al.* (1988) studied a_w of various market products and it ranges from 0.74 - 0.96. But the results are lower than this report.

According to Pigott & Tucker (1990) a_w at 0.6 keep product safe from chemical and bacteriological deterioration. So the product may be kept at 30 to 40 equilibrium relative humidity. The a_w in unpacked lots one, showed a decrease in dry and wet salted product but it was high in wet salted products due to heavy moisture loss. Further Ramachandran *et al.* (1990) reported that a_w of the dried products depends on the relative humidity. Packed lot two, showed a_w slowly reduced in dry and wet salted mackerel and was same in dry and wet salted ribbonfish lots and shark. The refrigerator stored lots three, and cold storage stored lots four, do not showed much change in a_w. This may be due to the fact that the products do not have any direct contact with surrounding atmosphere to lose moisture as the product was kept in controlled temperature. So the action of a_w was less in above two cases. This shows that the proper control of moisture and a_w are very important in deciding the keeping quality of salted and dried products.

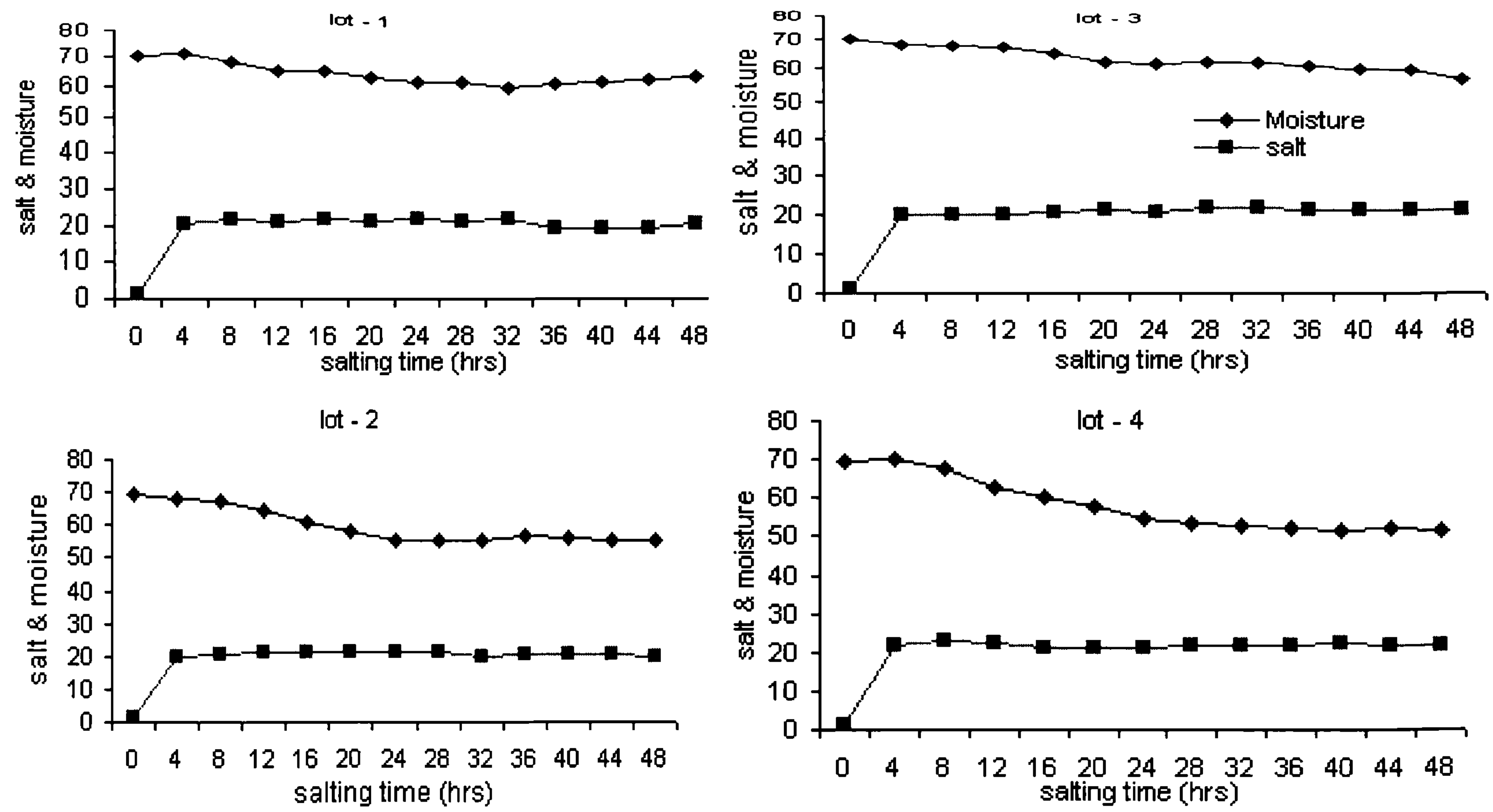


Figure - 6.1. Change in Moisture & Salt during Dry Salting of Mackerel

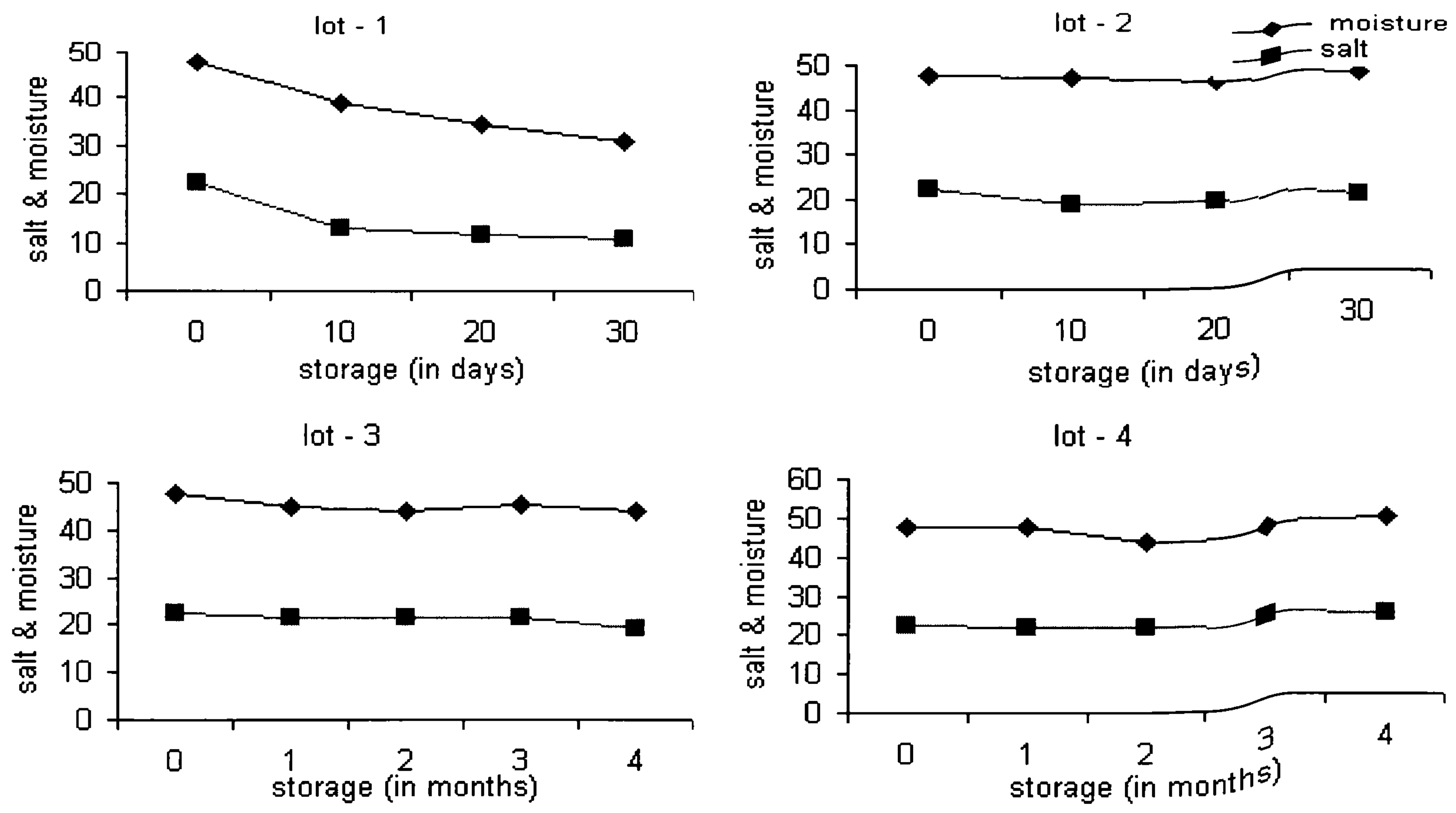


Figure - 6.2. Change in Moisture & Salt in dry salted Mackerel during storage

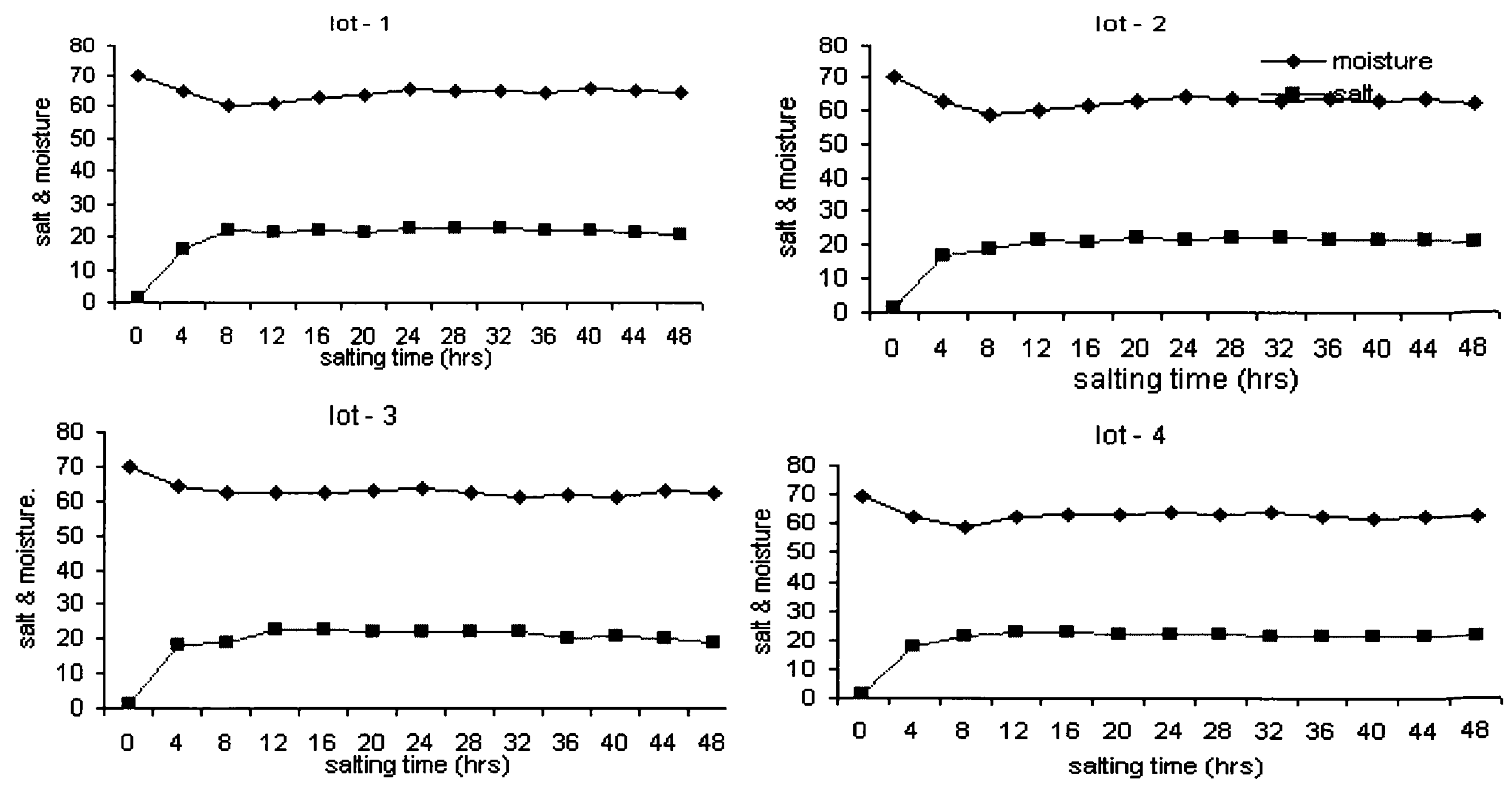


Figure - 6.3. Change in Moisture & Salt during wet salting of Mackerel

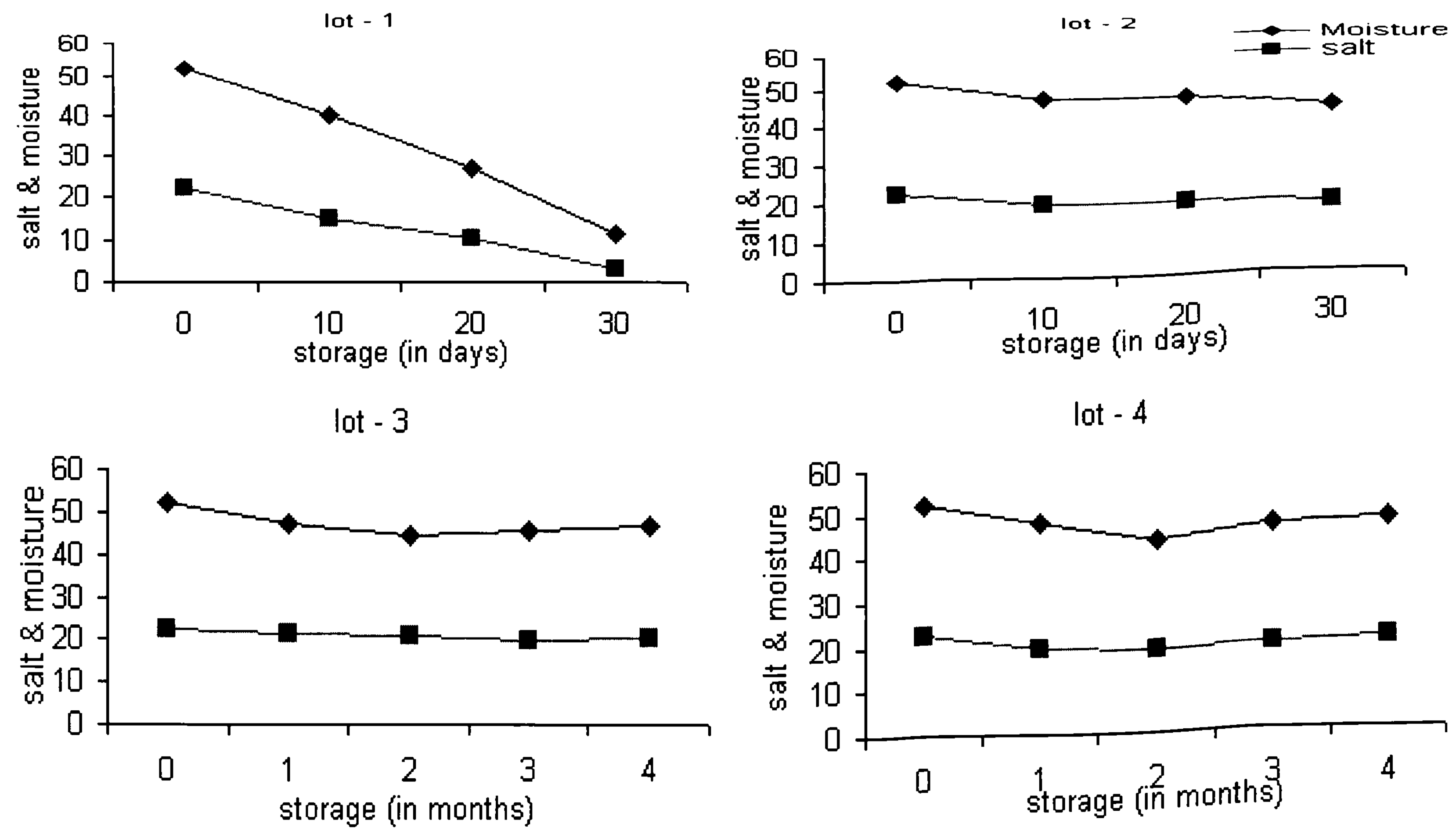


Figure - 6.4. Change in Moisture & Salt in wet salted Mackerel during storage

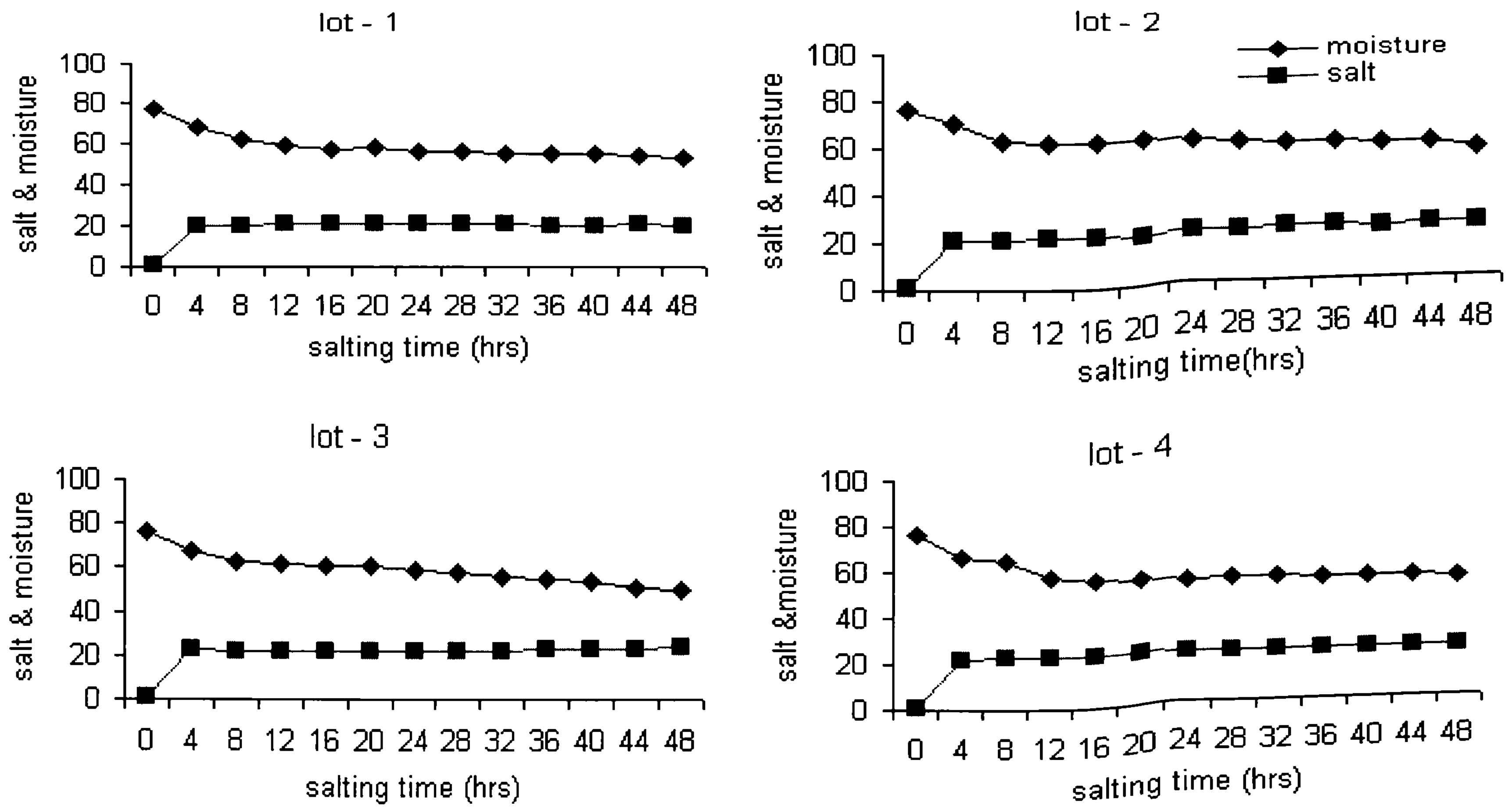


Figure 6.5. Change in Moisture & Salt during dry salting of Ribbonfish

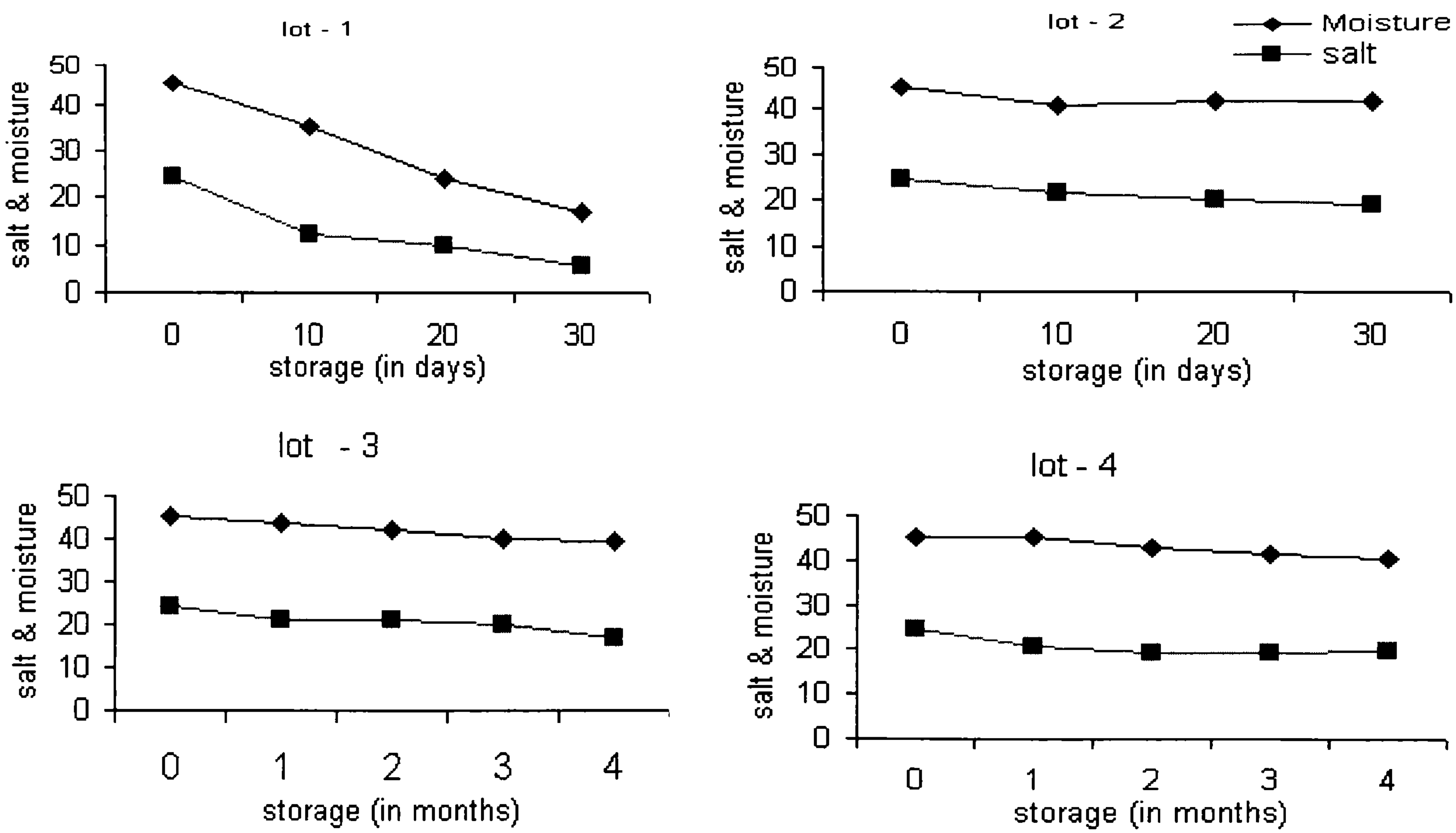


Figure - 6.6. Change in Moisture & Salt in dry salted Ribbonfish during storage

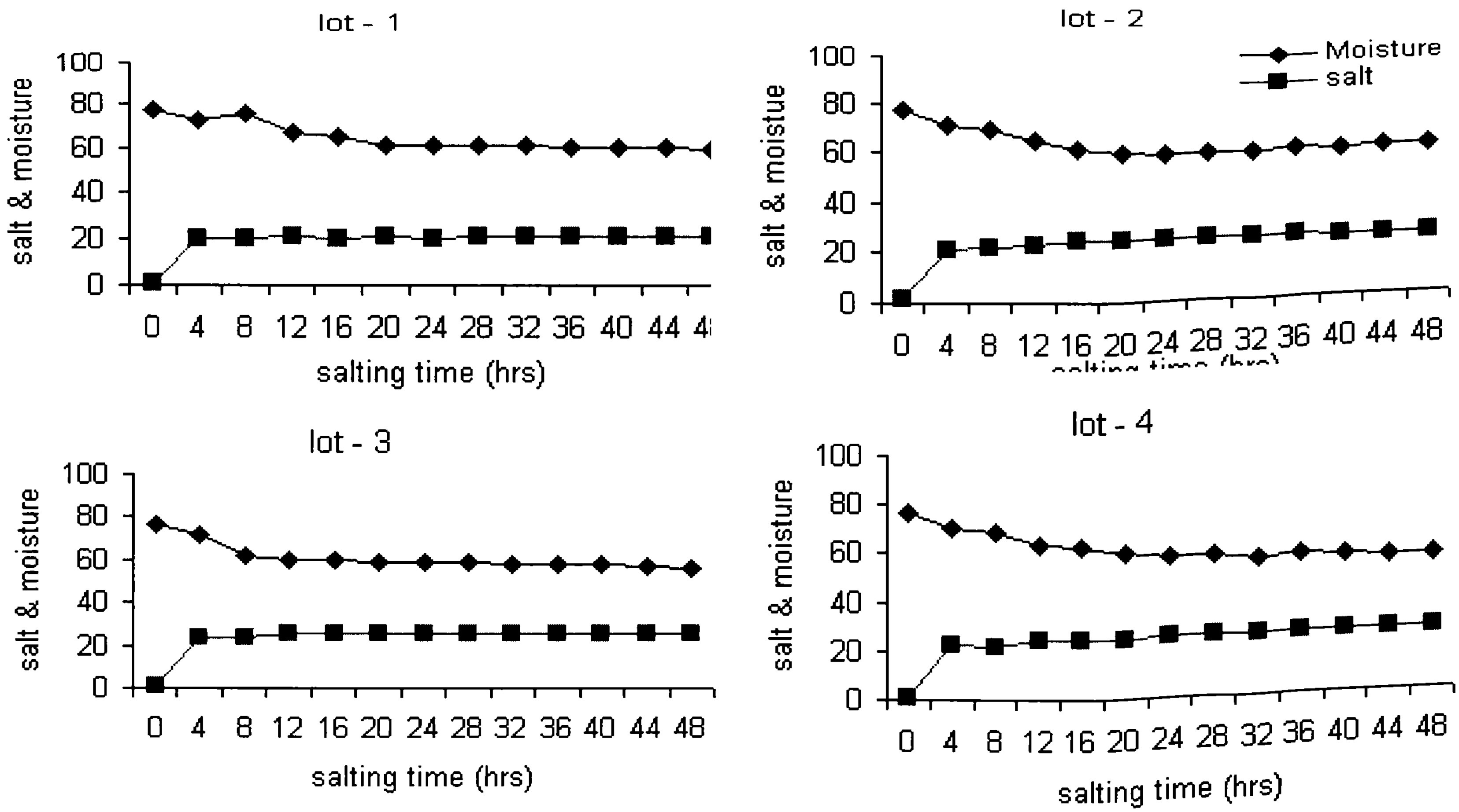


Figure - 6.7. Change in Moisture & Salt during wet salting of Ribbon fish

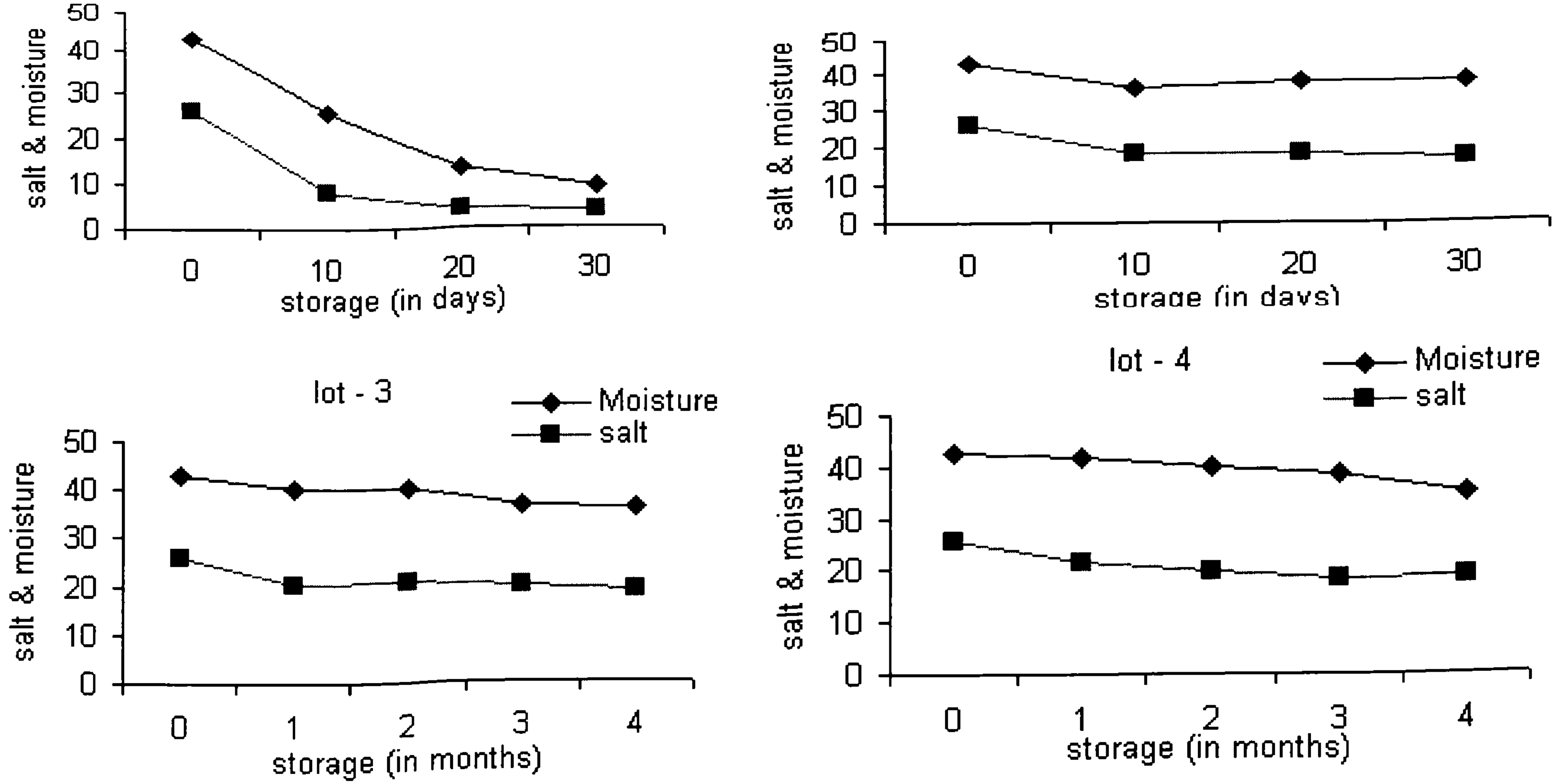


Figure – 6.8. Change in Moisture & Salt in wet salted Ribbonfish during storage

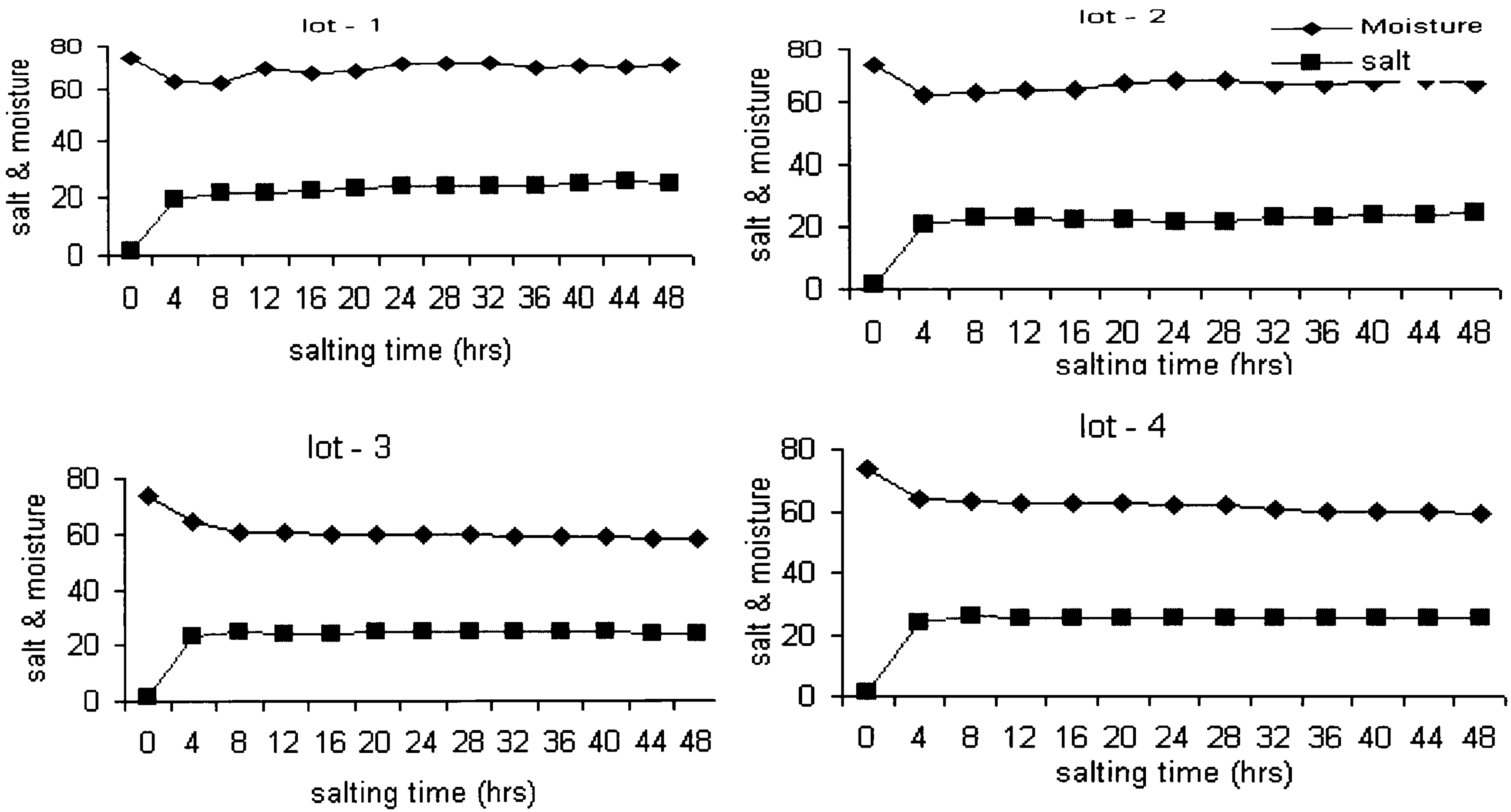


Figure - 6.9. Change in Moisture & Salt during dry salting of Shark

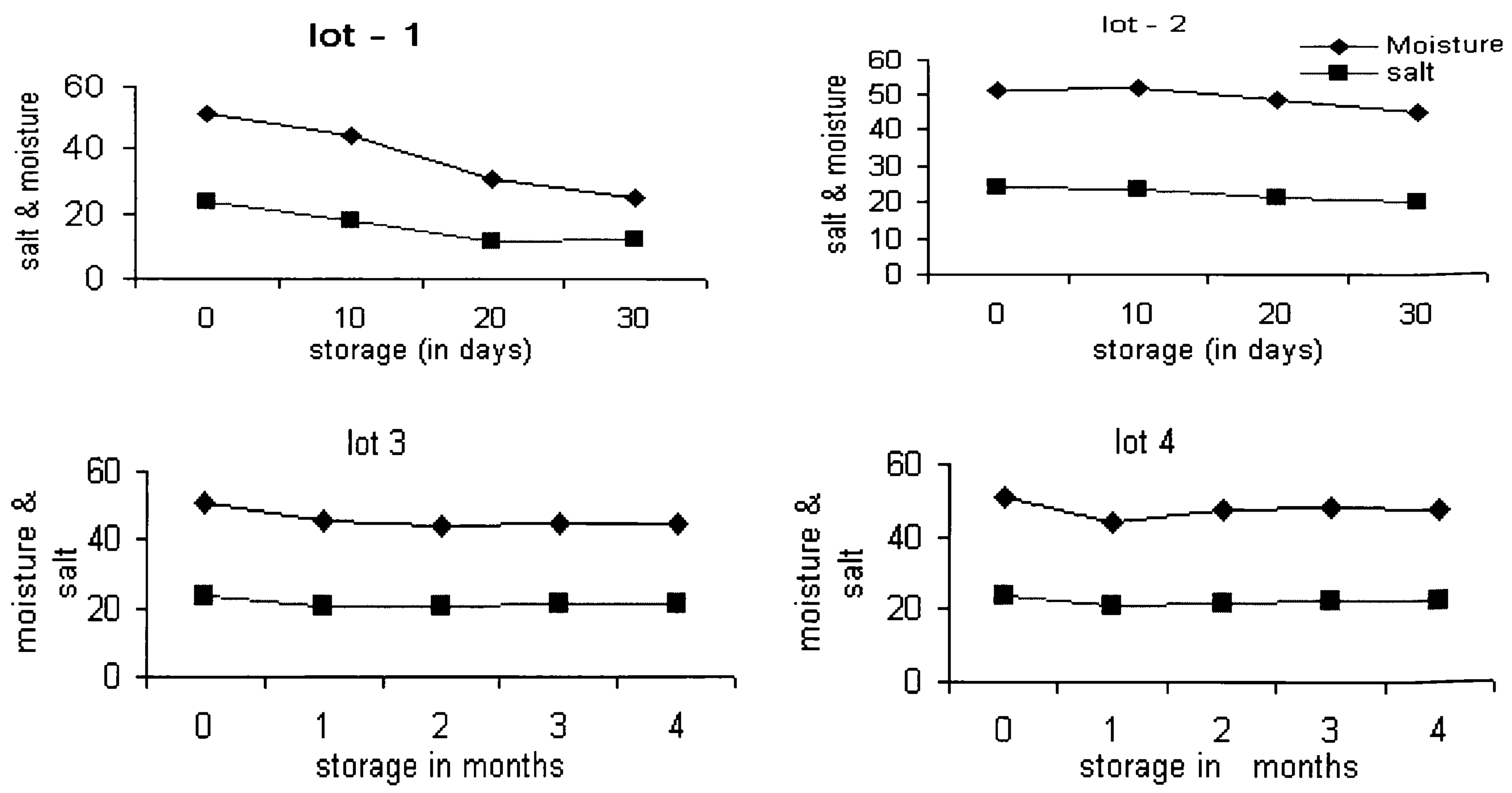


Figure - 6.10. Change in Moisture & Salt in dry salted Shark during storage

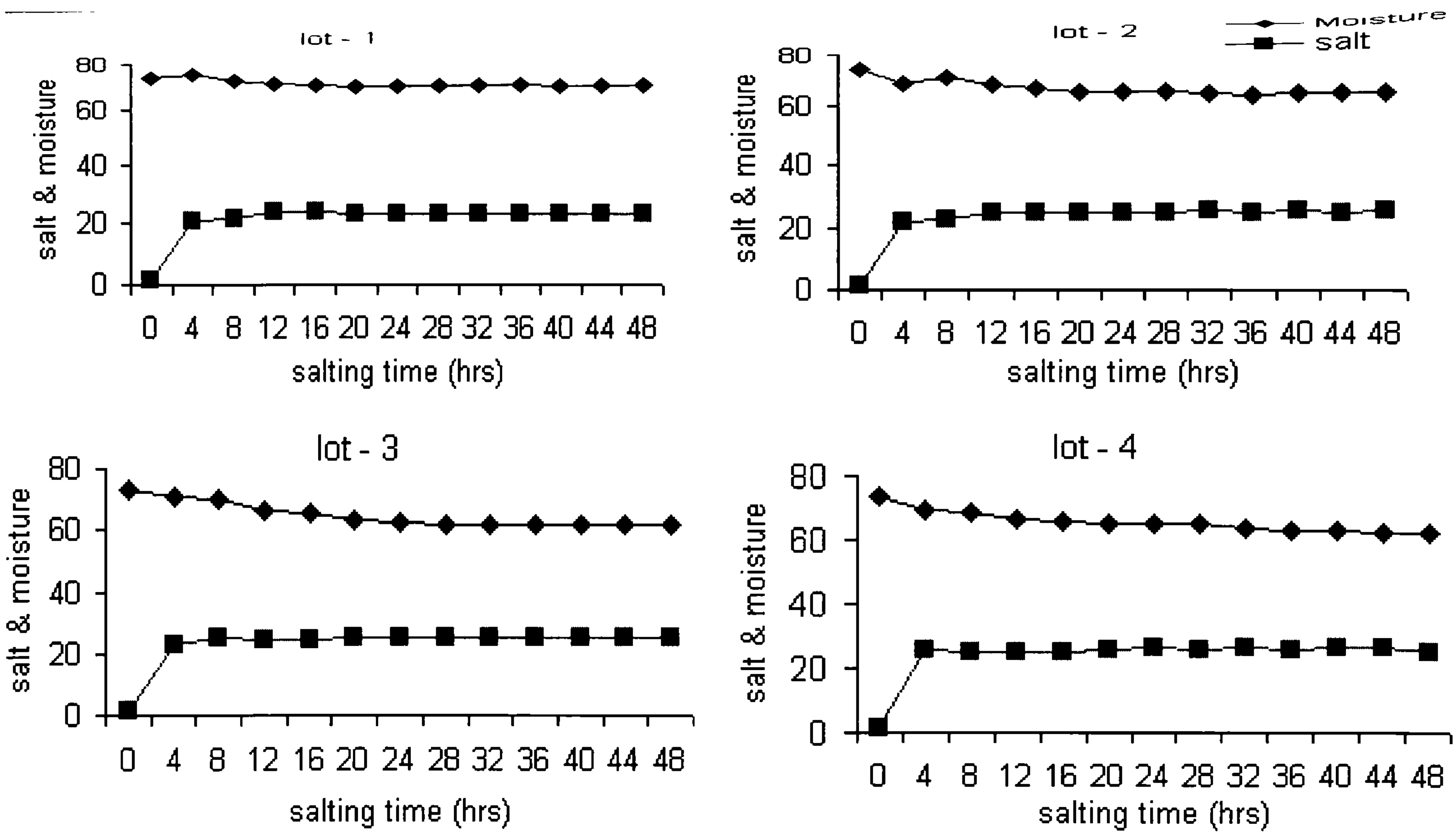


Figure - 6.11. Change in Moisture & Salt during wet salting of Shark

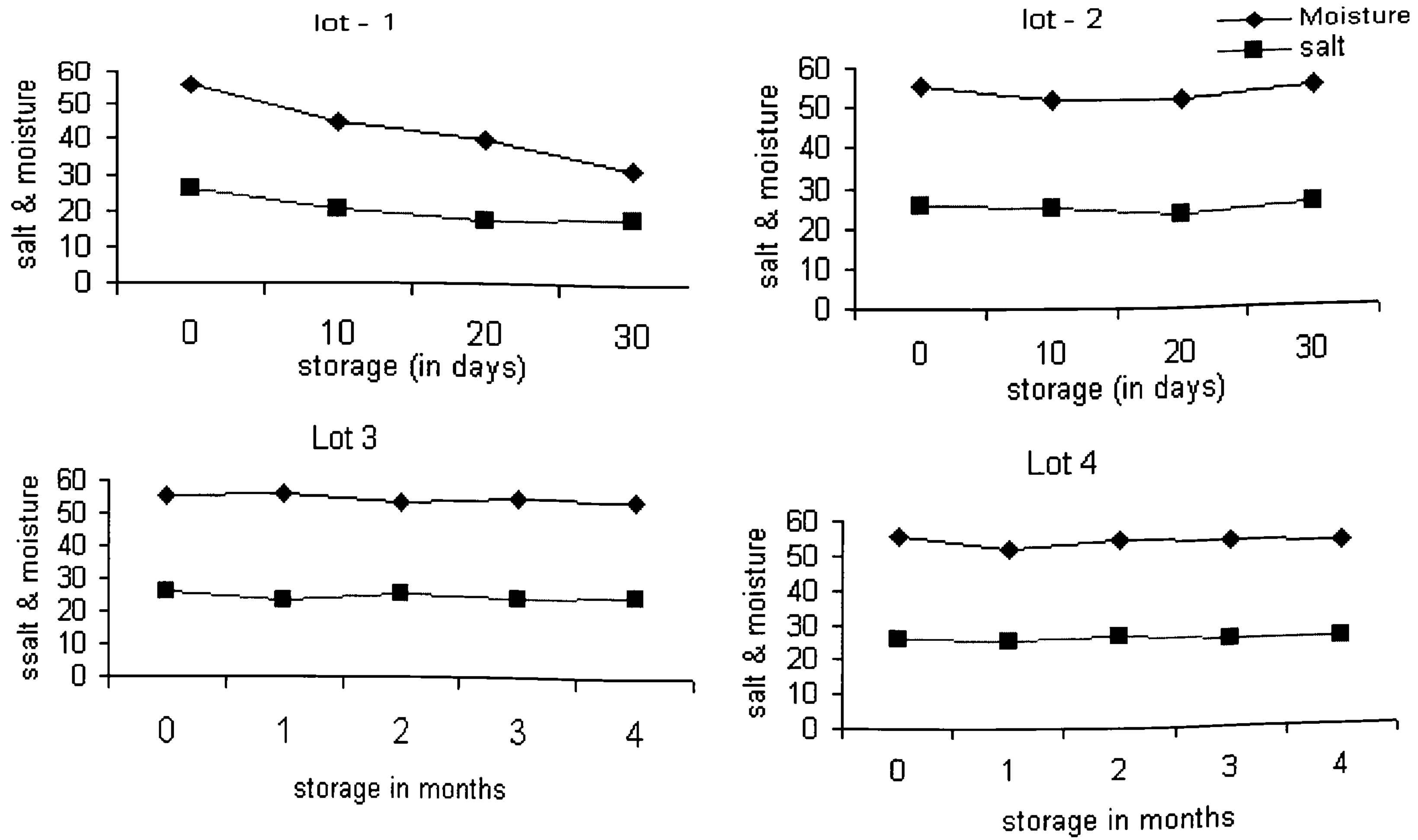


Figure - 6.12. Change in Moisture & Salt in wet salted Shark during storage

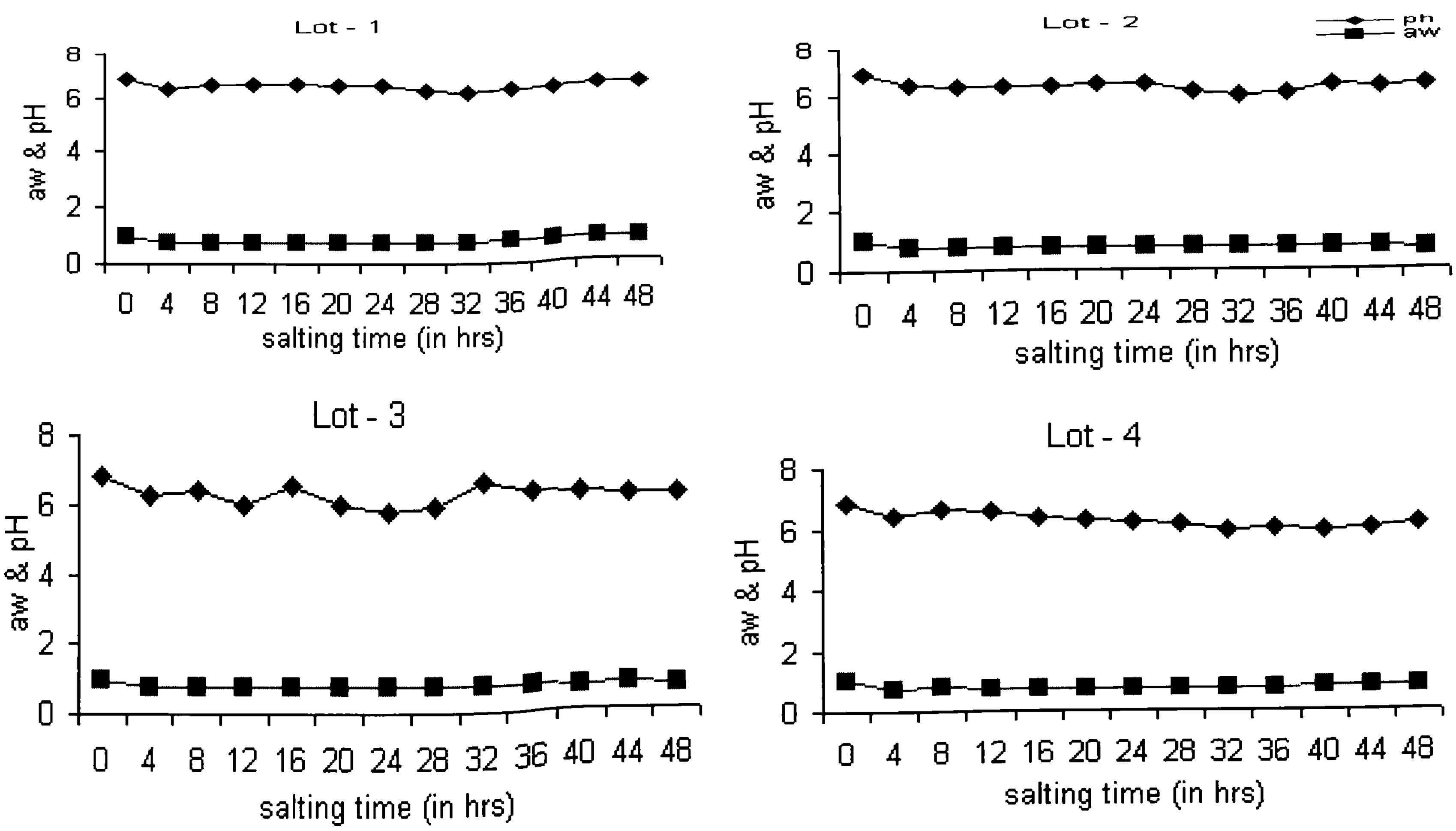


Figure - 6.13. Change in pH & a_w during dry salting of Mackerel

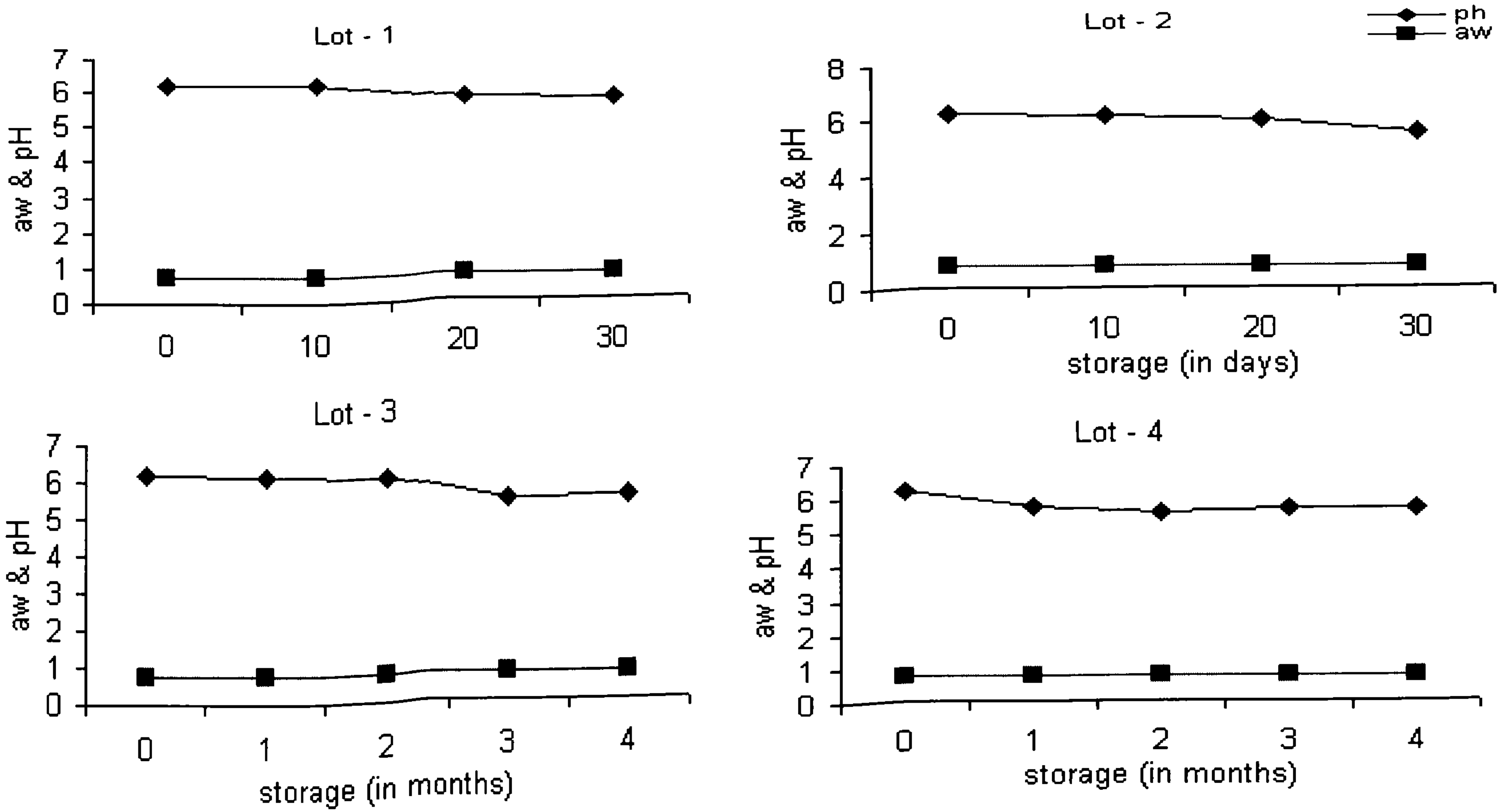


Figure - 6.14. Change in pH & a_w in dry salted Mackerel during storage

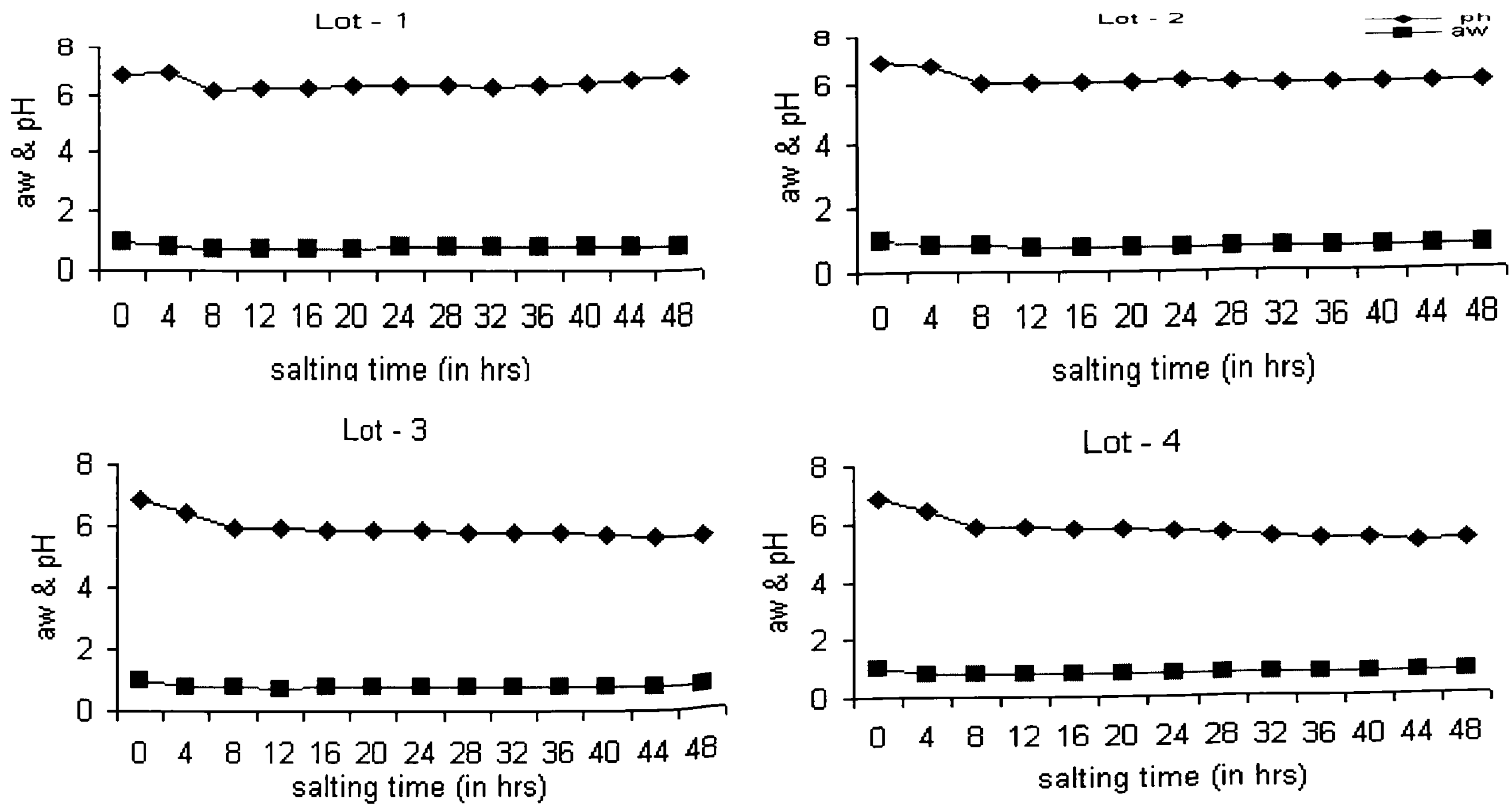


Figure - 6.15. Change in pH & a_w during wet salting of Mackerel

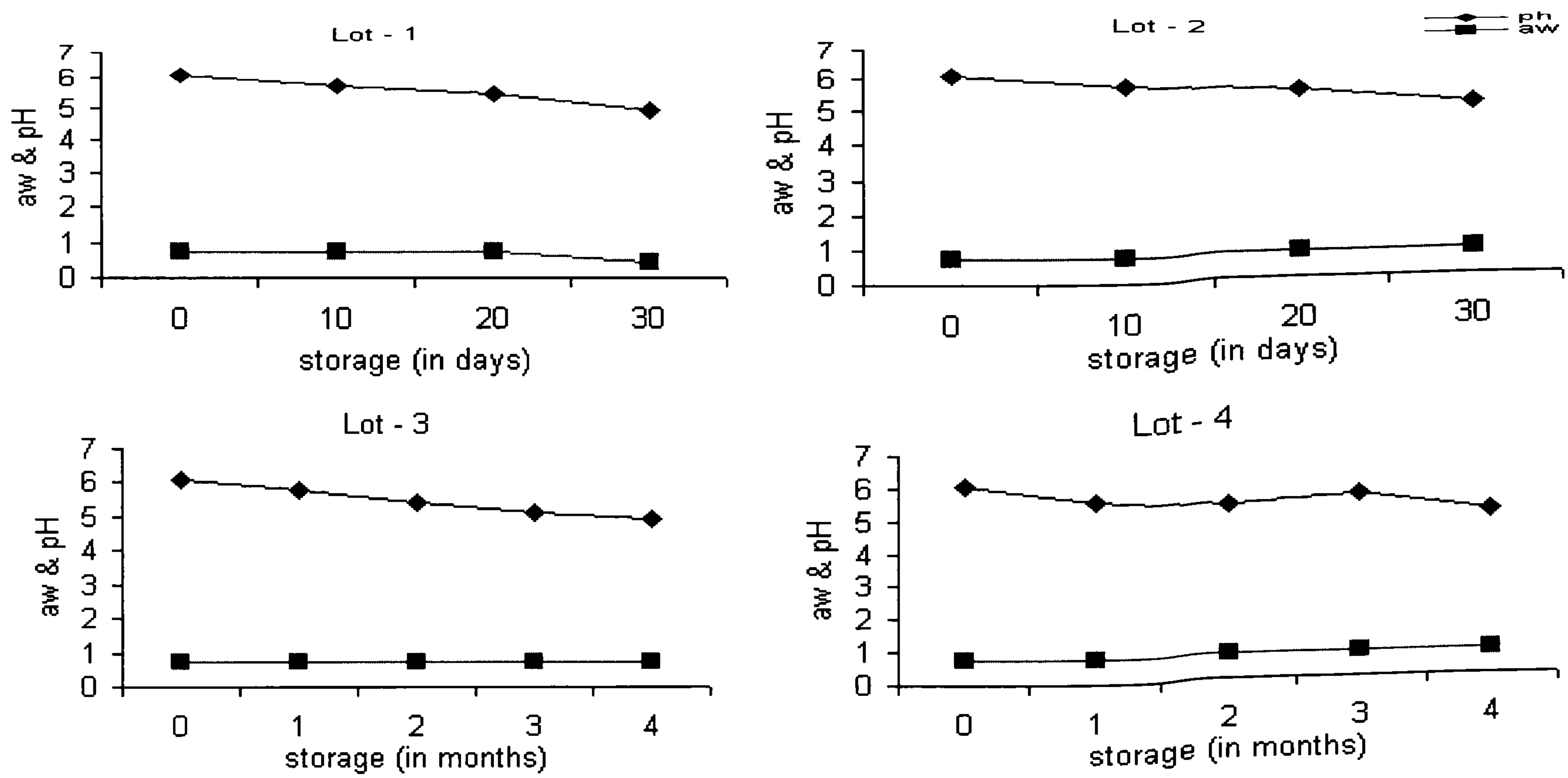


Figure - 6.16. Change in pH & a_w in wet salted Mackerel during storage

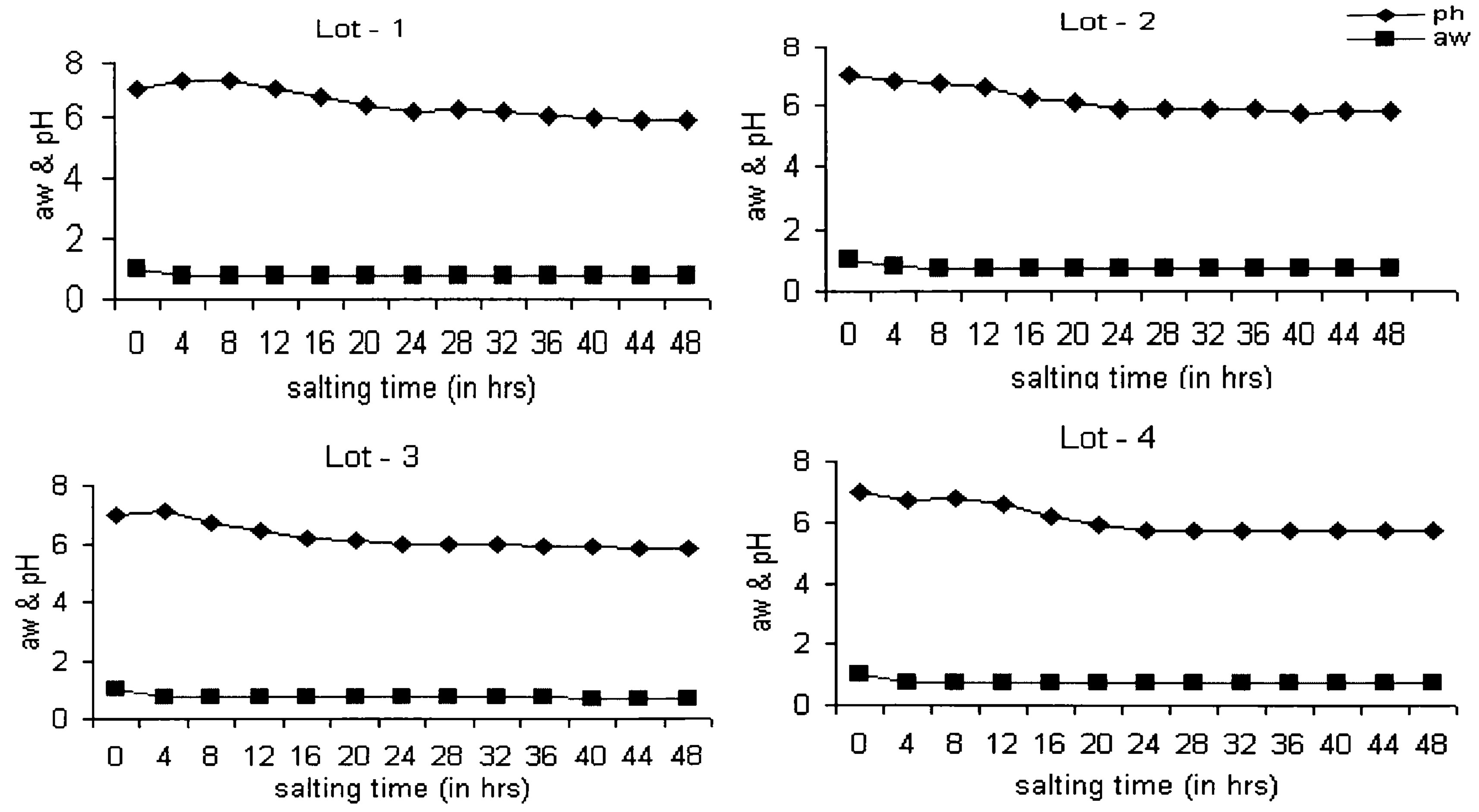


Figure - 6.17 Change in pH & a_w during dry salting of Ribbonfish.

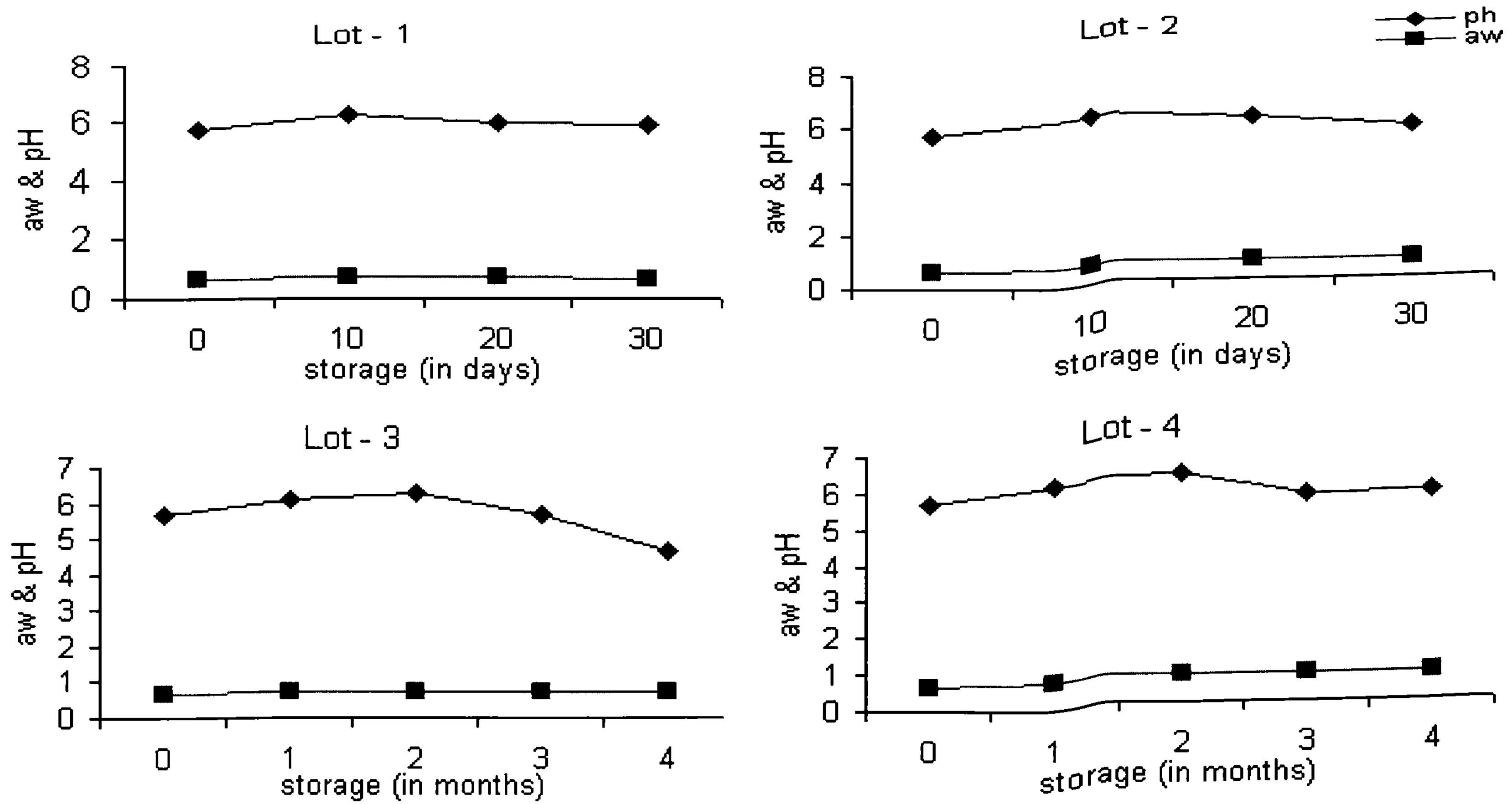


Figure - 6.18. Change in pH & a_w in dry salted Ribbonfish during storage

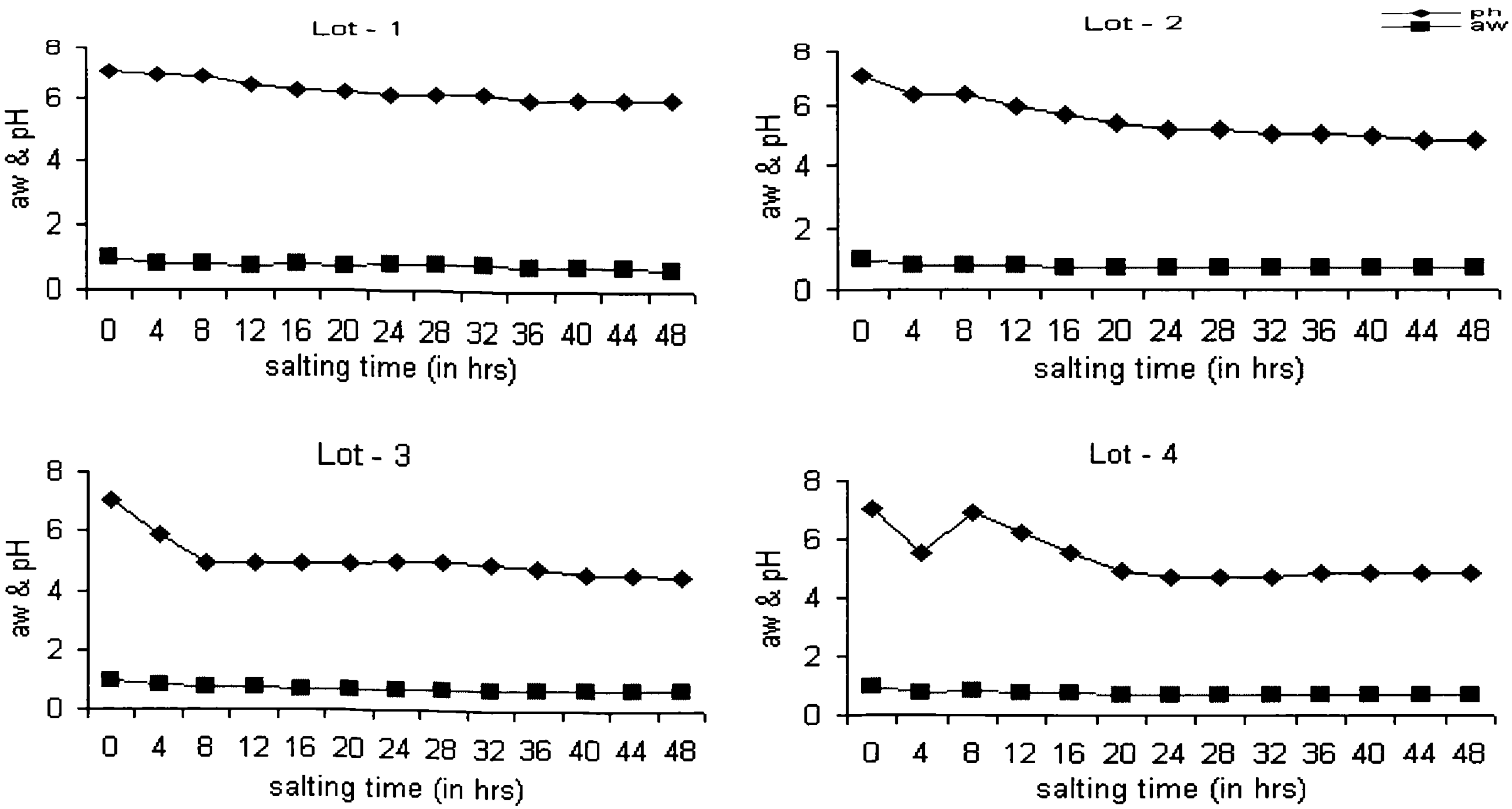


Figure - 6.19. Change in pH & a_w during wet salting of Ribbonfish

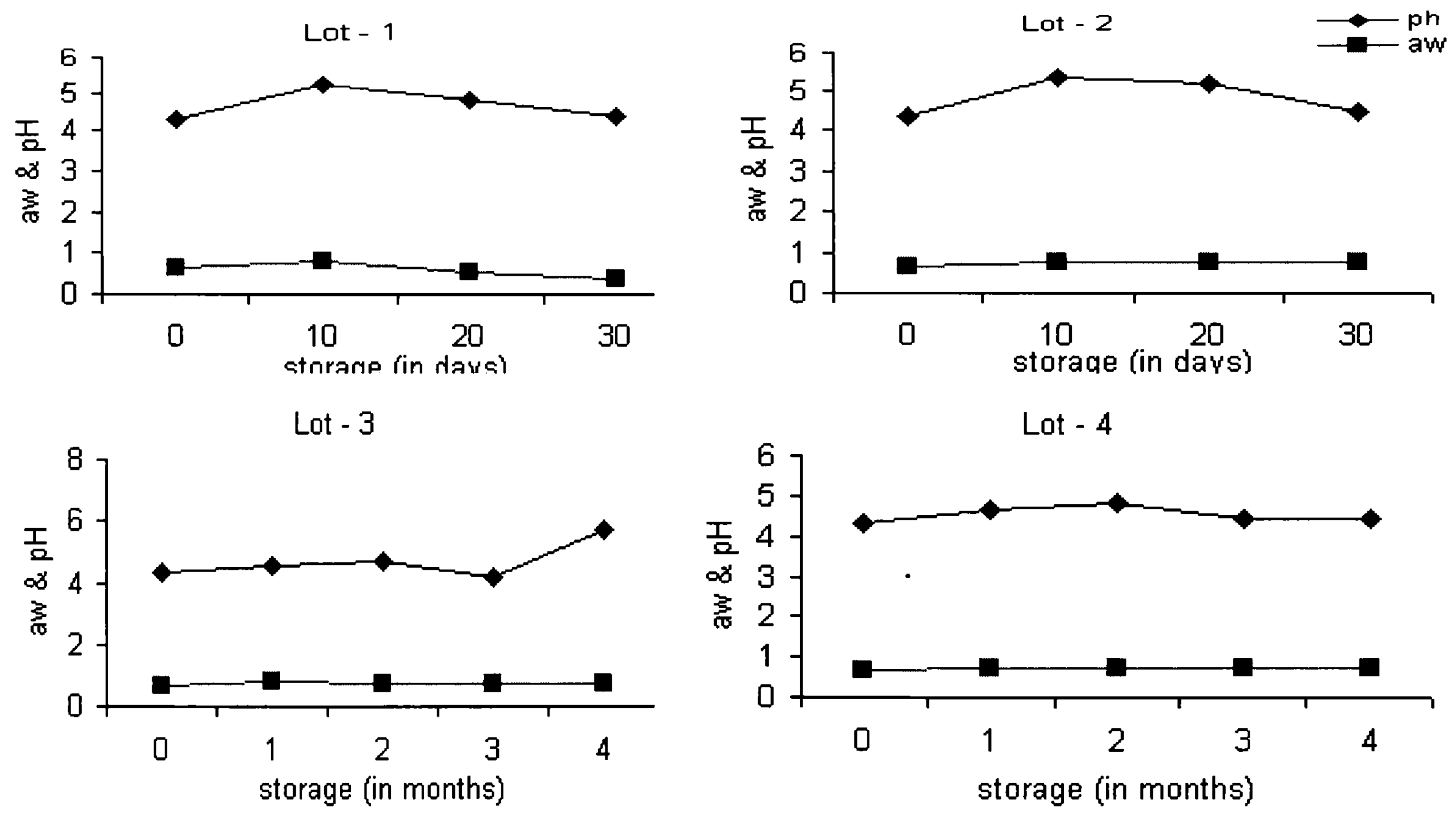


Figure 6.20. Change in pH & a_w in wet salted Ribbonfish during storage

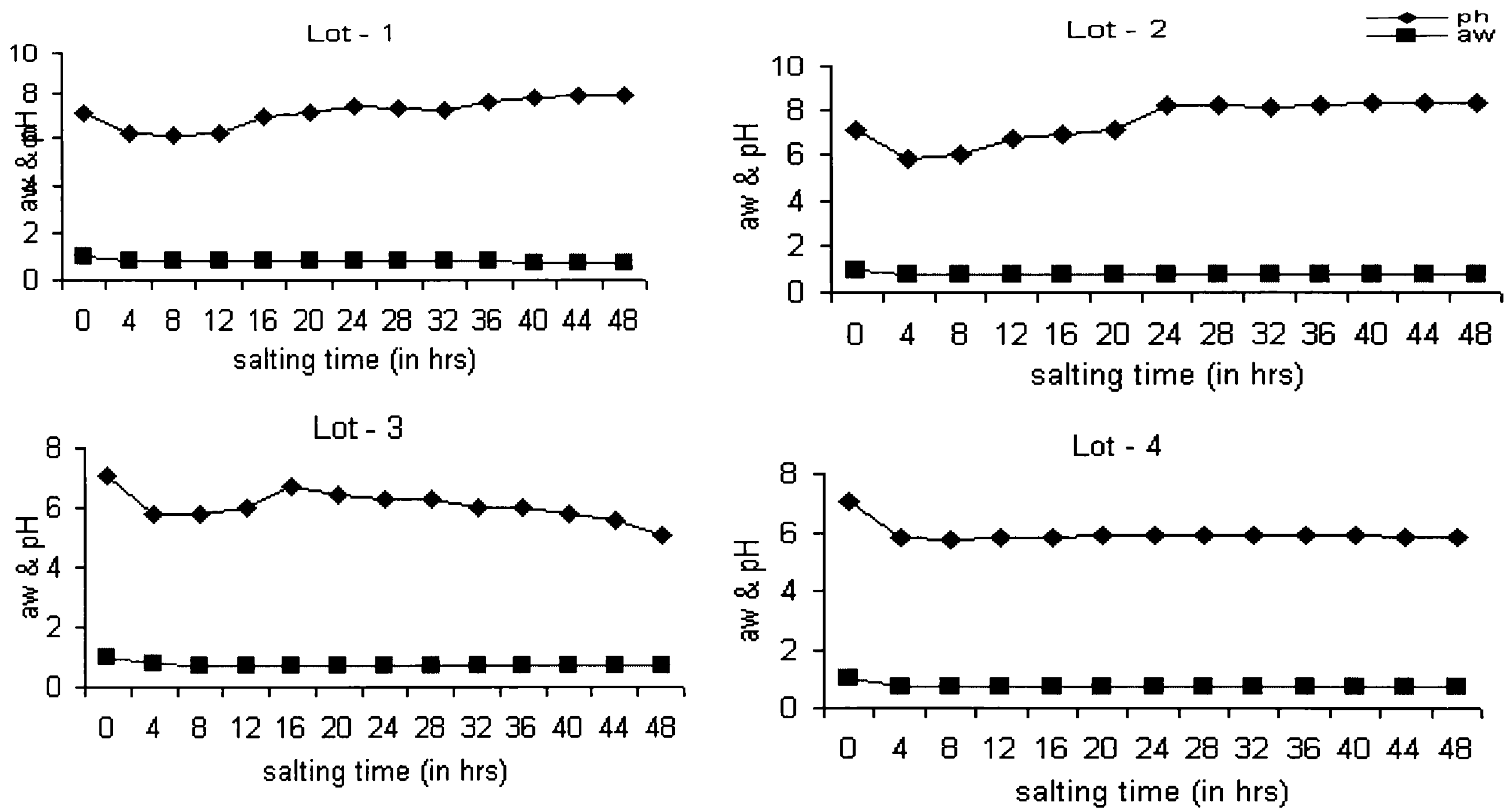


Figure - 6.21. Change in pH & a_w during dry salting of Shark

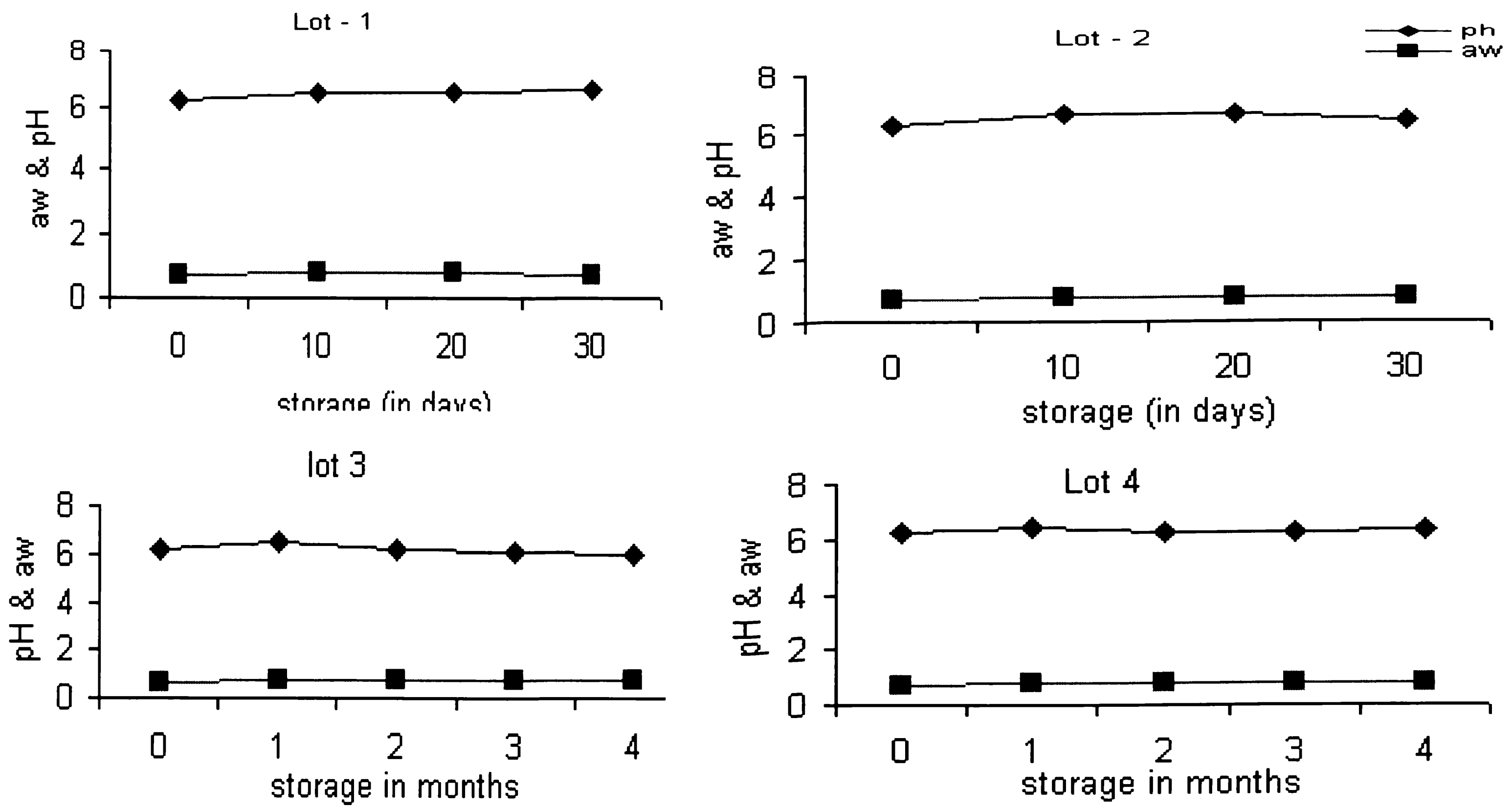


Figure - 6.22 Change in pH & a_w in dry salted Shark during storage

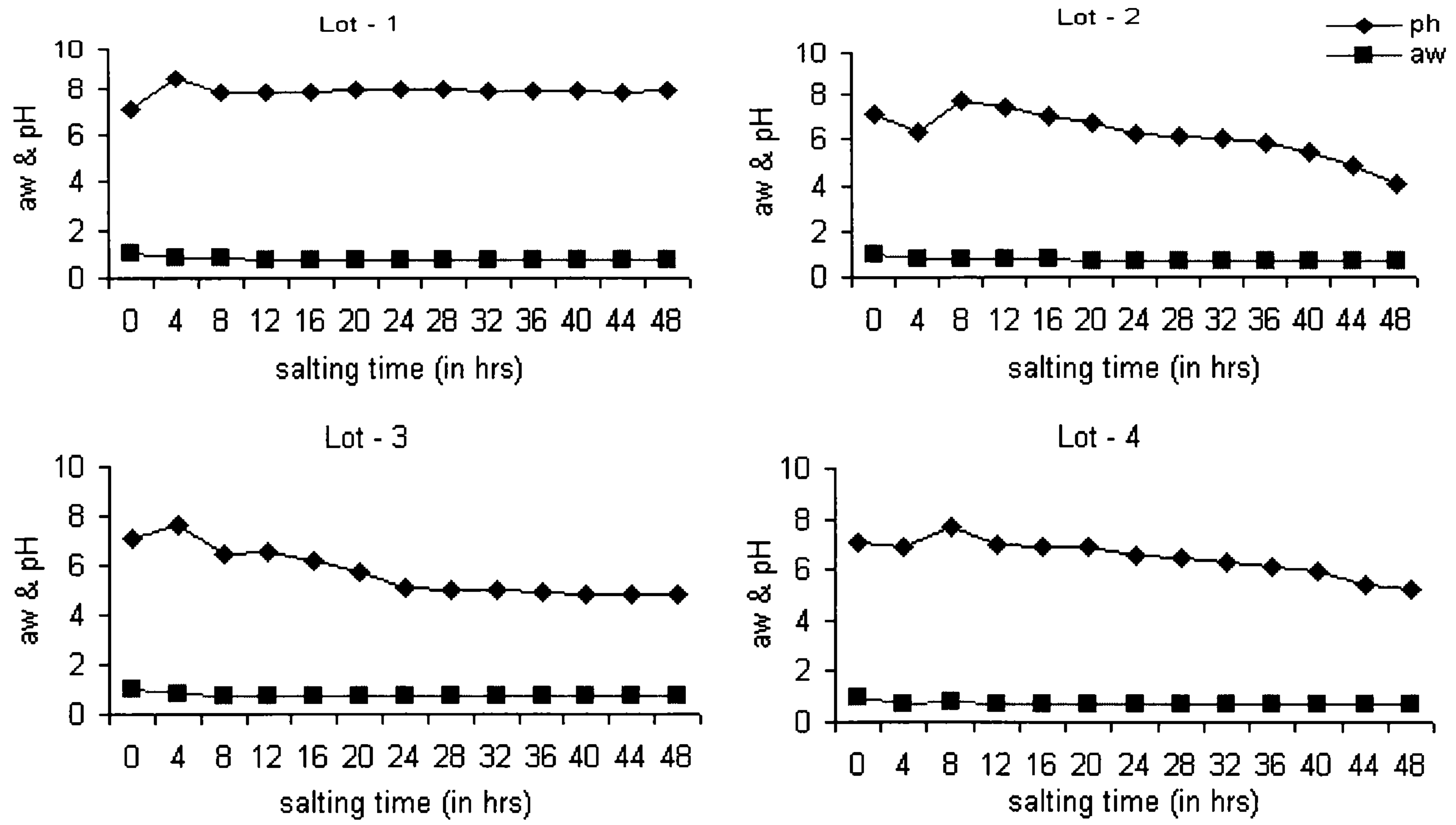


Figure - 6.23. Change in pH & a_w during wet salting of Shark

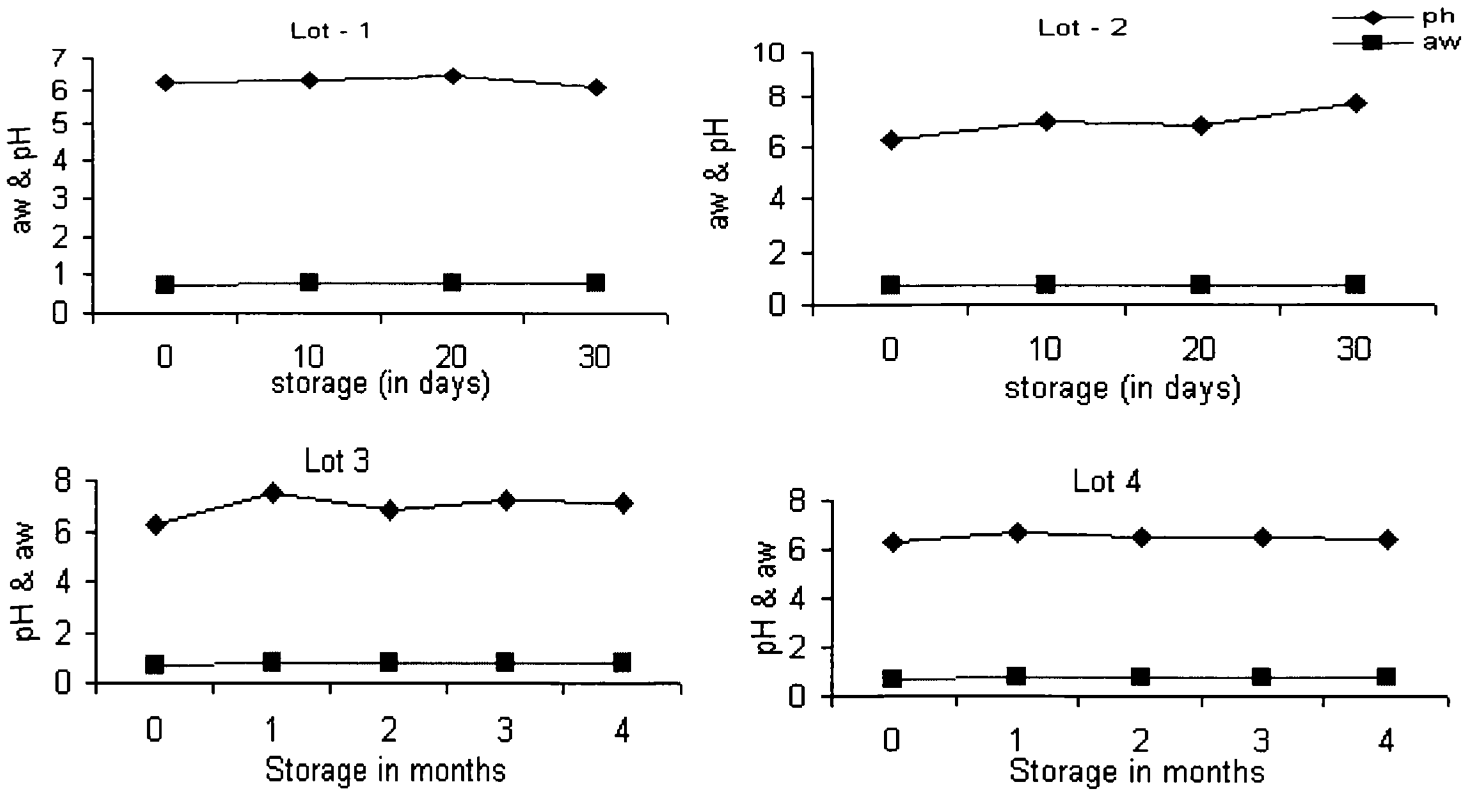


Figure - 6.24. Change in pH & a_w in wet salted Shark during storage

Table - 6.1. Effect of sun Drying on Moisture & Salt (g / 100 gm) on Mackerel.

On Dry Salted Mackerel								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
Hours	Moisture	Salt	Moisture	Salt	Moisture	Salt	Moisture	Salt
0 hrs	62.49	20.09	54.96	20.09	56.82	21.13	51.3	21.86
4 hrs	54.59	21.03	50.44	20.63	50.9	21.48	48.94	22.28
8 hrs	50.62	21.33	48.02	21.42	47.58	22.35	47.16	22.76
In Wet Salted Mackerel								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
0 hrs	64.02	20.89	62.03	21.03	62.36	19.19	62.38	20.91
4 hrs	56.65	22.34	54.12	22.26	54.92	20.62	54.56	21.64
8 hrs	55.24	19.8	52.07	22.4	52.65	21.1	54.61	21.83

Table - 6.2. Effect of sun Drying on moisture & Salt (g / 100 gm) on Ribbonfish

In Dry Salted Ribbonfish								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
Hours	Moisture	Salt	Moisture	Salt	Moisture	Salt	Moisture	Salt
0 hrs	53.19	20.48	56.2	22.8	49.88	23.49	51.72	22.21
4 hrs	46.03	22.01	45.73	23.37	45.62	24.05	46.9	23.35
8 hrs	43.31	23.12	45.16	24.44	43.85	24.98	45.86	23.98
In Wet Salted Ribbonfish								
	Lot - 1		Lot – 2		Lot - 3		Lot - 4	
0 hrs	59.01	21.03	59.09	24.18	56.04	25.55	55.82	25.56
4 hrs	46.74	21.42	44.38	24.1	44.55	25.65	42.89	25.62
8 hrs	44.78	21.51	42.14	24.63	42.7	25.83	41.74	25.65

Table - 6.3. Effect of sun drying on Moisture & Salt (g / 100 gm) on Shark.

In dry salted Shark								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
Hours	Moisture	Salt	Moisture	Salt	Moisture	Salt	Moisture	Salt
0 hrs	68.09	24.89	65.08	23.93	58.02	24.2	59.03	25.08
4 hrs	60.61	25.02	59.47	25.45	54.3	24.09	52.8	25.78
8 hrs	58.05	25.6	56.11	26.92	51.03	23.72	50.91	25.2
In wet salted Shark								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
0 hrs	68.04	23.08	63.21	25.12	61.76	25.32	62.01	25.13
4 hrs	64.72	23.28	57.02	25.62	56.78	25.23	56.72	25.33
8 hrs	62.34	23.38	55.53	25.79	54.04	25.51	53.09	26.65

Table - 6.4. Effect of sun drying on pH and a_w on Mackerel

In dry salted Mackerel								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
	pH	a_w	pH	a_w	pH	a_w	pH	a_w
0 hrs	6.51	0.79	6.27	0.73	6.19	0.73	6.09	0.8
4 hrs	6.4	0.77	6.16	0.74	6.14	0.77	6.1	0.75
8 hrs	6.45	0.74	6.24	0.72	6.19	0.76	6.11	0.74
In wet salted Mackerel								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
48 hrs	6.73	0.77	5.94	0.73	5.64	0.78	5.31	0.76
4 hrs	7.01	0.74	6.26	0.77	5.62	0.75	5.45	0.74
8 hrs	6.35	0.76	6.06	0.74	5.84	0.73	5.42	0.73

Table - 6.5. Effect of sun drying on pH and a_w on Ribbonfish

In dry salted Ribbonfish								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
Hours	pH	a_w	pH	a_w	pH	a_w	pH	a_w
0 hrs	5.9	0.73	5.72	0.7	5.82	0.68	5.7	0.71
4 hrs	5.7	0.68	5.7	0.67	5.6	0.65	5.7	0.67
8 hrs	5.8	0.64	5.7	0.66	5.7	0.66	5.8	0.65
On wet salted Ribbonfish								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
0 hrs	5.9	0.69	4.8	0.73	4.5	0.69	4.8	0.69
4 hrs	5.7	0.66	4.5	0.69	4.3	0.69	4.9	0.63
8 hrs	5.3	0.69	4.5	0.66	4.3	0.66	5.01	0.6

Table - 6.6. Effect of sun drying on pH and a_w on Shark.

On dry salted Shark								
Stage / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
Hours	pH	a_w	pH	a_w	pH	a_w	pH	a_w
0 hrs	7.81	0.75	8.23	0.76	5.09	0.72	5.82	0.72
4 hrs	8.51	0.72	8.17	0.71	6.07	0.7	6.69	0.69
8 hrs	6.96	0.69	8.07	0.68	6.2	0.69	7.04	0.67
On wet salted Shark								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
0 hrs	7.81	0.77	4.09	0.72	4.82	0.73	5.18	0.73
4 hrs	7.99	0.76	6.2	0.73	5.01	0.71	5.43	0.69
8 hrs	8.07	0.75	6.24	0.71	5.09	0.68	5.68	0.71

Table 1 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	137.6957	12	11.47464	0.369279	0.951294	2.686633
Columns	12725.19	1	12725.19	409.525	1.22E-10	4.747221
Error	372.8767	12	31.07305			
Total	13235.77	25				

Table 2 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	162.4403	12	13.53669	0.294736	0.978004	2.686633
Columns	10781.43	1	10781.43	234.7453	3.05E-09	4.747221
Error	551.1386	12	45.92822			
Total	11495.01	25				

Table 3. Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.664225	1	0.664225	0.257849	0.700879	161.4462
Columns	795.522	1	795.522	308.8177	0.036188	161.4462
Error	2.576025	1	2.576025			
Total	798.7623	3				

Table 4. Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	276.7614	12	23.06345	0.378137	0.947331	2.686633
Columns	9267.059	1	9267.059	151.938	3.58E-08	4.747221
Error	731.9087	12	60.99239			
Total	10275.73	25				

Table 5 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.367225	1	3.367225	0.738714	0.548016	161.4462
Columns	987.5306	1	987.5306	216.6481	0.043185	161.4462
Error	4.558225	1	4.558225			
Total	995.4561	3				

Table 6 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.664225	1	0.664225	0.257849	0.700879	161.4462
Columns	795.522	1	795.522	308.8177	0.036188	161.4462
Error	2.576025	1	2.576025			
Total	798.7623	3				

Table 7 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.500625	1	1.500625	0.341904	0.663156	161.4462
Columns	746.6556	1	746.6556	170.1188	0.048714	161.4462
Error	4.389025	1	4.389025			
Total	752.5453	3				

Table 8 Results of two - way ANOVA on moisture and salt in D.S. mackerel lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.4225	1	0.4225	0.330879	0.667684	161.4462
Columns	651.7809	1	651.7809	510.4401	0.028159	161.4462
Error	1.2769	1	1.2769			
Total	653.4803	3				

e 9. Result of two - way ANOVA on moisture and salt in D.S. mackerel lot 1on storage.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	228.9167	3	76.30558	21.84687	0.01534	9.276619
umns	1105.205	1	1105.205	316.4287	0.000387	10.12796
ror	10.47824	3	3.492746			
tal	1344.6	7				

ble 10. Result of two - way ANOVA on moisture and salt in D.S. mackerel lot 2 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	15.67214	3	5.224046	5.789833	0.091595	9.276619
lumns	1464.758	1	1464.758	1623.398	3.36E-05	10.12796
ror	2.706837	3	0.902279			
tal	1483.137	7				

ble 11. Result of two - way ANOVA on moisture and salt in D.S. mackerel lot 3 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	11.7327	4	2.933175	4.358196	0.091491	6.388234
lumns	1446.006	1	1446.006	2148.518	1.3E-06	7.70865
ror	2.6921	4	0.673025			
tal	1460.431	9				

ble 12. Result of two - way ANOVA on moisture and salt in D.S. mackerel lot 4 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	8.62494	4	2.156235	1.788168	0.293635	6.388234
lumns	1478.413	1	1478.413	1226.049	3.97E-06	7.70865
ror	4.82334	4	1.205835			
tal	1491.861	9				

ble 13 Results of two - way ANOVA on moisture and salt in W.S. mackerel lot 1

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	107.3006	12	8.94172	0.285169	0.980565	2.686633
olumns	12281.8	1	12281.8	391.6909	1.58E-10	4.747221
rror	376.2701	12	31.35584			
otal	12765.37	25				

ble 14 Results of two - way ANOVA on moisture and salt in W.S. mackerel lot 2.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	78.30456	12	6.52538	0.182642	0.996903	2.686633
olumns	11242.4	1	11242.4	314.6696	5.63E-10	4.747221
rror	428.7317	12	35.72764			
otal	11749.44	25				

ble 15. Results of two - way ANOVA on moisture and salt in W.S. mackerel lot 3.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	97.04385	12	8.086987	0.257551	0.986885	2.686633
olumns	11962.24	1	11962.24	380.9685	1.85E-10	4.747221
rror	376.7944	12	31.39954			
otal	12436.07	25				

ble 16. Results of two - way ANOVA on moisture and salt in W.S. mackerel lot 4.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	101.4975	12	8.458129	0.250323	0.988286	2.686633
olumns	11491.63	1	11491.63	340.1012	3.59E-10	4.747221
rror	405.4664	12	33.78887			
otal	11998.6	25				

Table 17. Results of two - way ANOVA on moisture and salt in W.S. mackerel lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.225625	1	0.225625	0.258086	0.700761	161.4462
Columns	1113.891	1	1113.891	1274.146	0.01783	161.4462
Error	0.874225	1	0.874225			
Total	1114.99	3				

Table 18. Results of two - way ANOVA on moisture & salt in W.S. mackerel lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.912025	1	0.912025	0.760639	0.543409	161.4462
Columns	946.4852	1	946.4852	789.3791	0.022649	161.4462
Error	1.199025	1	1.199025			
Total	948.5963	3				

Table 19. Results of two - way ANOVA on moisture & salt in W.S. mackerel lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.801025	1	0.801025	0.423683	0.632661	161.4462
Columns	1084.056	1	1084.056	573.3848	0.026571	161.4462
Error	1.890625	1	1.890625			
Total	1086.747	3				

Table 20 Results of two - way ANOVA on moisture & salt in W.S. mackerel lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0144	1	0.0144	2.938776	0.336183	161.4462
Columns	1079.123	1	1079.123	220229.1	0.001357	161.4462
Error	0.0049	1	0.0049			
Total	1079.142	3				

Table 21. Result of two - way ANOVA on moisture and salt in W.S. mackerel lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	986.2731	3	328.7577	7.227379	0.069255	9.276619
Columns	774.2113	1	774.2113	17.02019	0.025824	10.12796
Error	136.4634	3	45.48782			
Total	1896.948	7				

Table 22. Result of two - way ANOVA on moisture and salt in W.S. mackerel lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	47.14634	3	15.71545	12.8152	0.032333	9.276619
Columns	1541.513	1	1541.513	1257.031	4.93E-05	10.12796
Error	3.678937	3	1.226312			
Total	1592.338	7				

Table 23. Result of two - way ANOVA on moisture and salt in W.S. mackerel lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	31.1463	4	7.786575	2.772814	0.173519	6.388234
Columns	1691.56	1	1691.56	602.3678	1.64E-05	7.70865
Error	11.23274	4	2.808185			
Total	1733.939	9				

Table 24. Result of two - way ANOVA on moisture and salt in W.S. mackerel lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	41.54326	4	10.38582	5.476379	0.064162	6.388234
Columns	1870.056	1	1870.056	986.0696	6.13E-06	7.70865
Error	7.5859	4	1.896475			
Total	1919.185	9				

25 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 1

VA

urce of Variation	SS	df	MS	F	P-value	F crit
s	89.34972	12	7.44581	0.113956	0.999665	2.686633
mns	10175.62	1	10175.62	155.7347	3.12E-08	4.747221
r	784.0737	12	65.33947			
al	11049.05	25				

le 26 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 2

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	75.68222	12	6.306851	0.103484	0.999793	2.686633
umns	11135.36	1	11135.36	182.7107	1.27E-08	4.747221
r	731.3438	12	60.94532			
al	11942.38	25				

ble 27 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 3

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	137.906	12	11.49217	0.15061	0.998714	2.686633
lumns	9493.084	1	9493.084	124.4113	1.09E-07	4.747221
ror	915.6484	12	76.30403			
tal	10546.64	25				

ble 28 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 4

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	138.1579	12	11.51316	0.148253	0.998805	2.686633
olumns	8663.64	1	8663.64	111.5603	1.98E-07	4.747221
ror	931.9055	12	77.65879			
tal	9733.704	25				

29 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 1 on drying.

VA

urce of Variation	SS	df	MS	F	P-value	F crit
s	0.648025	1	0.648025	0.176707	0.746664	161.4462
mns	488.631	1	488.631	133.2427	0.055014	161.4462
r	3.667225	1	3.667225			
al	492.9463	3				

e 30 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 2 on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.0625	1	0.0625	0.092951	0.811608	161.4462
lumns	463.9716	1	463.9716	690.0232	0.024224	161.4462
or	0.6724	1	0.6724			
tal	464.7065	3				

le 31 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 3 on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.1764	1	0.1764	0.09679	0.807983	161.4462
lumns	408.8484	1	408.8484	224.3338	0.042441	161.4462
or	1.8225	1	1.8225			
tal	410.8473	3				

le 32 Results of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 4 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.042025	1	0.042025	0.060275	0.846735	161.4462
lumns	515.9712	1	515.9712	740.0355	0.023392	161.4462
or	0.697225	1	0.697225			
tal	516.7105	3				

Table 33 Result of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	621.4216	3	207.1405	14.26241	0.027905	9.276619
Columns	592.3682	1	592.3682	40.78678	0.007774	10.12796
Error	43.5706	3	14.52353			
Total	1257.36	7				

Table 34 Result of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	24.3216	3	8.1072	6.129822	0.085321	9.276619
Columns	886.6261	1	886.6261	670.3744	0.000126	10.12796
Error	3.96775	3	1.322583			
Total	914.9154	7				

Table 35 Result of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	49.0465	4	12.26162	22.33183	0.005353	6.388234
Columns	1145.542	1	1145.542	2086.351	1.37E-06	7.70865
Error	2.19626	4	0.549065			
Total	1196.785	9				

Table 36 Result of two - way ANOVA on moisture and salt in D.S. ribbonfish lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	32.07964	4	8.01991	5.585246	0.062176	6.388234
Columns	1238.546	1	1238.546	862.5516	8E-06	7.70865
Error	5.74364	4	1.43591			
Total	1276.37	9				

Table 37 Results of two - way ANOVA on moisture and salt in W.S. ribbonfish lot 1

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	156.1462	12	13.01218	0.235623	0.990824	2.686633
Columns	13099.58	1	13099.58	237.2051	2.87E-09	4.747221
Error	662.696	12	55.22467			
Total	13918.42	25				

Table 38 Results of two - way ANOVA on moisture and salt in W.S. ribbonfish lot 2.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	85.06095	12	7.088412	0.10247	0.999803	2.686633
Columns	10584.41	1	10584.41	153.0088	3.45E-08	4.747221
Error	830.1022	12	69.17519			
Total	11499.57	25				

Table 39 Results of two - way ANOVA on moisture and salt in W.S. ribbonfish lot 3.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	79.76816	12	6.647347	0.090353	0.999896	2.686633
Columns	9208.25	1	9208.25	125.1612	1.05E-07	4.747221
Error	882.8537	12	73.57114			
Total	10170.87	25				

Table 40 Results of two - way ANOVA on moisture and salt in W.S. ribbonfish lot 4.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	107.4288	12	8.952403	0.11228	0.999688	2.686633
Columns	9585.408	1	9585.408	120.2193	1.31E-07	4.747221
Error	956.7919	12	79.73266			
Total	10649.63	25				

Table 41 Results of two - way ANOVA on moisture & salt in W.S. ribbonfish lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.874225	1	0.874225	0.8321	0.529212	161.4462
Columns	590.247	1	590.247	561.8056	0.026843	161.4462
Error	1.050625	1	1.050625			
Total	592.1719	3				

Table 42 Results of two - way ANOVA on moisture & salt in W.S. ribbonfish lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.731025	1	0.731025	0.381095	0.647909	161.4462
Columns	357.021	1	357.021	186.1205	0.046581	161.4462
Error	1.918225	1	1.918225			
Total	359.6703	3				

Table 43 Results of two - way ANOVA on moisture & salt in W.S. ribbonfish lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.697225	1	0.697225	0.67677	0.561747	161.4462
Columns	319.8732	1	319.8732	310.4887	0.03609	161.4462
Error	1.030225	1	1.030225			
Total	321.6007	3				

Table 44 Results of two - way ANOVA on moisture & salt in W.S. ribbonfish lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.3136	1	0.3136	0.900891	0.516604	161.4462
Columns	278.2224	1	278.2224	799.26	0.022509	161.4462
Error	0.3481	1	0.3481			
Total	278.8841	3				

Table 45. Result of two - way ANOVA on moisture and salt in w.s. ribbonfish lot 1on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	963.6057	3	321.2019	18.4249	0.01952	9.276619
Columns	298.6568	1	298.6568	17.13166	0.025603	10.12796
Error	52.2991	3	17.43303			
Total	1314.562	7				

Table 46. Result of two - way ANOVA on moisture and salt in w.s. ribbonfish lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	71.37854	3	23.79285	17.46162	0.02105	9.276619
Columns	689.1328	1	689.1328	505.7562	0.000193	10.12796
Error	4.087738	3	1.362579			
Total	764.5991	7				

Table 47. Result of two - way ANOVA on moisture and salt in w.s. ribbonfish lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	58.44374	4	14.61094	15.45665	0.010629	6.388234
Columns	802.9952	1	802.9952	849.4742	8.25E-06	7.70865
Error	3.78114	4	0.945285			
Total	865.2201	9				

Table 48. Result of two - way ANOVA on moisture and salt in w.s. ribbonfish lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	67.51706	4	16.87926	8.013	0.034199	6.388234
Columns	880.0316	1	880.0316	417.7726	3.38E-05	7.70865
Error	8.42594	4	2.106485			
Total	955.9746	9				

Table 49 Results of two - way ANOVA on moisture and salt in D.S. shark lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	197.194	12	16.43284	0.523027	0.862201	2.686633
Columns	13976.15	1	13976.15	444.8354	7.5E-11	4.747221
Error	377.0244	12	31.4187			
Total	14550.37	25				

Table 50 Results of two - way ANOVA on moisture and salt in D.S. shark lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	95.15075	12	7.929229	0.229065	0.991827	2.686633
Columns	13141.81	1	13141.81	379.6487	1.89E-10	4.747221
Error	415.3885	12	34.61571			
Total	13652.35	25				

Table 51 Results of two - way ANOVA on moisture and salt in D.S. shark lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	53.52068	12	4.460057	0.083431	0.999931	2.686633
Columns	9522.533	1	9522.533	178.1311	1.47E-08	4.747221
Error	641.496	12	53.458			
Total	10217.55	25				

Table 52 Results of two - way ANOVA on moisture and salt in D.S. shark lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	77.04135	12	6.420112	0.124861	0.999475	2.686633
Columns	9816.425	1	9816.425	190.9135	9.9E-09	4.747221
Error	617.0183	12	51.41819			
Total	10510.48	25				

Table 53 Results of two - way ANOVA on moisture and salt in D.S. shark lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.2401	1	0.2401	0.056034	0.852026	161.4462
Columns	1123.59	1	1123.59	262.2209	0.039264	161.4462
Error	4.2849	1	4.2849			
Total	1128.115	3				

Table 54 Results of two - way ANOVA on moisture and salt in D.S. shark lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.893025	1	0.893025	0.153119	0.762549	161.4462
Columns	998.876	1	998.876	171.2684	0.048551	161.4462
Error	5.832225	1	5.832225			
Total	1005.601	3				

Table 55 Results of two - way ANOVA on moisture and salt in D.S. shark lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.3124	1	3.3124	1.575458	0.428272	161.4462
Columns	827.1376	1	827.1376	393.4067	0.032069	161.4462
Error	2.1025	1	2.1025			
Total	832.5525	3				

Table 56 Results of two - way ANOVA on moisture and salt in D.S. shark lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.525225	1	1.525225	3.555096	0.310443	161.4462
Columns	695.1132	1	695.1132	1620.216	0.015813	161.4462
Error	0.429025	1	0.429025			
Total	697.0675	3				

Table 57 Result of two - way ANOVA on moisture and salt in D.S. shark lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	454.3653	3	151.4551	6.902788	0.073445	9.276619
Columns	920.6341	1	920.6341	41.95924	0.007467	10.12796
Error	65.82345	3	21.94115			
Total	1440.823	7				

Table 58 Result of two - way ANOVA on moisture and salt in D.S. shark lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	15.63414	3	5.211379	0.841942	0.554562	9.276619
Columns	1306.883	1	1306.883	211.1379	0.000707	10.12796
Error	18.56914	3	6.189713			
Total	1341.086	7				

Table 59 Result of two - way ANOVA on moisture and salt in D.S. shark lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	35.2181	4	8.804525	5.069877	0.072483	6.388234
Columns	1493.528	1	1493.528	860.0128	8.05E-06	7.70865
Error	6.94654	4	1.736635			
Total	1535.693	9				

Table 60 Result of two - way ANOVA on moisture and salt in D.S. shark lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	25.48714	4	6.371785	5.9371	0.056349	6.388234
Columns	1618.493	1	1618.493	1508.079	2.63E-06	7.70865
Error	4.29286	4	1.073215			
Total	1648.273	9				

Table 61 Results of two - way ANOVA on moisture and salt in W.S. shark lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	154.7826	12	12.89855	0.460552	0.903141	2.686633
Columns	15330.88	1	15330.88	547.4006	2.22E-11	4.747221
Error	336.0803	12	28.00669			
Total	15821.74	25				

Table 62 Results of two - way ANOVA on moisture and salt in W.S. shark lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	109.3238	12	9.110315	0.208647	0.994474	2.686633
Columns	11843.27	1	11843.27	271.2383	1.33E-09	4.747221
Error	523.9647	12	43.66372			
Total	12476.56	25				

Table 63 Results of two - way ANOVA on moisture and salt in W.S. shark lot 3

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	132.4508	12	11.03757	0.226948	0.992135	2.686633
Columns	11374.2	1	11374.2	233.8693	3.12E-09	4.747221
Error	583.6186	12	48.63488			
Total	12090.27	25				

Table 64 Results of two - way ANOVA on moisture and salt in W.S. shark lot 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	139.752	12	11.646	0.259795	0.98643	2.686633
Columns	11329.91	1	11329.91	252.7437	2E-09	4.747221
Error	537.9319	12	44.82766			
Total	12007.59	25				

Table 65 Results of two - way ANOVA on moisture and salt in W.S. shark lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.2996	1	1.2996	0.845213	0.526733	161.4462
Columns	1616.04	1	1616.04	1051.015	0.019631	161.4462
Error	1.5376	1	1.5376			
Total	1618.877	3				

Table 66 Results of two - way ANOVA on moisture and salt in W.S. shark lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.4356	1	0.4356	0.632312	0.572322	161.4462
Columns	934.5249	1	934.5249	1356.547	0.01728	161.4462
Error	0.6889	1	0.6889			
Total	935.6494	3				

Table 67 Results of two - way ANOVA on moisture and salt in W.S. shark lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.5129	1	1.5129	0.663524	0.564831	161.4462
Columns	902.4016	1	902.4016	395.7728	0.031974	161.4462
Error	2.2801	1	2.2801			
Total	906.1946	3				

Table 68 Results of two - way ANOVA on moisture and salt in W.S. shark lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.380625	1	1.380625	0.229072	0.715817	161.4462
Columns	837.2342	1	837.2342	138.9133	0.053885	161.4462
Error	6.027025	1	6.027025			
Total	844.6419	3				

69. Result of two - way ANOVA on moisture and salt in w.s. shark lot 1 on storage.

OVA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	252.3131	3	84.10437	3.11333	0.187941	9.276619
ns	1031.034	1	1031.034	38.16626	0.008539	10.12796
r	81.04285	3	27.01428			
al	1364.39	7				

e 70. Result of two - way ANOVA on moisture and salt in w.s. shark lot 2 on storage.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	10.0641	3	3.3547	1.95752	0.297549	9.276619
umns	1673.311	1	1673.311	976.4034	7.2E-05	10.12796
r	5.14125	3	1.71375			
tal	1688.517	7				

le 71. Result of two - way ANOVA on moisture and salt in w.s. shark lot 3 on storage.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.52436	4	0.13109	0.095178	0.978654	6.388234
umns	2307.665	1	2307.665	1675.487	2.13E-06	7.70865
r	5.50924	4	1.37731			
tal	2313.698	9				

le 72. Result of two - way ANOVA on moisture and salt in w.s. shark lot 4 on storage.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	4.00686	4	1.001715	0.651935	0.655687	6.388234
umns	2003.64	1	2003.64	1304.008	3.51E-06	7.70865
r	6.1461	4	1.536525			
tal	2013.793	9				

Table 73 Results of two - way ANOVA on pH and a_w in D.S. mackerel lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.284215	12	0.023685	2.572981	0.057584	2.686633
Columns	208.6278	1	208.6278	22664.3	4.96E-21	4.747221
Error	0.110462	12	0.009205			
Total	209.0225	25				

Table 74 Results of two - way ANOVA on pH and a_w in D.S. mackerel lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.466246	12	0.038854	2.373218	0.074277	2.686633
Columns	197.0102	1	197.0102	12033.51	2.21E-19	4.747221
Error	0.196462	12	0.016372			
Total	197.6729	25				

Table 75 Results of two - way ANOVA on pH and a_w in D.S. mackerel lot 3

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.428946	12	0.119079	1.25249	0.351409	2.686633
Columns	207.3833	1	207.3833	2181.289	6.07E-15	4.747221
Error	1.140885	12	0.095074			
Total	209.9531	25				

Table 76 Results of two - way ANOVA on pH and a_w in D.S. mackerel lot 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.664246	12	0.055354	1.686167	0.189042	2.686633
Columns	194.2671	1	194.2671	5917.689	1.55E-17	4.747221
Error	0.393938	12	0.032828			
Total	195.3253	25				

77 Results of two - way ANOVA on pH and a $_w$ in D.S. mackerel lot 1 on drying.

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ource of Variation	SS	df	MS	F	P-value	F crit
s	1E-04	1	1E-04	0.0625	0.844042	161.4462
mns	32.1489	1	32.1489	20093.06	0.004491	161.4462
r	0.0016	1	0.0016			
a	32.1506	3				

e 78 Results of two - way ANOVA on pH and a $_w$ in D.S. mackerel lot 2 on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	0.0009	1	0.0009	0.36	0.655958	161.4462
umns	29.9209	1	29.9209	11968.36	0.005819	161.4462
r	0.0025	1	0.0025			
al	29.9243	3				

ble 79 Results of two - way ANOVA on pH and a $_w$ in D.S. mackerel lot 3 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.0004	1	0.0004	0.444444	0.625666	161.4462
olumns	29.16	1	29.16	32400	0.003537	161.4462
rror	0.0009	1	0.0009			
otal	29.1613	3				

able 80 Results of two - way ANOVA on pH and a $_w$ in D.S. mackerel lot 4 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2.5E-05	1	2.5E-05	0.111111	0.795167	161.4462
olumns	28.67603	1	28.67603	127449	0.001783	161.4462
rror	0.000225	1	0.000225			
otal	28.67628	3				

Table 81. Result of two - way ANOVA on pH and a_w in D.S. mackerel lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.1267	3	0.042233	1.120743	0.463774	9.276619
Columns	54.18405	1	54.18405	1437.878	4.03E-05	10.12796
Error	0.11305	3	0.037683			
Total	54.4238	7				

Table 82. Result of two - way ANOVA on pH and a_w in D.S. mackerel lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.152237	3	0.050746	1.036775	0.488506	9.276619
Columns	53.40611	1	53.40611	1091.127	6.1E-05	10.12796
Error	0.146838	3	0.048946			
Total	53.70519	7				

Table 83. Result of two - way ANOVA on pH and a_w in D.S. mackerel lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.2593	4	0.064825	1.02628	0.490273	6.388234
Columns	65.17809	1	65.17809	1031.87	5.6E-06	7.70865
Error	0.25266	4	0.063165			
Total	65.69005	9				

Table 84. Result of two - way ANOVA on pH and a_w in D.S. mackerel lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.13144	4	0.03286	1.070707	0.4744	6.388234
Columns	62.60004	1	62.60004	2039.754	1.44E-06	7.70865
Error	0.12276	4	0.03069			
Total	62.85424	9				

Table 85 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.488515	12	0.04071	2.203497	0.092795	2.686633
Columns	207.4963	1	207.4963	11231.19	3.34E-19	4.747221
Error	0.2217	12	0.018475			
Total	208.2065	25				

Table 86 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.793746	12	0.066146	2.498898	0.063225	2.686633
Columns	183.7529	1	183.7529	6941.963	5.96E-18	4.747221
Error	0.317638	12	0.02647			
Total	184.8642	25				

Table 87 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.937638	12	0.078137	1.865719	0.14692	2.686633
Columns	171.4191	1	171.4191	4093.09	1.41E-16	4.747221
Error	0.502562	12	0.04188			
Total	172.8593	25				

Table 88 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.937638	12	0.078137	1.865719	0.14692	2.686633
Columns	171.4191	1	171.4191	4093.09	1.41E-16	4.747221
Error	0.502562	12	0.04188			
Total	172.8593	25				

Table 89 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.1089	1	0.1089	1	0.5	161.4462
Columns	35.2836	1	35.2836	324	0.035331	161.4462
Error	0.1089	1	0.1089			
Total	35.5014	3				

Table 90 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.013225	1	0.013225	1.83045	0.405214	161.4462
Columns	29.21403	1	29.21403	4043.464	0.010011	161.4462
Error	0.007225	1	0.007225			
Total	29.23448	3				

Table 91 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.01	1	0.01	0.694444	0.557716	161.4462
Columns	24.9001	1	24.9001	1729.174	0.015307	161.4462
Error	0.0144	1	0.0144			
Total	24.9245	3				

Table 92 Results of two - way ANOVA on pH and a_w in W.S. mackerel lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0004	1	0.0004	4	0.295167	161.4462
Columns	22.09	1	22.09	220900	0.001355	161.4462
Error	0.0001	1	0.0001			
Total	22.0905	3				

Table 93. Result of two - way ANOVA on pH and a_w in W.S. mackerel lot 1on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.6495	3	0.2165	2.433952	0.242102	9.276619
Columns	45.79245	1	45.79245	514.8111	0.000187	10.12796
Error	0.26685	3	0.08895			
Total	46.7088	7				

Table 94. Result of two - way ANOVA on pH and a_w in W.S. mackerel lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.33125	3	0.110417	0.969985	0.509699	9.276619
Columns	46.08	1	46.08	404.8023	0.000268	10.12796
Error	0.3415	3	0.113833			
Total	46.75275	7				

Table 95. Result of two - way ANOVA on pH and a_w in W.S. mackerel lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.41456	4	0.10364	0.972689	0.510383	6.388234
Columns	55.93225	1	55.93225	524.939	2.15E-05	7.70865
Error	0.4262	4	0.10655			
Total	56.77301	9				

Table 96. Result of two - way ANOVA on pH and a_w in W.S. mackerel lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.32054	4	0.080135	0.965075	0.513328	6.388234
Columns	55.97956	1	55.97956	674.1682	1.31E-05	7.70865
Error	0.33214	4	0.083035			
Total	56.63224	9				

Table 97. Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.949946	12	0.162496	1.291599	0.332328	2.686633
Columns	211.7554	1	211.7554	1683.141	2.85E-14	4.747221
Error	1.509715	12	0.12581			
Total	215.215	25				

Table 98. Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.685238	12	0.140437	1.629061	0.205005	2.686633
Columns	186.8496	1	186.8496	2167.452	6.3E-15	4.747221
Error	1.034485	12	0.086207			
Total	189.5693	25				

Table 99. Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 3

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.5329	12	0.127742	1.641018	0.201549	2.686633
Columns	194.3218	1	194.3218	2496.331	2.71E-15	4.747221
Error	0.934115	12	0.077843			
Total	196.7888	25				

Table 100. Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.883015	12	0.156918	1.471813	0.256664	2.686633
Columns	185.2446	1	185.2446	1737.504	2.36E-14	4.747221
Error	1.279385	12	0.106615			
Total	188.407	25				

Table 101 Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0009	1	0.0009	0.183673	0.742238	161.4462
Columns	25.9081	1	25.9081	5287.367	0.008755	161.4462
Error	0.0049	1	0.0049			
Total	25.9139	3				

Table 102 Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2.5E-05	1	2.5E-05	1	0.5	161.4462
Columns	25.35123	1	25.35123	1014049	0.000632	161.4462
Error	2.5E-05	1	2.5E-05			
Total	25.35128	3				

Table 103 Results of two - way ANOVA on pH and a_W in D.S. ribbonfish lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.003025	1	0.003025	1.493827	0.436549	161.4462
Columns	24.95003	1	24.95003	12321	0.005735	161.4462
Error	0.002025	1	0.002025			
Total	24.95508	3				

Table 104 Results of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0016	1	0.0016	0.444444	0.625666	161.4462
Columns	25.9081	1	25.9081	7196.694	0.007504	161.4462
Error	0.0036	1	0.0036			
Total	25.9133	3				

Table 105. Result of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0986	3	0.032867	2.143478	0.273636	9.276619
Columns	54.4968	1	54.4968	3554.139	1.04E-05	10.12796
Error	0.046	3	0.015333			
Total	54.6414	7				

Table 106. Result of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.1677	3	0.0559	1.351874	0.405109	9.276619
Columns	54.39245	1	54.39245	1315.416	4.61E-05	10.12796
Error	0.12405	3	0.04135			
Total	54.6842	7				

Table 107. Result of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.78794	4	0.196985	0.995452	0.501709	6.388234
Columns	61.20676	1	61.20676	309.3047	6.14E-05	7.70865
Error	0.79154	4	0.197885			
Total	62.78624	9				

Table 108. Result of two - way ANOVA on pH and a_w in D.S. ribbonfish lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.18934	4	0.047335	1.279843	0.408402	6.388234
Columns	67.54801	1	67.54801	1826.362	1.79E-06	7.70865
Error	0.14794	4	0.036985			
Total	67.88529	9				

Table 109 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.253015	12	0.104418	1.73153	0.177302	2.686633
Columns	196.57	1	196.57	3259.659	5.5E-16	4.747221
Error	0.723646	12	0.060304			
Total	198.5467	25				

Table 110 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.525454	12	0.293788	1.433196	0.271282	2.686633
Columns	144.4322	1	144.4322	704.5894	5.01E-12	4.747221
Error	2.459854	12	0.204988			
Total	150.4176	25				

Table 111 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.379985	12	0.281665	1.577821	0.220536	2.686633
Columns	121.9545	1	121.9545	683.1594	6.01E-12	4.747221
Error	2.142185	12	0.178515			
Total	127.4766	25				

Table 112 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	5.024415	12	0.418701	1.374872	0.29496	2.686633
Columns	136.6674	1	136.6674	448.7689	7.12E-11	4.747221
Error	3.654462	12	0.304538			
Total	145.3463	25				

113 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 1 on drying.

VA

Source of Variation	SS	df	MS	F	P-value	F crit
s	0.034225	1	0.034225	0.7404	0.547657	161.4462
umns	23.28063	1	23.28063	503.6371	0.028349	161.4462
or	0.046225	1	0.046225			
al	23.36108	3				

ble 114 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 2 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.000225	1	0.000225	1	0.5	161.4462
olumns	14.63063	1	14.63063	65025	0.002497	161.4462
rror	0.000225	1	0.000225			
tal	14.63108	3				

ble 115 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 3 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.000225	1	0.000225	1	0.5	161.4462
olumns	13.14063	1	13.14063	58402.78	0.002634	161.4462
rror	0.000225	1	0.000225			
tal	13.14108	3				

ble 116 Results of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 4 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.0016	1	0.0016	0.326531	0.669501	161.4462
olumns	18.8356	1	18.8356	3844	0.010267	161.4462
rror	0.0049	1	0.0049			
tal	18.8421	3				

Table 117. Result of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.4777	3	0.159233	2.887277	0.203533	9.276619
Columns	32.88605	1	32.88605	596.3019	0.000151	10.12796
Error	0.16545	3	0.05515			
Total	33.5292	7				

Table 118. Result of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.427637	3	0.142546	1.266558	0.425303	9.276619
Columns	33.17051	1	33.17051	294.7289	0.000431	10.12796
Error	0.337638	3	0.112546			
Total	33.93579	7				

Table 119. Result of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.8166	4	0.20415	1.075549	0.472712	6.388234
Columns	39.04576	1	39.04576	205.7097	0.000137	7.70865
Error	0.75924	4	0.18981			
Total	40.6216	9				

Table 120. Result of two - way ANOVA on pH and a_w in W.S. ribbonfish lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.10784	4	0.02696	1.580305	0.33417	6.388234
Columns	35.87236	1	35.87236	2102.717	1.35E-06	7.70865
Error	0.06824	4	0.01706			
Total	36.04844	9				

Table 121. Results of two - way ANOVA on pH and a_w in D.S. shark lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2.083538	12	0.173628	0.951134	0.533864	2.686633
Columns	261.1446	1	261.1446	1430.548	7.5E-14	4.747221
Error	2.190585	12	0.182549			
Total	265.4187	25				

Table 122. Results of two - way ANOVA on pH and a_w in D.S. shark lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4.592638	12	0.38272	0.961117	0.526819	2.686633
Columns	288.5779	1	288.5779	724.7	4.24E-12	4.747221
Error	4.778438	12	0.398203			
Total	297.9489	25				

Table 123. Results of two - way ANOVA on pH and a_w in D.S. shark lot 3

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.903062	12	0.158588	1.410704	0.28018	2.686633
Columns	183.806	1	183.806	1635.024	3.39E-14	4.747221
Error	1.349015	12	0.112418			
Total	187.0581	25				

Table 124. Results of two - way ANOVA on pH and a_w in D.S. shark lot 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.059162	12	0.088263	2.314874	0.080131	2.686633
Columns	175.812	1	175.812	4610.997	6.91E-17	4.747221
Error	0.457546	12	0.038129			
Total	177.3287	25				

Table 125 Results of two - way ANOVA on pH and a_w in D.S. shark lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.6241	1	0.6241	1.080506	0.48768	161.4462
Columns	49.4209	1	49.4209	85.5625	0.068558	161.4462
Error	0.5776	1	0.5776			
Total	50.6226	3				

Table 126 Results of two - way ANOVA on pH and a_w in D.S. shark lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.009025	1	0.009025	361	0.033475	161.4462
Columns	54.68603	1	54.68603	2187441	0.00043	161.4462
Error	2.5E-05	1	2.5E-05			
Total	54.69508	3				

Table 127 Results of two - way ANOVA on pH and a_w in D.S. shark lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0036	1	0.0036	0.734694	0.548875	161.4462
Columns	29.5936	1	29.5936	6039.51	0.008191	161.4462
Error	0.0049	1	0.0049			
Total	29.6021	3				

Table 128 Results of two - way ANOVA on pH and a_w in D.S. shark lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.030625	1	0.030625	1	0.5	161.4462
Columns	38.37803	1	38.37803	1253.16	0.017979	161.4462
Error	0.030625	1	0.030625			
Total	38.43928	3				

Table 129. Result of two - way ANOVA on pH and a_w in D.S. shark lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.042937	3	0.014312	1.83985	0.314509	9.276619
Columns	64.46801	1	64.46801	8287.265	2.92E-06	10.12796
Error	0.023338	3	0.007779			
Total	64.53429	7				

Table 130. Result of two - way ANOVA on pH and a_w in D.S. shark lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0801	3	0.0267	1.658385	0.343959	9.276619
Columns	65.6658	1	65.6658	4078.621	8.46E-06	10.12796
Error	0.0483	3	0.0161			
Total	65.7942	7				

Table 131. Result of two - way ANOVA on pH and a_w in D.S. shark lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.1005	4	0.025125	0.990538	0.503565	6.388234
Columns	74.36529	1	74.36529	2931.807	6.96E-07	7.70865
Error	0.10146	4	0.025365			
Total	74.56725	9				

Table 132. Result of two - way ANOVA on pH and a_w in D.S. shark lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.01874	4	0.004685	1.812379	0.289382	6.388234
Columns	76.50756	1	76.50756	29596.74	6.85E-09	7.70865
Error	0.01034	4	0.002585			
Total	76.53664	9				

Table 133 Results of two - way ANOVA on pH and a_w in W.S. shark lot 1

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.419162	12	0.03493	0.60333	0.803106	2.686633
Columns	322.9958	1	322.9958	5578.943	2.21E-17	4.747221
Error	0.694746	12	0.057896			
Total	324.1097	25				

Table 134 Results of two - way ANOVA on pH and a_w in W.S. shark lot 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	6.6242	12	0.552017	1.129956	0.417928	2.686633
Columns	194.0485	1	194.0485	397.2094	1.45E-10	4.747221
Error	5.862354	12	0.488529			
Total	206.5351	25				

Table 135 Results of two - way ANOVA on pH and a_w in W.S. shark lot 3

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	6.273115	12	0.52276	1.203486	0.376765	2.686633
Columns	159.0188	1	159.0188	366.0898	2.34E-10	4.747221
Error	5.212454	12	0.434371			
Total	170.5044	25				

Table 136 Results of two - way ANOVA on pH and a_w in W.S. shark lot 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.307815	12	0.275651	1.169005	0.395596	2.686633
Columns	214.1594	1	214.1594	908.2248	1.12E-12	4.747221
Error	2.8296	12	0.2358			
Total	220.2968	25				

Table 137 Results of two - way ANOVA on pH and a_w in W.S. shark lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.001225	1	0.001225	0.604938	0.579167	161.4462
Columns	52.92563	1	52.92563	26136.11	0.003938	161.4462
Error	0.002025	1	0.002025			
Total	52.92888	3				

Table 138 Results of two - way ANOVA on pH and a_w in W.S. shark lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0001	1	0.0001	0.111111	0.795167	161.4462
Columns	30.25	1	30.25	33611.11	0.003472	161.4462
Error	0.0009	1	0.0009			
Total	30.251	3				

Table 139 Results of two - way ANOVA on pH and a_w in W.S. shark lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0016	1	0.0016	1	0.5	161.4462
Columns	19.0969	1	19.0969	11935.56	0.005827	161.4462
Error	0.0016	1	0.0016			
Total	19.1001	3				

Table 140 Results of two - way ANOVA on pH and a_w in W.S. shark lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0225	1	0.0225	2.25	0.374334	161.4462
Columns	23.4256	1	23.4256	2342.56	0.013151	161.4462
Error	0.01	1	0.01			
Total	23.4581	3				

Table 141. Result of two - way ANOVA on pH and a_w in W.S. shark lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.03045	3	0.01015	1.041026	0.487204	9.276619
Columns	60.83045	1	60.83045	6239.021	4.47E-06	10.12796
Error	0.02925	3	0.00975			
Total	60.89015	7				

Table 142. Result of two - way ANOVA on pH and a_w in W.S. shark lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.52895	3	0.176317	1.109957	0.466839	9.276619
Columns	75.76805	1	75.76805	476.9786	0.00021	10.12796
Error	0.47655	3	0.15885			
Total	76.77355	7				

Table 143. Result of two - way ANOVA on pH and a_w in W.S. shark lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.51984	4	0.12996	1.128517	0.454771	6.388234
Columns	97.28161	1	97.28161	844.7517	8.34E-06	7.70865
Error	0.46064	4	0.11516			
Total	98.26209	9				

Table 144. Result of two - way ANOVA on pH and a_w in W.S. shark lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0526	4	0.01315	1.567342	0.33696	6.388234
Columns	82.25424	1	82.25424	9803.843	6.24E-08	7.70865
Error	0.03356	4	0.00839			
Total	82.3404	9				

Chapter 7

CHEMICAL CHANGES OF FISH DURING SALTING, DRYING AND STORAGE – NITROGEN FRACTIONS

Introduction

The nitrogen fraction plays an important role in the nutritive aspects of fish. The ...tive value of fish is mainly related to the protein content. Protein is a highly delicate ...chemical compound, which undergoes denaturation upon exposure to extreme ...nditions. During curing the fish is initially exposed to brine, which removes most of the ...ater from the fish and then dried so as to remove water content further. So the keeping ...ality increases.

Sikorski *et al.*, (1995) and Kleimannov *et al.*, (1958) indicated the impacts of ...otein denaturation. Devadasan (2000) reported that curing results in loss of substantial ...mount of soluble protein in self-brine and decrease in its solubility. As far as nutritional ...ue is concerned, this is less significant. Prasad & Rao (1994) reported that the ...oisture, TVB, TPC and red discolouration increased as storage period increased than ...the initial period. Kandoran *et al.*, (1965) studied TVN loss in dry salted shark. The ...oteinous compound loss on salting in mackerel is reported by Mathew & Ragunath ...996), decrease of NPN content in wet salting of shark and ray (Mrochkov, 1958; ...ankar & Solanki, 1992) and change in SSN, in sardine and shark and ray ...rishnakumar *et al.*, 1986 and Sankar & Solanki, 1992). Change in urea content during ...ry salting (Kandodran *et al.*, 1965) and wet salted shark (Ramachandran & Solanki, ...991). Sikorski *et al.* (1995) stated that uptake of salt in fish causes rapid protein ...enaturation and coagulation and reduce further penetration of salt in fish. Connell ...957) cited in Devadasan (2000) noted that in dried fish, the protein gel system of the ...esh fish is in a disorganised state resulting in a much lower solubility. Ragulin (1958) ...stated that the nitrogen compound and FFA are extracted with water and the degree of ...oss depends on temperature and salt concentration and the loss is more in dry salting ...than wet salting.

The aim is to analyse:

- The total protein content of fishes like Mackerel, Ribbonfish and Shark at fresh condition
- To study the changes in TVN during dry and wet salting with different preservatives, drying and storage conditions
- To study the changes in NPN during dry and wet salting with different preservatives, drying and storage at different conditions
- To study the changes in SSN during dry and wet salting with different preservatives, drying and storage at different conditions and
- To study the changes in urea (only for shark) during dry and wet salting with different preservatives, drying and storage at different conditions

'1. Materials and Methods

The processed fish prepared as in M.M in the chapter 4 and Table no 1, 2 and 3 as used to find the total nitrogen, total volatile nitrogen (TVN), non protein nitrogen PN), salt soluble nitrogen (SSN) and urea. The fresh fish before salting or dried fish ere cleaned without bone or skin and chopped into small pieces on a dried plastic ard or wooden piece and then kept in a dried grinder. The meat was ground and this eat was used for the various experiments. The prepared sample was kept in the gerator until further use. The graphs of 4 lots of dry and wet salted samples were uped in one serial number.

'1.1. Total Nitrogen

Total nitrogen content of fish was estimated as per AOAC. (1980). The illation continued for 4 min after the colour of the boric acid changed into green. This rated against the standard N / 50 sulphuric acid.

$$\text{Total nitrogen} = \frac{\text{Volume made up x Titration value x N x 100.}}{\text{Weight of sample x Dilution factor}}$$

Total protein = Total Nitrogen X 6.25.

7.3.2. Total Volatile Nitrogen

5 gm of sample was mixed in a mortar with 10% TCA and filtered to a 50 ml standard flask. The TCA extract was used to estimate TVN by the method of Convey (1947).

Vol. of N / 50 Sodium Hydroxide used = vol. of N / 50 sulphuric acid used.

= ------ mg /100gm.

7.3.3. Non - Protein Nitrogen

5 ml of the above TCA extract from (7.3.2) was digested with 10ml Conc; sulphuric acid after adding the digestion mixture as per (AOAC, 1980) to a colourless solution. The solution was made up to 50 ml standard volumetric flask. 5ml of this sample was used for digestion in the reaction chamber as in the estimation of total nitrogen as described under 7.3.1. Calculation was done as in the case of total nitrogen.

7.3.4. Salt - Soluble Nitrogen

About 3 gm of fish tissue was extracted with 60 ml pre-cooled sodium chloride buffer (King & Poulter, 1985). The buffer solution was prepared using 5% sodium chloride and 0.02 M sodium bicarbonate at 7.5 pH. The sample was homogenised and centrifuged at 7000 rpm for 20 sec at 4 – 5^0c in a super speeded refrigerated centrifuge. The volume of the supernatant was measured. 5 ml of the extract was digested as mentioned under 7.3.1 and SSN was calculated as above as for Total nitrogen.

The urea in the shark is hydrolyzed with urease and the ammonia liberated was estimated by the method of Convey (1947). 1ml of 10%TCA extract was added in the outer chamber of Convey's microdiffusion unit and added 0.5ml buffered urease at other side and covered with lid and incubated at 45^0c for 20 min. then added 1ml boric acid indicator solution in the inner chamber. Added 1ml 45% potassium carbonate solution in the outer chamber and mixed and covered. The mixture was incubated at 45°c for one hour and titrated against N / 100 sulphuric acid for faint permanent red colour.

$$\text{Urea} = \frac{\text{Volume made up x titration value x 0.14 x 100}}{\text{Weight of sample x Volume of solution used}}$$

4. Results

4.1. Total Nitrogen

The raw mackerel had 18.08 gm / 100gm, ribbonfish had 19.36 gm / 100gm and shark had 21.16 gm / 100gm total nitrogen.

4.2. Total Volatile Nitrogen, Non-Protein Nitrogen and Salt Soluble Nitrogen changes during salting, drying and storage

4.2.1. Dry salted Mackerel

The TVN, NPN and SSN contents of the fresh mackerel were 106.04 mg, 17.53 mg and 43.31 gm / 100 gm respectively. The TVN in lot 1 was 41.91 and 36.14% more at 4, 8 and decreased by 5.04% and 42.28% at 24 hours and 48 hours. The NPN content was 11.49, and 1.31% more at 4, 8 hours but decreased by 15.80% and 21.56% at 24 and 48 hours. SSN content was 54.03, 22.72 and 11.78% more but 8.10% less than the fresh meat at 4, 8, 24 and 48 hours of salting than fresh fish. The ANOVA result

:; 1 show that the salting hours effects and TVN, NPN and SSN effects are significant :‹ 0.05) (Table 1). The TVN content in lot two was 0.83, 1.41, 38.5 and 23.10% :eased at same hours of salting and NPN content 28.01% increased, 9.07, 25.73 and :.53% decreased at same hours of salting. The SSN content was 17.85% more and ·'3, 23.69 and 33.87% less at same hours of salting. Lot two showed that TVN, NPN :c SSN effects are highly significant ($p < 0.001$). There is significant different between 'N & NPN and NPN & SSN and no significance between column c1 and c2 and c2 and :at initial stage but increases as time increases. Salting hour effects are not significant :5% level (Table 2). The TVN content in lot three was 1.48% less and 8.45% more at 4 :c 8 hours and 25.32 and 41.71% less at 24 and 48 hours of salting and the NPN :ntent was 5.65, 12.49, 17.97 and 20.08 % decreased at same hours of salting. The :SN content was 1.87, 18.33, 25.49 and 36.27% less at the same hours of salting. In lot : there is significance between ($p < 0.001$) TVN and NPN and NPN and SSN. TVN, PN and SSN have no significance initially but it increases as the time increases. There :no significant difference between salting hours (Table 3). The TVN content in lot 4 was :'02 and 16.22% more at 4, 8, and 24.8 and 39.42% less at 24 and 48 hours during :lting, the NPN content was 19.39 and 9.58% more and 12.84 and 22.82% less at :ame hours of salting and the SSN content was 4.55% more and 27.04, 33.29 and :82% less in the same hours of salting (Figure – 7.1). In lot 4, there is significance :etween ($p < 0.001$) TVN and NPN and NPN and SSN. Columns have no significance :tally but it increases as the time increases. There is significant difference ($p < 0.05$) :etween salting hours (Table 4).

The drying changes in lot 1, in TVN was 1.69 and 3.72 % less, NPN was 16.44 :d 27.13% less and SSN was and 35.28 and 57.64% less after 4 hours at noon and :er 8 hours at evening than salted fish. In lot 2, the TVN content was 1.04 and 8.74% :ecreased, NPN content was 10.01 and 20.02% less and the SSN content 29.09 and

...th and increased in 3rd month and decreased in 4th month, NPN content was 17.08, ...% less and 9.34% more and further decreased on the fourth month by 7.35% less. ... content was 10.05 and 25.8% less and 13.35 and 11.48% more in one to four ...ths (Figure – 7.2). TVN, NPN and SSN effects are significant ($p < 0.001$). There is ...significance between TVN and NPN and NPN and SSN. But storage period effects ...not significant in both lots 3 and 4 (Table 11 & 12).

...2.2. Wet salted Mackerel

The TVN contents in lot one decreased by 21.26, 33.96, 14.13 and 24.47% ...ing salting at 4, 8, 24 and 48 hours of salting. NPN content decreased by 37.42, ...83, 45.29 and 66.8% and the SSN content was 21.7, 35.4, 49.53 and 62.83% less at ...8, 24 and 48 hours of salting than fresh fish. In lot two, TVN content was 28.95, 37.95, ...75 and 43.3% decreased, NPN content was 39.07, 53.34, 38.56 and 52.82% ...creased and SSN content 24.57, 45.02, 53.45 and 63.38% less in the same salting ...ours. In 3rd lot, the TVN content was 37.55, 37.01, 32.94 and 32.22% less in above ...ours, NPN content was 34.85, 41.18, 44.15 and 69.71% decreased and the SSN ...ntent was 26.58, 29.02, 51.61 and 72.73% less in the same salting period. The TVN ...ntent in lot four was 37.44, 33.13, 16.14 and 44.31% less, NPN content was 27.23, ...12, 43.41 and 67.88% less and SSN content was 40.87, 37.47, 61.39 and 67.76% ...ss in the same period of salting (Figure – 7.3). There is significance between TVN and ...PN and NPN and SSN ($P < 0.001$) and there is significance between column c1 and c2 ...t no significance between c2 and c3. The salting time effects are significant ($p < 0.01$) ...all four lots (Table 13 – 16).

Changes after drying in lot one, TVN content was 29.2% less than salted sample ...ter four hours drying at noon, but it was 17.58% more after eight hours drying. NPN ...ntent was 13.23% and 4.12% less and SSN content was 9.59 and 13.98% less than ...ted fish. There is significance between ($p < 0.01$) TVN and NPN and NPN and SSN 'ble 17). The TVN content in lot two, after drying decreased 14.74 and 10.16%, NPN content was 19.88% more and 2.23% less and SSN content was 14.75 and 16.39% less the same period of drying. There is significance between ($p < 0.01$) TVN and NPN and NPN and SSN and between drying hours there is no significant difference (Table 18). In lot three, TVN content was 13.52 and 25.23% less, the NPN content was 3.4% less and 14.71% more and SSN content was 5.67% more and 2.03% less at noon and evening. There is significance between ($p < 0.05$) TVN and NPN but there is no significance between NPN and SSN and drying hours (Table 19). In lot four, the TVN content was 12.73 and 19.27% less, NPN content was 19.54% more and 6.04% less and SSN content was 2.65% more and 9.09% less in the same period of drying (Table – ''). Between rows there is no significant difference. TVN, NPN and SSN effects were significant ($p < 0.01$). There is no significance between TVN and NPN and there is significance between NPN and SSN and no significance in drying period (Table 20).

The TVN, NPN and SSN content in unpacked lot one decreased as the storage time increased as 10, 20 and 30 days of storage than dried fish. The TVN content in packed lots two, the values increased initially by 30.98% and 29.14%, which subsequently decreased by 19.95%. NPN content was 15.59 and 54.77% more and :39% less and SSN content decreased in the same storage period. In both lots TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significance between TVN and NPN but there is significance between NPN and SSN. But storage period effects are not significant in both lots one and two (Table 21 & 22). The lot three had the TVN content 18.90 and 25.53 and 11.11% less in one to three months and 11.38% more in 4th month than dried fish. NPN content was 28.07 and 53.73% less and 35.55 and '4.73% more in one to four months SSN content decreased than packed product in one to four months. There is significance ($p < 0.001$) between TVN and NPN and NPN and SSN. Storage period effects are not significant (Table 23). The TVN content of lot four

:61% decreased during the same drying period. There is significance between TVN and NPN and NPN and SSN. There is no significant difference between drying hours in ot 1 and 2 (Table 5 & 6). There is significant difference between ($p < 0.05$) TVN, NPN and SSN. In lot 3, the TVN content was 21.23% and 24.64% less, the NPN content was '28 and 18.98% more and the SSN content was 38.41 and 51.7% decreased in the same period. In lot 4, the TVN content was 23.33 and 20.92% less, the NPN content was 1.02% more and 11.75% less and SSN content was 17.99 and 34.85% less in the same drying period (Table – 7.1). There is significant difference between ($p < 0.01$) TVN, NPN and SSN. There is significance between TVN and NPN but no significant difference between NPN and SSN. There is no significant difference between rows in lots 3 and 4 (Table 7 & 8).

The TVN content in unpacked lots had 30.98% more initially than dried meat after 10 days and 16.19% less after 20 days and 2.22% more after 30 days storage. NPN content was 36.38 and 40.70% more and 4.76% less and the SSN content was '5.15 and 41.04% more and 6.15% less after 10, 20 and 30 days storage. There is significant difference ($p < 0.001$) between TVN and NPN and there is significance between NPN and SSN. The significance between TVN, NPN and SSN and storing period effects are not significant (Table 9). The TVN content in lot two was 2.84% decreased and 38.86 and 26.08 increased. The NPN content was 9.25% more followed by a decrease of 1.05%. SSN content was 20.63, 37.58 and 24.83% more in the same period. There is no significance between TVN and NPN and there is significance between NPN and SSN and storing period. The TVN, NPN and SSN effects are significant ($p < 0.001$) (Table 10). The TVN content in lot 3 was 18.11, 27.00, 14.68 and :98% decreased in 1 to 4 months; the NPN content was 9.96 and 20.70% less but '3.68% and 4.41% more at one to four months. SSN content was 3.36 and 4.42% less and 33.68 and 18.60% more at one to four months. In lot four, TVN decreased up to 2nd creased initially for three months but increased in 4th month as 21.86%, NPN content was more than packed lot for one to four months and SSN content was less than packed lot for 4 months (Figure – 7.4). TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significance between TVN and NPN and there is significance between NPN and SSN and column c1 and c2 and c2 and c3. Storage period effects are not significant (Table 24).

7.2.3. Dry salted Ribbonfish

The ribbonfish had 111.73 mg TVN, 10.19 gm NPN and 38.74 gm / 100gm SSN in fresh condition. In all four lots, the results of TVN, NPN and SSN are similar as in dry salted mackerel except slight changes as noted in (Figure – 7.5). There is significance ($p < 0.001$) between TVN and NPN and NPN and SSN and column c1 and c2 but no significance in c2 and c3. Rows effects also significant ($p < 0.05$) in lots 1,3 and 4. But salting hour effects are not significant in lot three alone (Table 25 - 28)

TVN and SSN decreased in all four lots during drying as in dry salted mackerel but the NPN was increasing than salted fish as noted in Table – 7.2. In lot one, the ANOVA result shows that there is significance ($p < 0.01$) between TVN and NPN and NPN and SSN but no significance between column c1 and c2 (Table 29). In lot 2, there is no significance between TVN and NPN and NPN and SSN but there is significance between column c1 and c2 and rows effects are not significant (Table 30). In lot three, TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significance between TVN and NPN and NPN and SSN but there is significance between column c1 and c2 and rows effects are not significance (Table 31) In lot 4, TVN, NPN and SSN effects are significant ($p < 0.05$) there is no significance between TVN and NPN and NPN and SSN but there is significance between column c1 and c2 and salting hours effects are not significant (Table 32).

The TVN, NPN and SSN content in unpacked lots 1 showed that the fractions increase during 10, 20 and 30 days of storage than dried fish. Storage period effects and TVN, NPN and SSN effects are significant ($p < 0.05$) ($p < 0.001$). There is significant difference between TVN and NPN but there is significance between NPN and SSN (Table 33). The TVN content in packed lots 2 showed an increase initially with a decline subsequently, NPN content was 23.57 and 1.79% % more 10.84% less and SSN content was 3.8, 22.64 and 8.03% % less during the same storage period above. Storage period effects are not significant and TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significant between TVN and NPN but there is significance between NPN and SSN (Table 34). In refrigerator stored lots three TVN content was less for 2 months and more on 3rd month and decreased. In cold storage stored lots four, TVN content decreased for 3 months but increased in 4th month. NPN content decreased in lot 3, but it increased initially then decreased in lot 4. SSN content in lot 3 was more initially but it decreased and increased latter. In lot 4, SSN decreased as the storage period increased (Figure – 7.6). In lot 3, TVN, NPN and SSN effects are significant ($p < 0.001$) storage period effects are not significant. There is no significance between TVN and NPN but there is significance between NPN and SSN column c1 and c2 (Table 35). In lot 4, TVN, NPN and SSN effects are significant ($p < 0.001$) storage period effects are not significant. There is no significance between TVN and NPN and NPN and SSN but there is significance between column c1 and c2 (Table 36).

7.4.2.4. Wet salted Ribbonfish

The TVN, NPN and SSN content in all 4 lots had similar results as in wet salted mackerel (Figure – 7.7). There is no significance between TVN and NPN and NPN and SSN ($P < 0.001$). There is significance between column c1 and c2 but no significance between c2 and c3. The salting hour effects are significant ($p < 0.01$) in lot 1 and in lot 2 ($p < 0.05$) and in lots 3 and 4 ($p < 0.001$) (Table 37 – 40).

The changes during drying in all four lots showed that the results are similar as ported earlier in wet salted mackerel except in lot three where NPN content increased (Table - 7.2). In lot one, TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significance between TVN and NPN and but there is significance between NPN and SSN column c1 and c2 and drying hour effects are not significant (Table 41). In lots two and three, Column effects are significant ($p < 0.01$). There is no significance between TVN and NPN but there is significance between NPN and SSN column c1 and c2 and drying hour effects are not significant (Table 42 - 43). In lot 4, TVN, NPN and SSN effects are significant ($p < 0.001$). There is no significance between TVN and NPN and NPN and SSN but there is significance between column c1 and c2 and drying hour effects are not significant (Table - 44).

The TVN, NPN and SSN content of unpacked lots 1, packed lots 2, refrigerator stored lots 3, and cold storage lots 4 had almost similar results as in wet salted mackerel during the above storage conditions (Figure – 7.8). TVN, NPN and SSN effects are significant ($p < 0.001$) but storage period effects are not significant. There is no significance between TVN and NPN but there is significance between NPN and SSN and column c1 and c2 and c2 and c3 in four lots during storage (Table 45 - 48).

7.4.2.5. Dry salted Shark

TVN, NPN and SSN content of fresh fish were 86.94 mg, 40.96 gm and 68.03 mg / 100gm respectively. In all 4 lots, the results of TVN, NPN and SSN are similar as in dry salted mackerel except slight changes as noted in Figure – 7.9. TVN, NPN and SSN effects and salting hour effects are significant ($p < 0.001$) in lot one. There is significance between TVN and NPN and NPN and SSN and there is significance between column c1 and c2 and c2 and c3 in four lots during salting but it decreases as salting time advances (Table 49 - 52).

TVN content in all four lots during drying decreased than salted fish. The NPN content increased in lot 1, 3 and 4 but decreased in lot two. The SSN content increased initially then decreased in lot one and three, but decreased during drying in lot two and increased in lot four (Table – 7.3). There is no significance between drying hours and between TVN, NPN and SSN effects in lot 1 to 3 and in lot 4, there is significant difference between columns ($p < 0.05$) but between drying hours are not significant (Table 53 – 56).

TVN content in unpacked lots one increased to 0.62% initially but decreased as storage period increased, NPN content was 11.52% more but decreased subsequently followed by an increase and SSN content increased than dried fish. TVN, NPN and SSN effects are significant ($p < 0.05$) but storage period effects are not significant. There is no significance between TVN and NPN but there is significance between NPN and SSN and column c1 and c2 and c2 and c3 (Table 57). The TVN content in packed lots two decreased as the period increased, the NPN content was 11.11% less initially followed by an increase of 5.82 and 8.29%. SSN content was 5.49, 18.58 and 20.54% more in the same storage periods. TVN, NPN and SSN effects are significant ($p < 0.01$) but storage period effects are not significant. There is no significance between TVN and NPN but there is significance between NPN and SSN (Table 58). TVN content in refrigerator lots 3, increased to 12.22% initially but decreased as storage period increased, NPN content was 8.05% less initially followed by an increase of 1.23% and a further drop. SSN content increased up to one to three months and decreased by 3.39% in 4th month. TVN content in cold storage lot four decreased initially 39.99 and 22.16% in two months but increased by 7.07% in 3rd month followed by a decrease of 2.85% in 4th month. NPN content decreased and SSN content was more up to one to three months then decreased by 6.88% in 4th month (Figure – 7.10). TVN, NPN and SSN effects are significant ($p < 0.001$) but storage period effects are not significant. There is significance between TVN and NPN and NPN and SSN in lot three but NPN and SSN significant between and column c1 and c2 and c2 and c3 in lot four (Table 59 - 60).

7.2.6. Wet salted Shark

In all four lots, the results of TVN, NPN and SSN are similar as in wet salted mackerel except slight changes as noted in (Figure – 7.11). TVN, NPN and SSN effects ($p < 0.001$) and salting time effects are significant ($p < 0.05$). There is no significance between TVN and NPN and NPN and SSN and column c1 and c2 and there is significance between c2 and c3 (Table 61). In lot 2, the TVN, NPN and SSN effects ($p < 0.001$) and salting time effects are significant ($p < 0.001$). There is significance between TVN and NPN and NPN and SSN and column c1 and c2 and there is significance between c2 and c3 but no significance as salting time increases (Table 62). In lot three, and lot four, the TVN, NPN and SSN effects ($p < 0.001$) and salting time effects are significant ($p < 0.001$). There is no significance between TVN and NPN and NPN and SSN and column c1 and c2 and there is significance between c2 and c3 initially but no significance as salting time increases in lot three and four (Table 63 - 64).

The drying change in TVN in all four lots, were decreased than salted fish, The NPN content increased in lot 1, 2, 3, and 4. The SSN content increased in lot 1 and 4 and decreased in lot 2 and 3 (Table – 7.3). In lot one, TVN, NPN and SSN effects are significant ($p < 0.05$) and drying time effects are not significant. The TVN and NPN are not significant but NPN and SSN and column c1 and c2 are significant (Table 65). In lot two, the TVN, NPN and SSN effects are significant ($p < 0.01$) and drying time effects are not significant. TVN and NPN are not significant but NPN and SSN and column c1 and c2 are significant (Table 66). In lot three, the TVN, NPN and SSN effects are significant ($p < 0.001$) and drying time effects are not significant. The TVN and NPN are not significant but NPN and SSN and column c1 and c2 are significant (Table 67). In lot four, the TVN, NPN and SSN effects are significant ($p < 0.05$) and drying time effects are also nificant ($p < 0.001$). The TVN and NPN and NPN and SSN are not significant and also umn c1 and c2 are not significant (Table 68).

The TVN, NPN and SSN content in unpacked lots one, decreased as storage iod increased. The TVN and NPN content in packed lots two, decreased as storage iod increased. SSN content was 26.41% more initially but decreased later than dried s. There is no significant difference between storage period and between TVN, NPN nd SSN in lots one and two (Table 69 - 70). The TVN content in refrigerator lots three reased initially for two month but decreased later. NPN content decreased in the orage period. And SSN content increased in one to four month. The TVN, NPN and SN effects are significant ($p < 0.05$) but storage period effects are not significant. There is significance between TVN and NPN and NPN and SSN and also column c1 and c2 nd c2 and c3 (Table 71). The TVN content in cold storage lot four decreased 33.39% ially but increased 4.25% and decreased 33.14 and 39.01% in 4 month than packed eat, NPN content decreased and SSN content increased at the above storage (Figure 12). The TVN, NPN and SSN effects are significant ($p < 0.05$) and storage period ects are not significant. There is no significance between TVN and NPN, between PN and SSN and also column c1 and c2 and c2 and c3 (Table 72).

4.3. Urea content in Shark Meat during salting, drying and storage

4.3.1. Dry and wet salted Shark

The urea content of fresh shark was 766.36 mg / 100gm. The urea contents in y salted lot one showed a considerable decrease of 84.94, 82.69, 81.96 and 80.77% uring at 4, 8, 24 and 48 hours of salting fresh fish. In wet salted lot the reduction were 60, 33.22, 50.21 and 57.41% respectively during the same period than fresh shark. dry salted lot two, the urea content was 87.89, 83.28, 83.85 and 84.17% less and in wet lot 94.16, 83.79, 86.02 and 87.92% less in the same salting hours. In dry salted lot ree, urea was 87.77, 88.51, 76.43 and 77.22% less and in wet lot the reduction was

:39, 80.52, 87.47 and 89.07%. In dry lot four, it was 84.43, 85.29, 71.76 and 78.65% ss and in wet lot 82.50, 74.52, 77.96 and 84.09% less than fresh shark (Figure – 7.13). r dry salted fish, the urea effects and salting time effects are significant ($p < 0.001$). ere is significance between lot one and two initially and no significance as salting time reases. There is no significance between lot two and three and there is significance tween lot three and four. Also there is no significance between column c1 and c2 but ere is significance between c2 and c3 and c3 and c4 initially but no significance as lting time advances (Table 73). In wet salted fish, the urea effects and salting time fects are significant ($p < 0.001$). There is no significance between lot one and two. ere is significance between lot two and three and there is no significance between lot ree and four. Also there is no significance between column c1 and c2 but there is gnificance between c2 and c3 and c3 and c4 initially but no significance as salting time vances (Table 74).

During drying, the urea in dry and wet lot one and two increased salted shark. In y lot three, urea was 19.18% more and 10.71% less from the initial level. In wet lot ey were 5.86 and 5.33% respectively during four and eight hours (noon and evening) drying. In dry lot four there was a decrease of 1.26 % followed by an increase of .36% during the same period (Table – 7.3). In both dry and wet salted shark, there is gnificant difference between urea effects ($p < 0.001$) but drying time effects are not gnificant. There is significance between lot 1 and 2, lot 2 and 3 and lot 3 and 4 and no gnificance between columns (Table 75 – 76).

The urea contents in unpacked dry lot one were 4.42 and 10.96% more and .01% less after 10, 20, and 30 days of storage than dried shark. The packed dry lot o had 66.16, 52.42% more and 16.77% less and in all wet salted lots there was an crease in urea in the respective storage times. In both dry and wet salted shark, there s no significant difference between urea and between storage period effects in lot one lot two (Table 77 – 78). The refrigerator stored dry lot three had 19.27% less and 15.91 and 32.52 and 26.15% more at one to four month. The cold storage stored dry lot four, had 13.75, 24.14, 16.74 and 11.62% more and in all wet salted lots there was an increase in urea level in all the storage periods up to four months (Figure – 7.14). In dry salted shark, there is no significant difference between urea but storage period effects are significant ($p < 0.05$) in lot three and four (Table 79). In wet salted shark, there is no significant difference between urea but storage period effects are significant ($p < 0.001$) in lot three and 4 (Table 80).

7.5. Discussion

The fresh fish have all the protein constituents from which various nitrogen compounds are derived or deviated to form simple constituents. According to Cutting (1961) and Daun (1975) the loss of protein was inevitable during processing. The fall of nutrients extend during salting and cause the loss of weight. Ragulin (1958) stated that during salting, a part of nitrogen and fat dissolve in salt solution and the degree of loss is dependent on the temperature. The fish at fresh condition have much nutrient and minerals but processing changes its structure and value. Protein undergoes proteolysis and Sikorski *et al.* (1995) and Kleimannov *et al.* (1958) reported that the total nitrogen content decreased as storage time increased. Gopakumar & Devadasan (1983) reported the total protein content of fresh mackerel as 18 – 20, ribbonfish 20 – 22 and shark 20 – 22% and the results agrees with them. Opstvedt (1988) stated that the sun drying for long period cause a slow but only slight, lowering of digestibility due to protein damage.

TVN content in dry salted mackerel lot one and four have an increase in four hours. But no such increase was noted in other lots. The value decreased as salting time increase. But in wet salted lots there is a sharp decrease in TVN content initially but little increase was noted as the salting time increase. But in dry and wet salted ribbonfish there is no increase of TVN initially and latter stage. In both cases, it decrease gradually the decrease was more in dry salted fish than wet salted fish. The TVN was more in 1 & 4 of the dry salted shark and 3 and 4 of the wet salted shark at initial four hours then reduced as in other lots. The decrease of TVN depends on the concentration of servative also. Mathew & Raghunath (1996) reported that TVN reduced during ng. The wet salted fish had less TVN content than fresh fish in control lot in some se. TVN had similar trend in wet and dry salted shark and this may be due to the cut rtion. The initial increase in TVN content during salting may be attributed due to the gradation of TVN producing compounds at a faster rate during this period followed by e leaching out of these compounds at later stages of salting.

TVN content increases in some lot were also due to the slow volatile nature of e substance and also due to the sudden moisture fall during salting. The salt intake as fast in dry and wet salted lot yet dissolving of TVN will be easier in brine solution. e loss of TVN in dry salted shark was high than dry salted mackerel and ribbonfish ecause the cut portion of the shark was more than other fishes as reported by andoran *et al.* (1965) and agrees with present result. Further Mathew & Raghunath 996) reported that the loss of proteinous compound were more during curing mackerel rine and at higher rate when the fish was gutted.

During drying, it was observed that all lots decreased in TVN up to noon and vening. The results in unpacked lots 1 showed that all lot except in dry salted mackerel nd wet and dry salted ribbonfish increased in TVN content initially but decreased latter s the moisture content decreased. Joseph *et al.* (1986) reported that TVN content creased with moisture. Basu *et al.* (1989) reported TVN content of various dried fishes nd the value ranges between 238.3 and 299.2 mg / 100gm. But samples had low value ue to the higher relative humidity of room condition. In packed lots 2, TVN content ecreased initially and increased as storage period increased in dry salted mackerel, it creased for 20 days and decreased in wet salted mackerel and dry salted ribbonfish.

TVN content increased initially but decreased after 20 days in wet salted ribbonfish. TVN content in shark showed that it decreased as storage period increased in dry wet salted shark. Balachandran & Muraleedharan (1975) in mackerel, Nair & akumar (1986) in Jew fish and threadfin bream and Nair *et al.* (1994) in shark rted that TVN content increased as the storage period increased in samples stored ambient temperature. Kalaimani *et al.* (1984 & 1988) reported similar results. nasan & Joseph (1966) suggested the acceptable level of TVN as 200 mg / 100 gm uscle. These products had less than the limit. Prasad & Rao (1994) narrated that d fish undergoes considerable amount of biochemical deterioration and need to store fish at 10^0 C.

In refrigerator stored lot 3, the TVN content was less initially than the packed s but increased as storage period increased in dry and wet salted mackerel and wet ated ribbonfish. But the values increased initially and decreased subsequently as orage period increased in dry salted ribbonfish and dry and wet salted shark. The cold orage stored lots four, showed that TVN content values remained the same for two onths and increased and decreased subsequently in dry salted mackerel and dry and et salted ribbonfish. The value decreased initially for three months then increased at 4th onth in wet salted mackerel and dry salted shark. But it decreased initially and creased subsequently followed by a decrease as storage period increased in wet alted shark. The results show that the TVN content of the protein molecules degraded nd proteolysis process continued in the product during the storage period. The creased initial value may be the preparatory operation of proteolysis. The decrease of VN value during storage shows that it was converted into other complex compounds.

The NPN content increased initially for four hours in all except in lot three of the y salted mackerel. The increase is highly pronounced in lot two. It decreased as salting eriod increased than fresh fish. The percentage increase of NPN content decreased as oncentration of preservative increased. The wet salted mackerel showed that it reased right from initial period of salting and the loss was high. In dry salted onfish, NPN content increased twice more than fresh fish in control lot 1 in initial four urs. But the level of increase, decreased in preservative added lots as the centration of preservative increased. NPN content decreased as the salting time creased. In wet salted ribbonfish, the increase of NPN content at initial stage is less n dry salting. NPN content is more in control lot but no specific increase in NPN was ted as the concentration of preservative increased. In both case the NPN content creased as salting period increased. In shark, NPN content does not increase in the ial four hours of salting both in dry and wet salting and decreased right from the initial final stage. The loss is more as the concentration of preservative increased in dry and et salting. NPN decrease as salt intake increases and agrees with Sankar & Solanki 992) and Mrochkov, (1958). The increase of values of NPN during the initial stage in y salted fish may be due to decrease in moisture. Further the skin works as barrier to fuse the NPN in the solution, in the case of mackerel and ribbonfish. The more cut rtion in the dry and wet salted shark cause more leach out of NPN. This is against the ove observation of dry salted mackerel and ribbonfish where skin works as a barrier. ankar & Solanki (1992) reported that NPN is soluble in salt fastly at higher temperature.

The dry salted mackerel showed that the NPN content decreased during drying t in wet salted mackerel it increased due to drying in some cases. The NPN content creased in dry salted ribbonfish except in 4[th] lot. In wet salted ribbonfish it increased or creased in certain cases. Trend is the same with dry and wet salted shark. The drying ocess is only to reduce moisture content through a simple and easy method. The initial oisture content and heat from sunlight are important factors. Valsan (1976) reported at the nitrogenous content of fresh fish and sun-dried fish products are almost equal.

s showed that sun drying caused moisture loss and NPN content increased. Result wed that the increase or decrease of NPN is very little.

The unpacked stored lot one showed that NPN content increased initially and creased subsequently in dry salted mackerel. NPN content was without much change ially followed by a decrease on 30th day in wet salted mackerel, dry and wet salted onfish. In dry salted shark lot the value increased followed by a decrease and sequent increase. In wet salted shark lot, it decreased as the storage period reased. The packed lots two, showed that the NPN content did not have steady ange, either it increased or decreased than packed fish in dry salted mackerel, wet ted ribbonfish and dry salted shark. But it increased for 10 or 20 days then decreased wet salted mackerel and dry salted ribbonfish. But it decreased in wet salted shark as e storage period increased.

The refrigerator stored lot three, showed that it had NPN less than dried product to two months and increased in third month and decreased in 4th month in dry and et salted mackerel. NPN content decreased as storage period increased in dry and wet ted ribbonfish and dry and wet salted shark. The cold storage stored lots four, showed at NPN content it is less than packed fish for initial two months and increased in 3rd onth then decreased in dry salted mackerel. But it was more than packed fish in wet ted mackerel. The NPN content was more than packed fish for two month then creased in 3rd month in dry salted ribbonfish. The NPN content decreased as storage riod increased in wet salted ribbonfish and dry and wet salted shark. It is assumed m the results that the low temperature may keep the nutrient unreactive for a certain riod and the reaction continue to increase as the storage period increase.

The results showed that SSN content was more at initial four hours of dry salting dry salted mackerel, the increase was high in lot one and two but the increase was s in lot three and four. The SSN content decreased as the salting period increased fer four hours and also depends on the concentration of preservative. The SSN content was more in control lot than other lots and the lowest value was noted in lot four. But these results are not available in wet salted lots either in control or in preservative added lots. The SSN content in wet salted mackerel showed that the control lot had more SSN than preservative added lots and the lower value was observed in lot three. The dry salted ribbonfish showed that SSN content decreased regularly as in dry salted mackerel. Lowest value was noted in lot three and more in control lot. But lots two and four had similar results at the end of salting time. The result of wet salted ribbonfish was similar with wet salted mackerel and lowest value was in lot four. The result of dry and wet salted shark was similar with wet salted mackerel. Only, lot one of the wet salted shark increased in SSN as in dry salted mackerel. SSN content decreased as the salting time increased and findings agrees with Krishnakumar *et al.* (1986), Jayasekaran & Saralaya (1991) in sardine during chilled sea water storage and Sankar & Solanki (1992) in shark and ray. The increase of SSN in initial stage was due to decrease of moisture and formation of complex sodium proteins (Tarr, 1960) in muscle. According to Tarr (1960) the protein chains react with sodium to ooze out the water molecule and cause swelling of protein, which depends on pH and salt. As the salt penetration increased the swelling of protein decreased and the quantity of protein decreased as described by Laveren & Legendre (1965). This action was more in control sample than preservative added sample.

During drying, all lot decreased in SSN content and this may be due the fact that evaporation and salting process continues during drying. The unpacked lot one showed that SSN content increased initially then decreased at 30 day in dry salted mackerel. But decreased as storage period increased in wet salted mackerel, dry and wet salted ribbonfish and wet salted shark. The SSN increased in 30 days storage in dry salted shark. The packed lot two, showed that it increased as storage period increased in dry ed mackerel and dry salted shark. But decreased as storage period increased in wet ed mackerel, dry and wet salted ribbonfish and it increased initially but decreased er in wet salted shark.

The refrigerator stored lot three, showed that SSN content was less than packed initially for two months then increased in 3rd month then decreased in dry salted ckerel and dry salted shark. The SSN content was less initially than packed fish and creased as storage period increased in wet salted mackerel, dry and wet salted onfish and it increased initially and decreased as storage period increased in wet ted shark. The cold storage stored lots 4, showed that it decreased initially for two nths and increased at 3rd month and then declined in dry and wet salted mackerel. e SSN content increased for two months but decreased at 3rd and 4th month in dry and et salted ribbonfish. The SSN content was more initially and decreased later in dry and et salted shark. The increase in SSN content in the initial stage was due to the oisture loss and the decrease during storage may be due to reaction of the same with odium chloride available in solid state. The reaction is limited to the low temperature. alette *et al.* (1968) reported that the sodium chloride reacts in solid state in meat.

Chari & Srinivasan (1980) reported that urea content of shark was 1.62 mg % e urea content in the present study is more. The results showed that all 4 dry salted lot creased in urea and agree with Kandoran *et al.* (1965). This showed that urea can be moved using dry salting. The result showed that the concentration of preservative ve no much effect. The wet salted lot showed that urea decreased as the salting time creased but the loss was less in control lot than other lots. The urea content decreased wet salted shark lot and agrees with Ramachandran & Solanki (1991). Urea content very low in lot 3 than other lot. It may be due to fast penetrative power of salt in meat nd extrude urea in the solution. The urea content in dry salted shark lot one increased to noon and evening and in lot two and three urea content increased till noon but reased at evening. In lot 4, urea decreased at noon but increased at evening. The content increased in all wet salted lot during drying. This is due to the moisture loss during drying.

The unpacked lots one showed that it increased slowly in dry salted shark and suddenly fall at 30th day. In wet salted shark, fast increase was noted and sudden fall was observed. The packed lot two showed the same character as above in dry salted lot but in wet salted lot it increased as the storage period increased. The refrigerator stored lot three, showed that urea content was less initially for two months and increased subsequently in dry salted shark. But in wet salted shark it increased as storage period increased. The cold storage stored lot four, showed that the urea content decreased initially for one month and increased a little subsequently in dry salted shark. In wet salted shark it increased as storage period increased and dropped at 4th month. This may be due to the more moisture content in the lot.

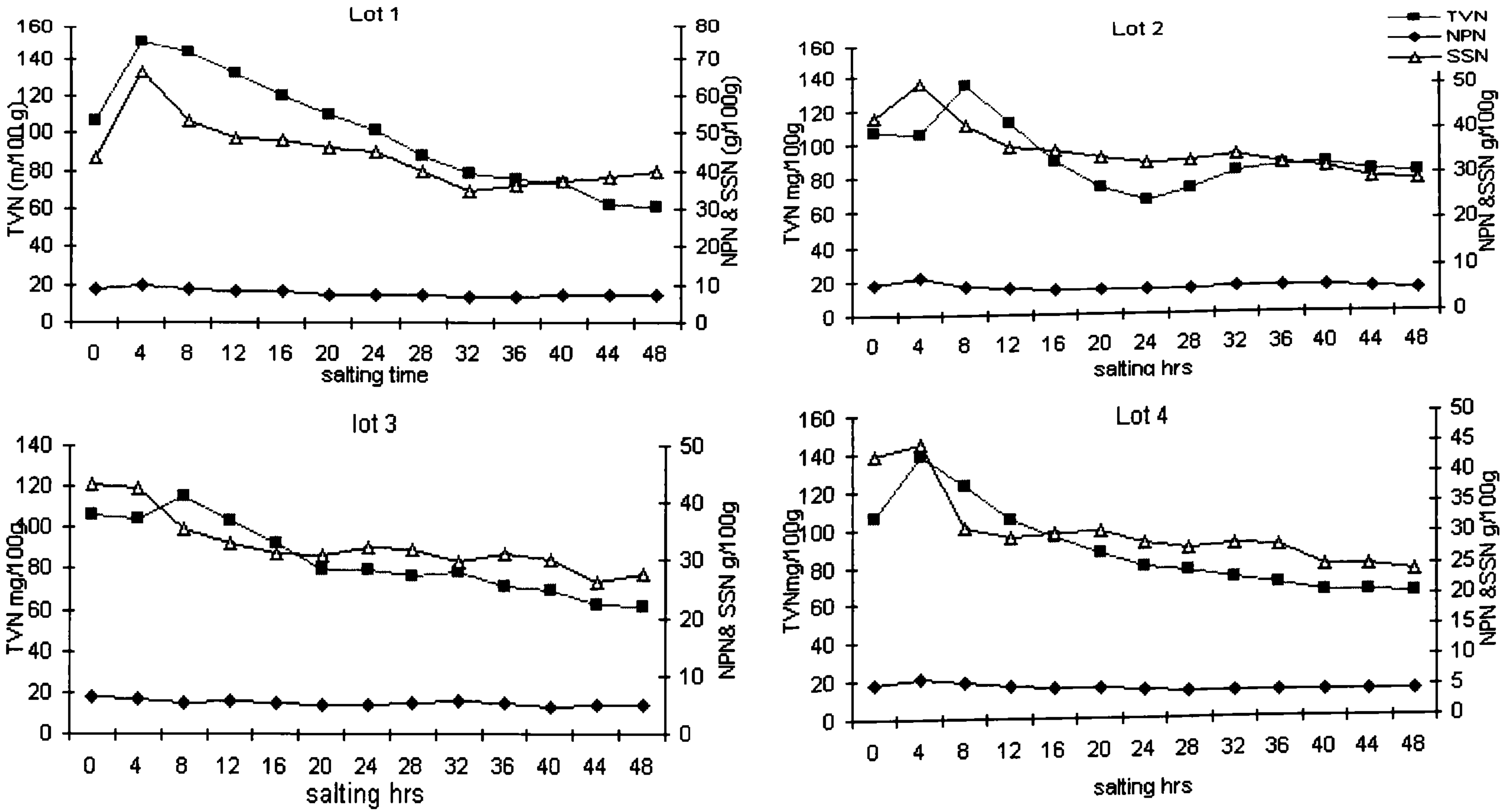

Figure. 7.1 Changes in TVN, NPN & SSN during dry salting of mackerel

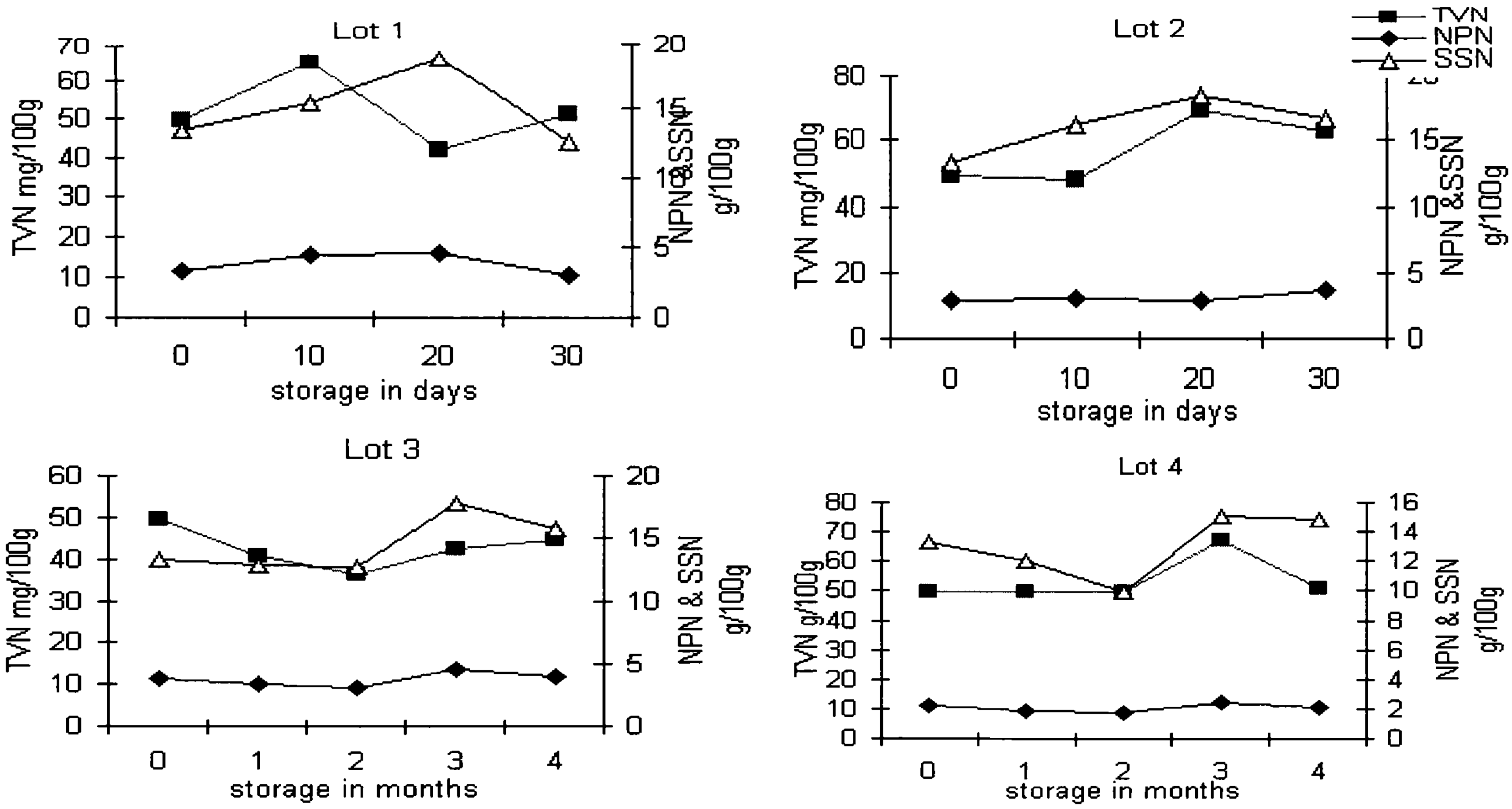

Figure 7. 2 Change in TVN, NPN & SSN in dry salted mackerel during storage

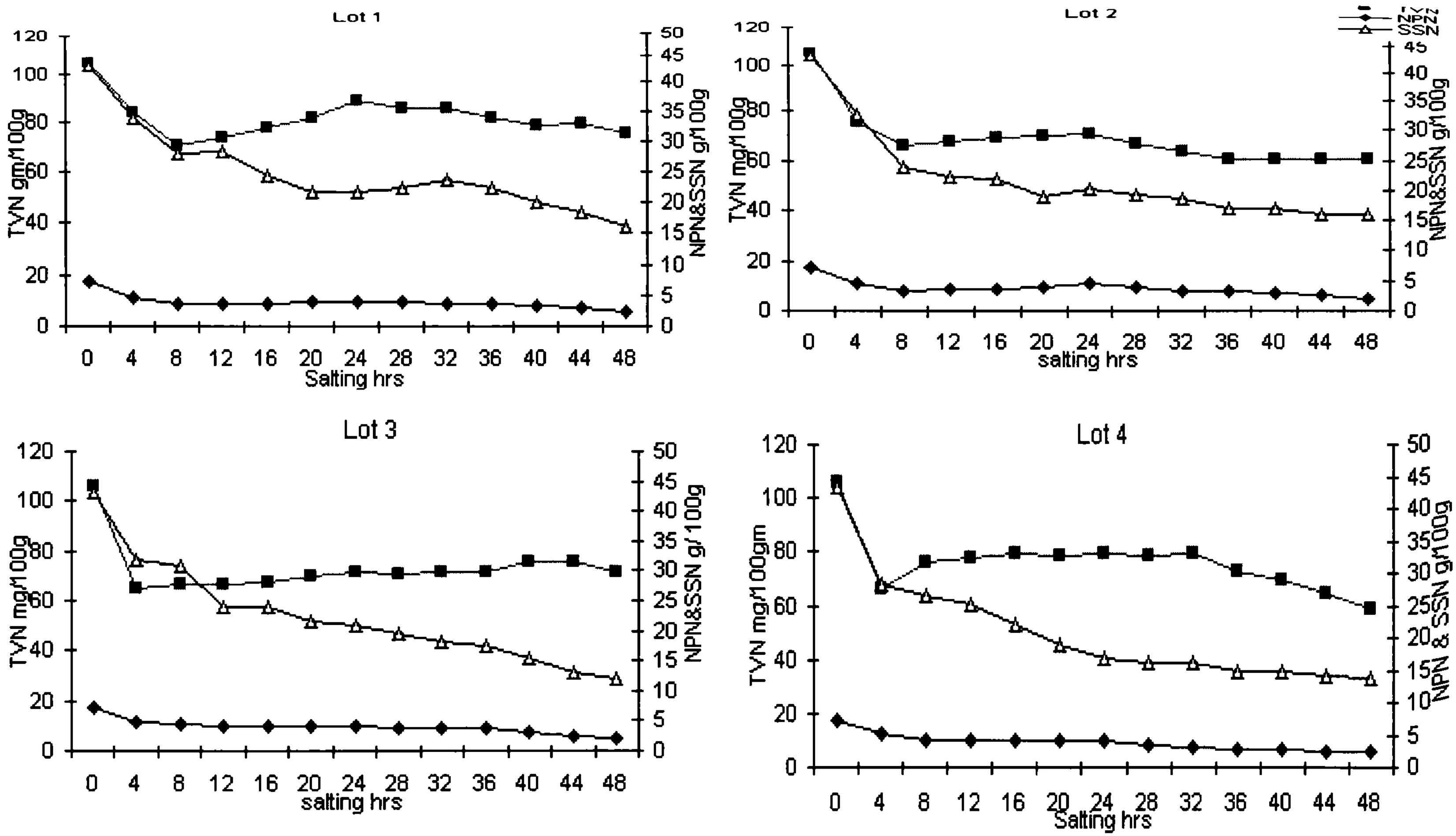

Figure 7. 3 Changes in TVN, NPN & SSN during wet salting of mackerel

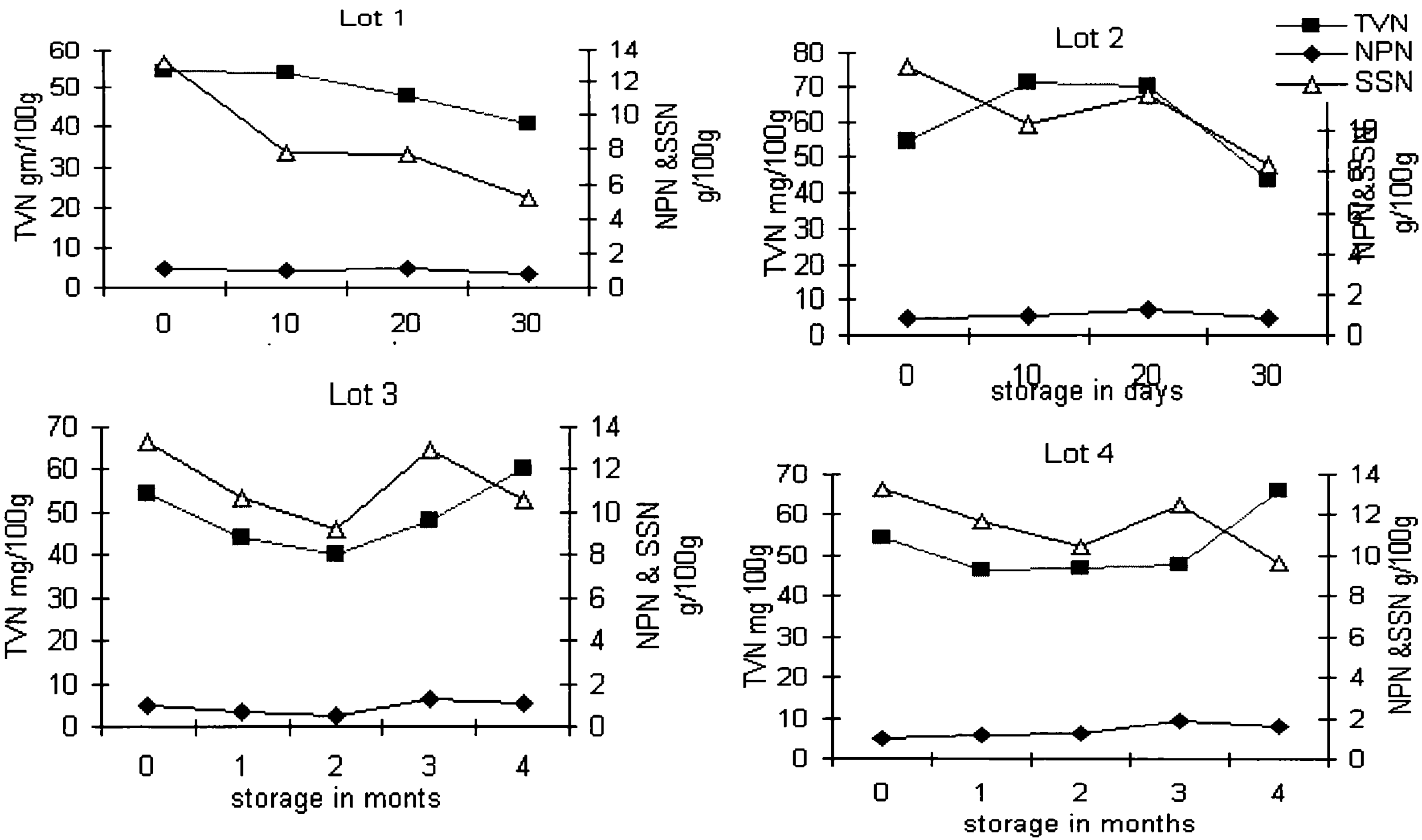

Figure 7. 4. Change in TVN, NPN & SSN in wet salted mackerel during storage

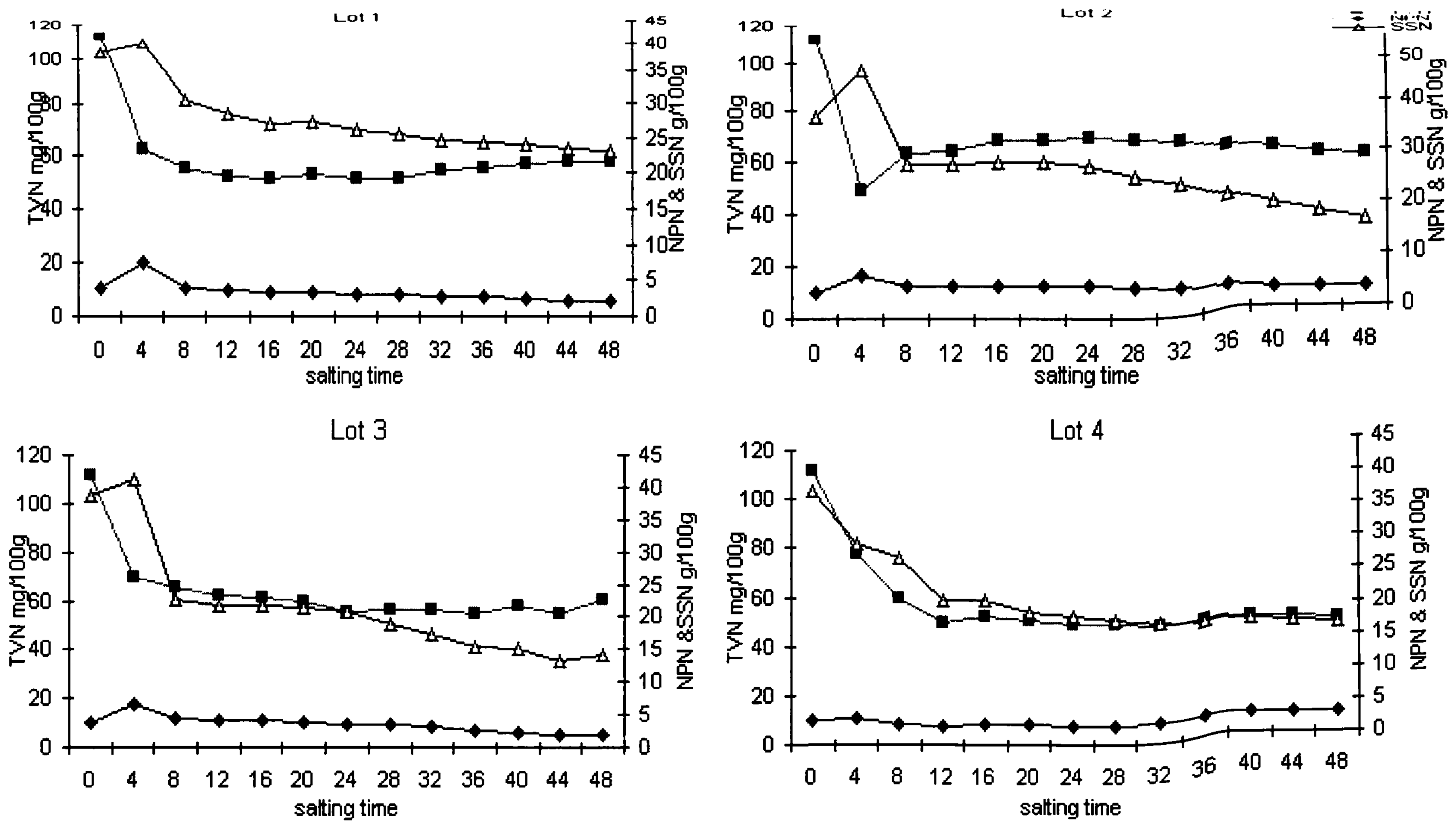

Figure 7. 5. Changes in TVN, NPN & SSN during dry salting of Ribbonfish

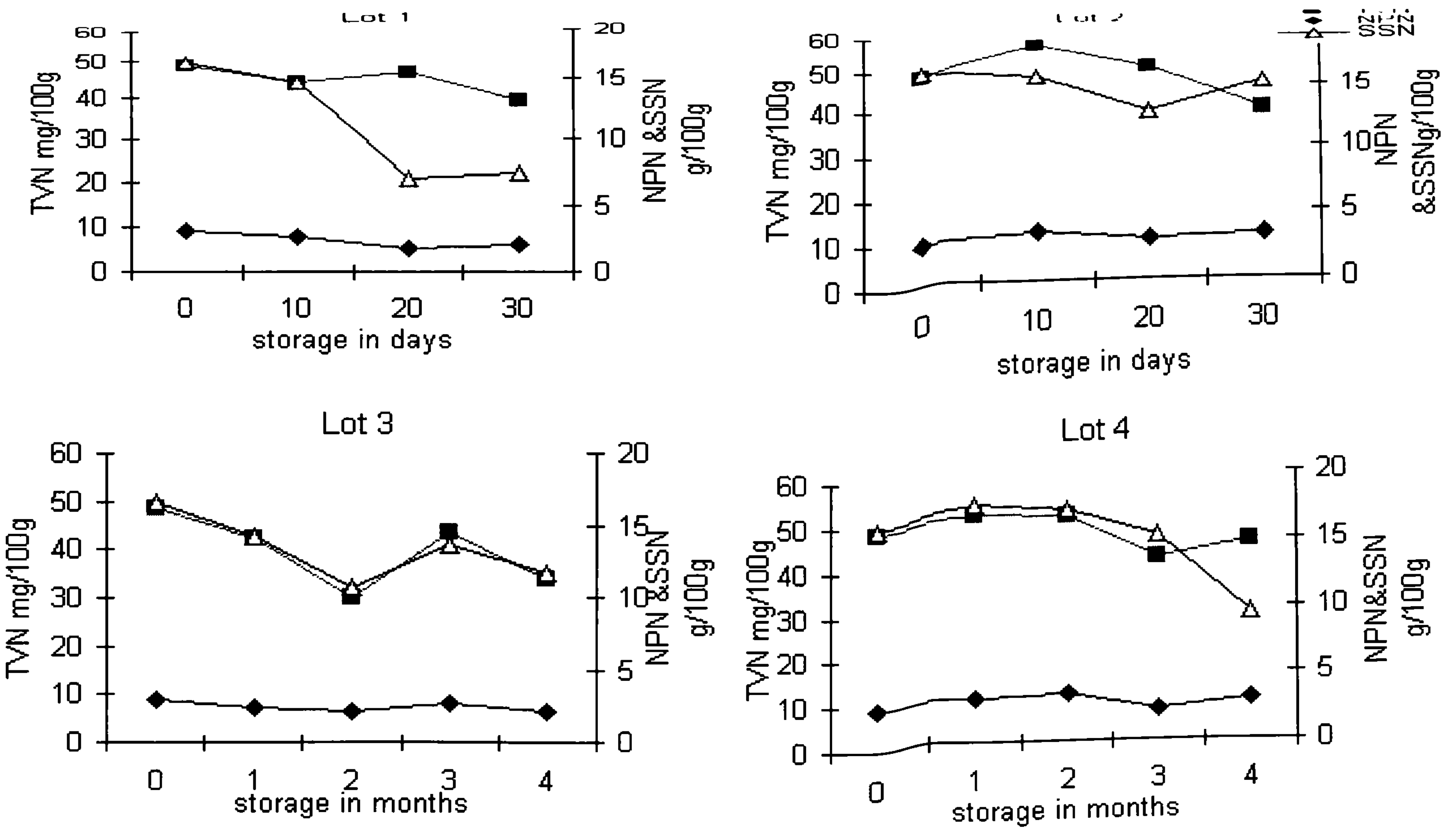

Figure 7. 6. Changes in TVN, NPN & SSN in dry salted Ribbonfish during storage

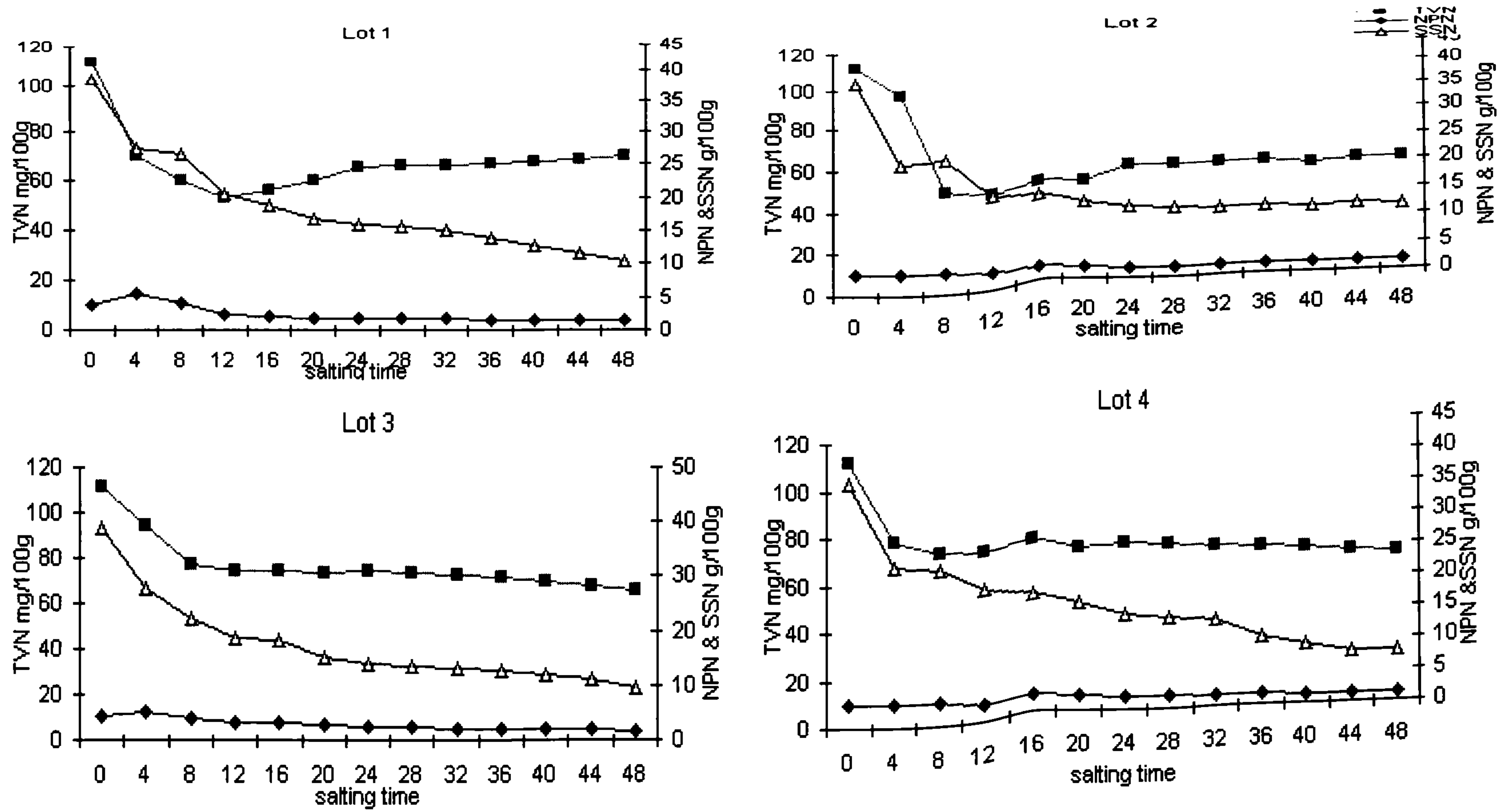

Figure 7.7. Change in TVN, NPN & SSN during wet salting of Ribbonfish

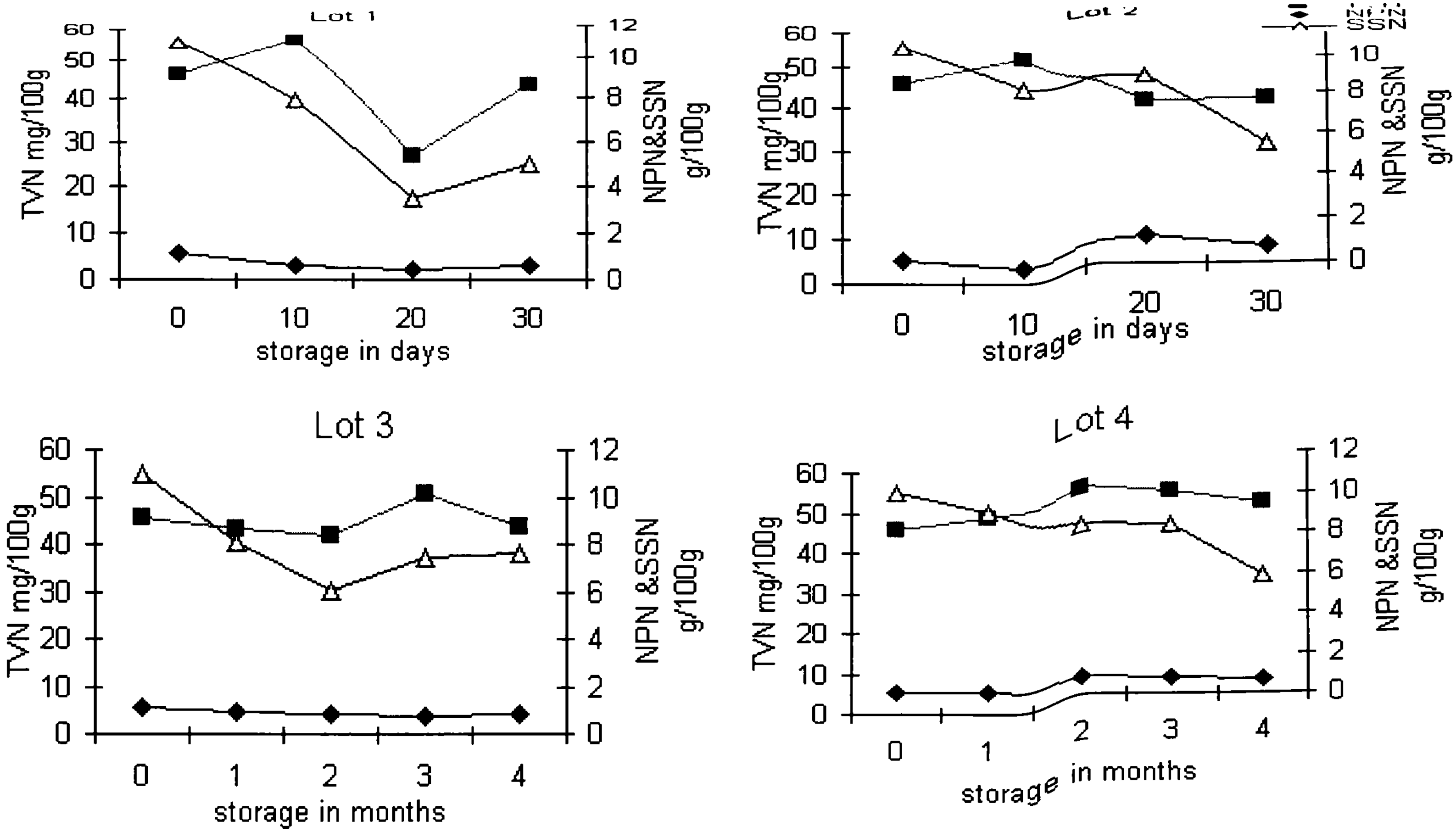

Figure 7.8. Change in TVN, NPN & SSN in wet salted Ribbonfish during storage

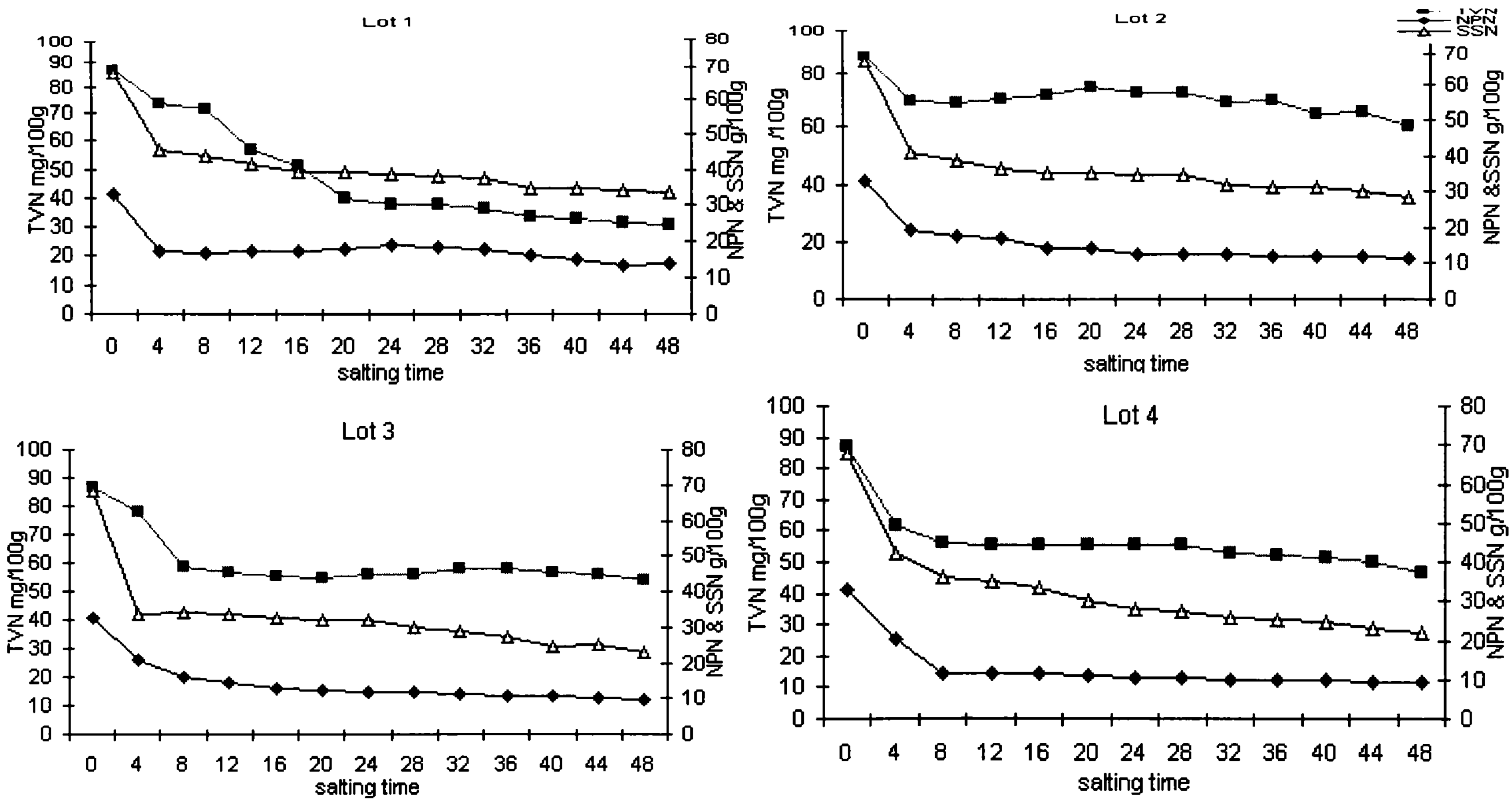

Figure 7.9. Change in TVN, NPN & SSN during dry salting of shark

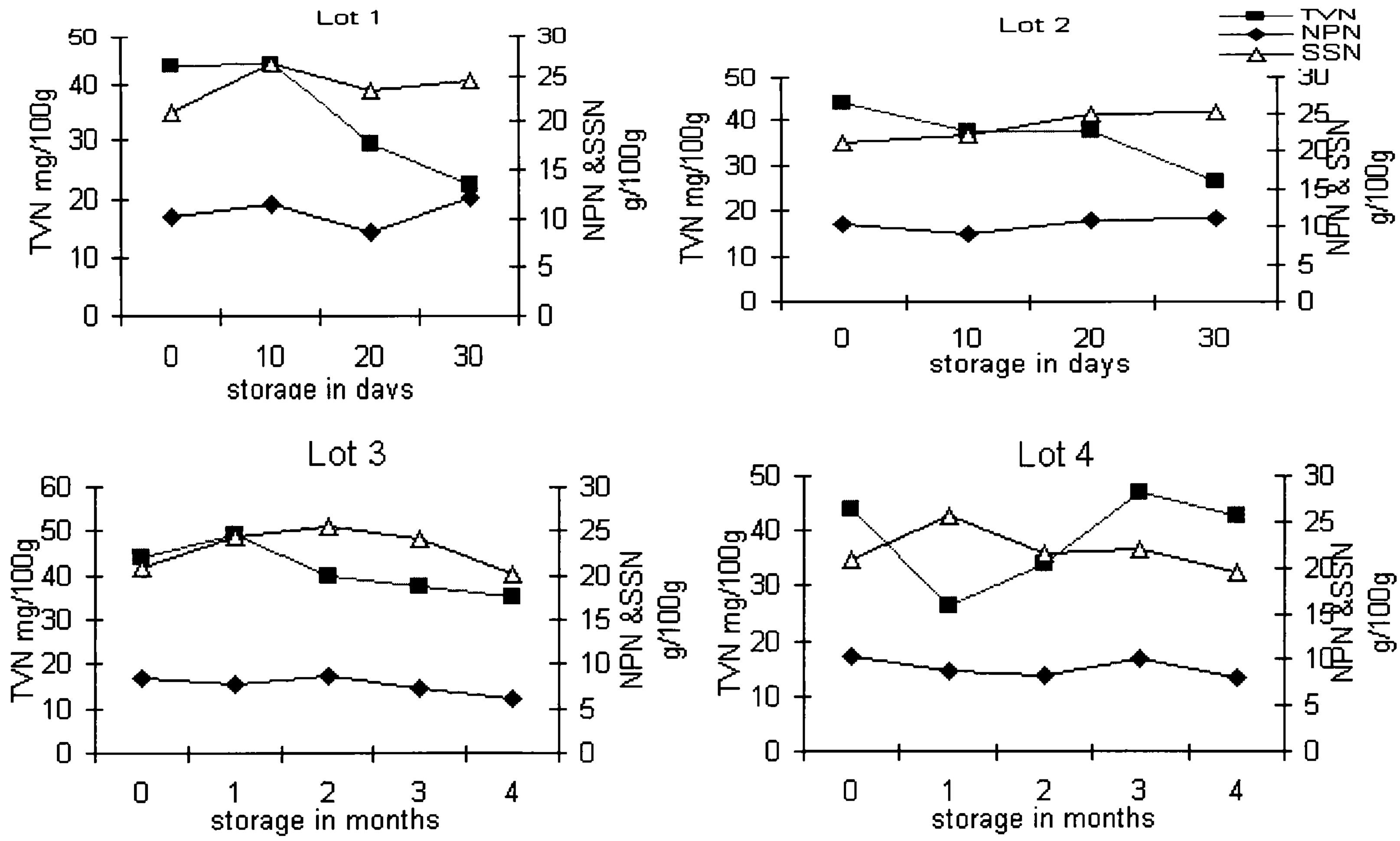

Figure 7.10. Change in TVN, NPN & SSN in dry salted shark during storage

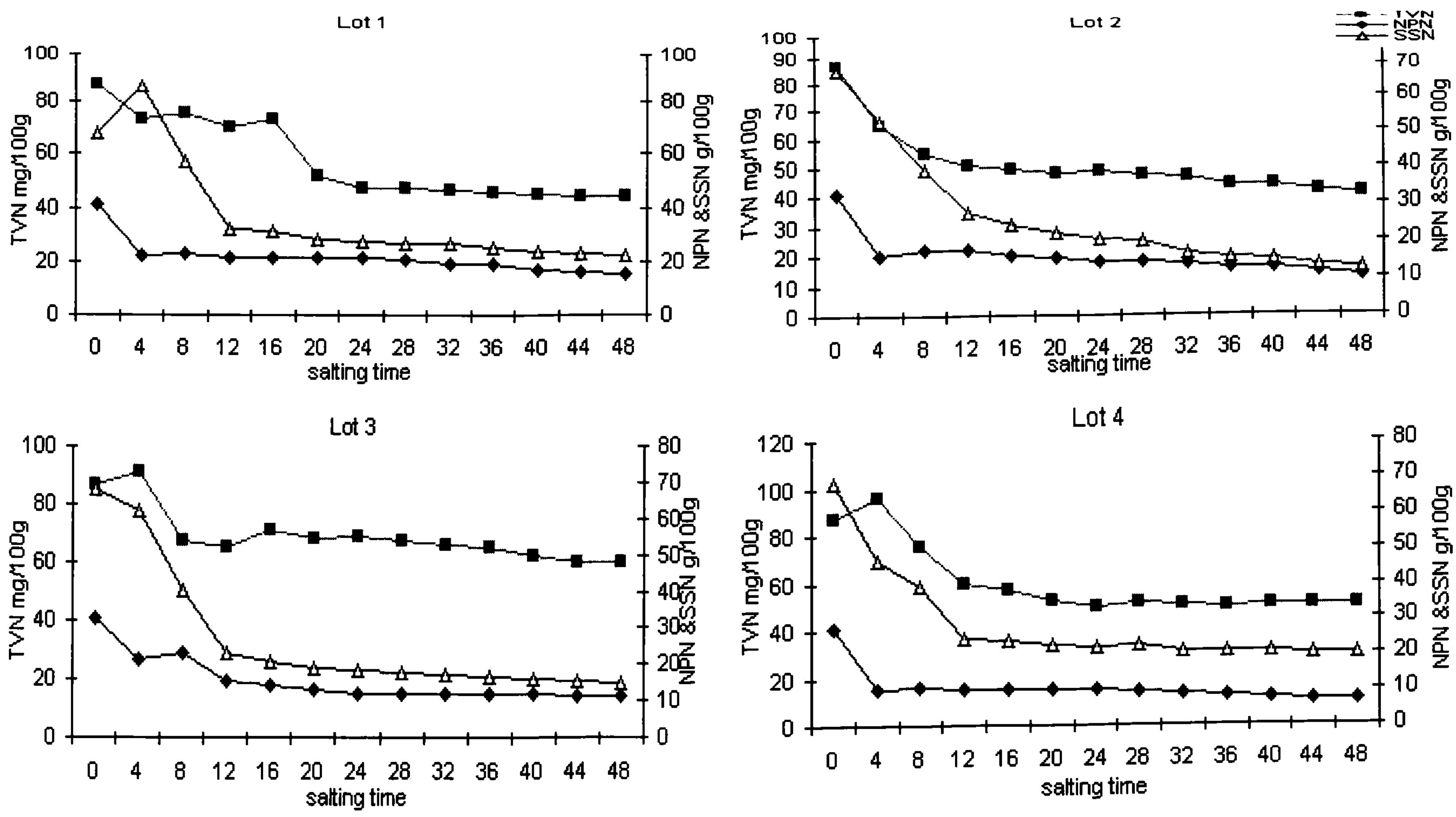

Figure 7. 11. Changes in TVN, NPN & SSN during wet salting of shark

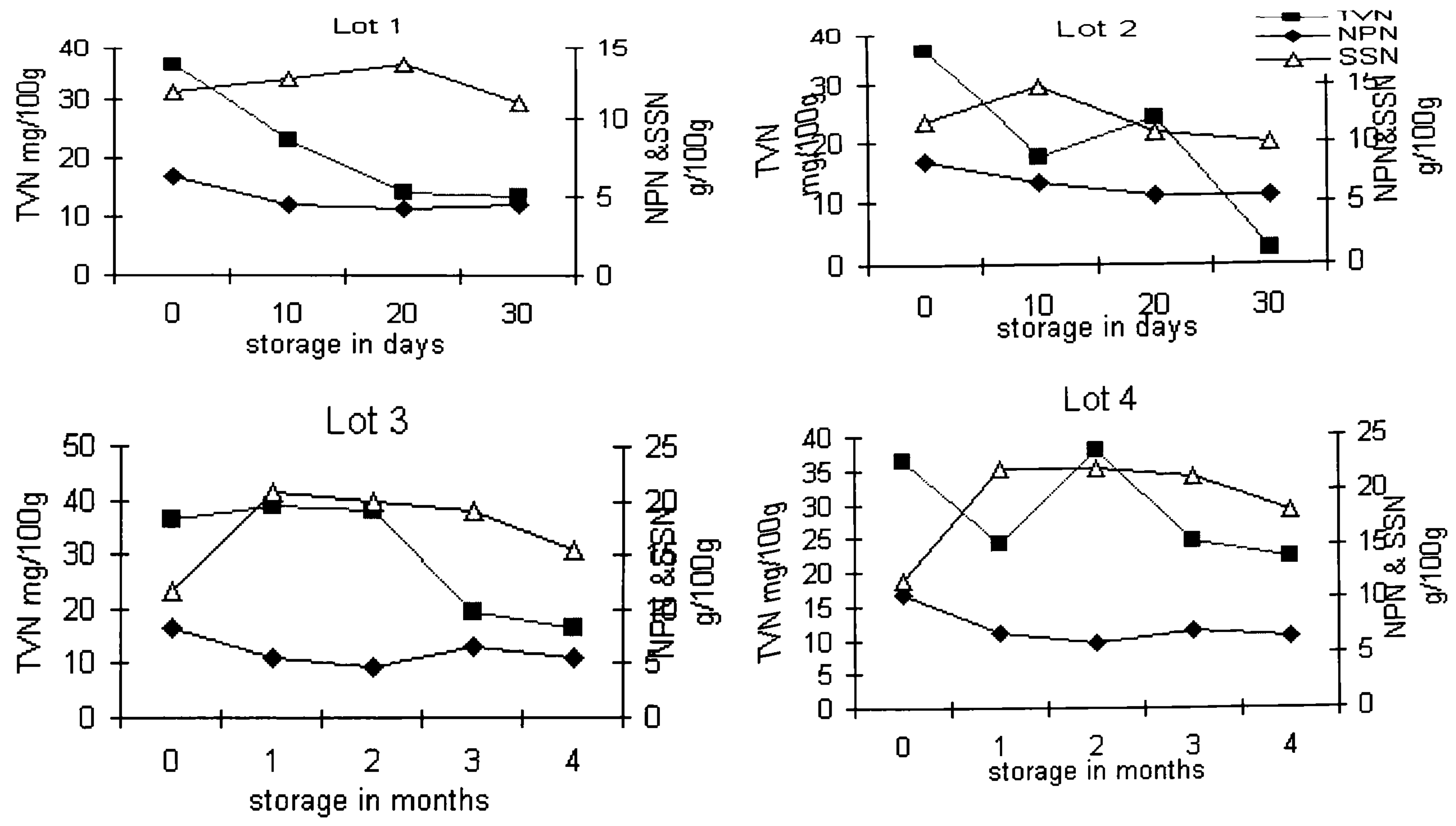

Figure 7.12. Change in TVN, NPN & SSN in wet salted shark during storage

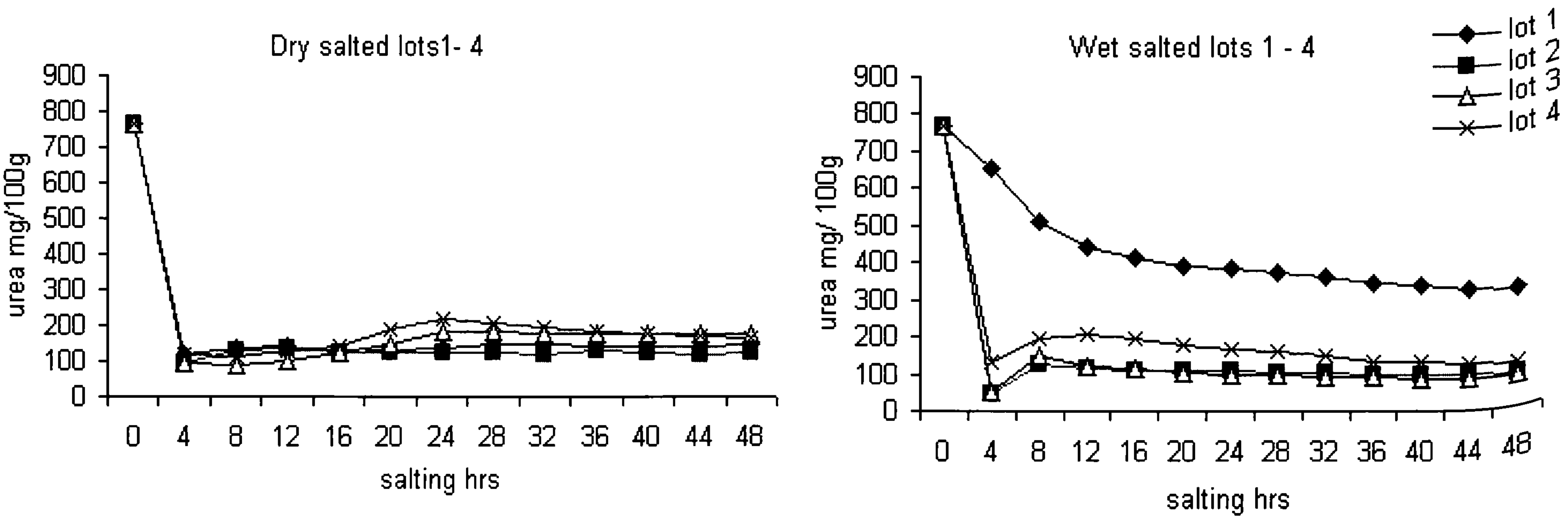

Figure 7.13. Change in urea during dry and wet salting of shark

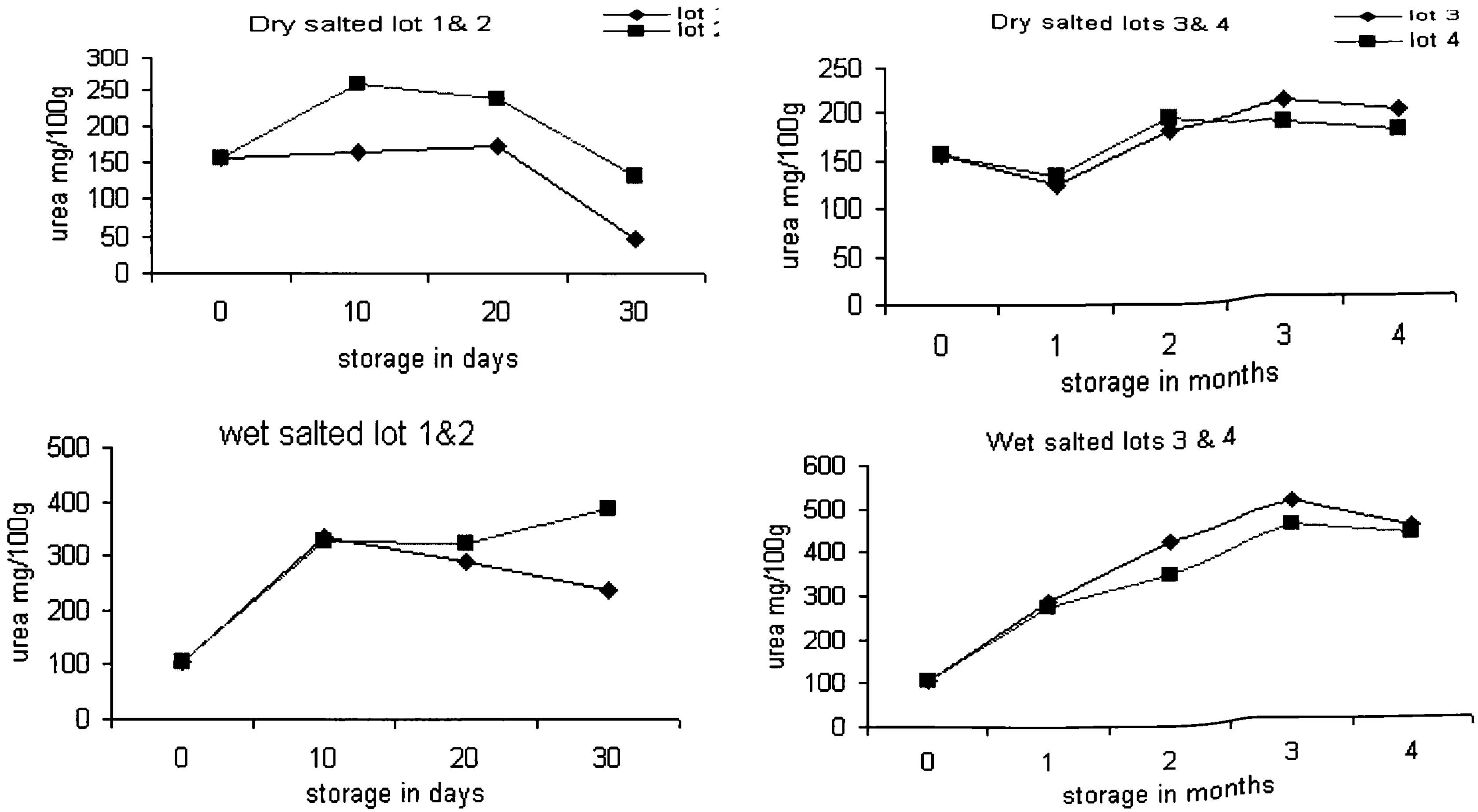

Figure 7.14. Change in urea in wet & dry salted shark during storage

	In Dry salted mackerel											
	Lot 1			Lot 2			Lot 3			Lot 4		
	TVN	NPN	SSN	TVN	NPN	SSN	TVN	NPN	SSN	TVN	NPN	SSN
0 Hours	61.21034	13.7553	39.8027	81.5497	13.58792	28.64121	61.81102	14.01112	27.60537	64.24317	13.53461	23.90635
After 4 hrs	63.17992	11.4953	25.7652	80.6901	12.2276	20.31881	48.69654	12.994	17.00611	49.25578	13.68978	19.60439
After 8 hrs	58.93074	10.0243	16.8692	74.4132	10.86957	16.25625	46.58031	11.35063	13.33461	50.809	11.94171	15.57532
	In Wet salted mackerel											
0 Hours	75.08805	5.82791	16.1081	60.3125	4.930437	15.86527	71.878	5.3074	11.81556	59.05678	5.631159	13.96058
After 4 hrs	59.95386	5.0519	14.5562	51.4286	5.910578	13.52236	62.15617	5.124224	12.48891	51.54024	7.834507	14.3319
After 8 hrs	61.40416	5.58318	13.9802	54.1832	4.819528	13.26935	53.74868	6.082365	11.573	47.6809	5.971114	12.6967

Table – 7.2.Effect of Sun Drying on TVN (m/100gm), NPN & SSN (gm/100gm) in Ribbonfish

	In Dry salted ribbon fish											
	Lot 1			Lot 2			Lot 3			Lot 4		
	TVN	NPN	SSN	TVN	NPN	SSN	TVN	NPN	SSN	TVN	NPN	SSN
0 Hours	57.8509	5.533006	22.96518	58.11829	7.35336	16.78465	60.12309	5.178268	14.28268	46.35309	7.936179	16.74264
After 4 hrs	52.8812	7.189179	21.08412	46.8583	8.3103	16.25207	54.76706	6.536656	13.01914	38.4181	8.832392	16.25235
After 8 hrs	51.2789	7.091198	20.79732	48.5051	8.95336	16.5575	52.38468	6.99911	13.4460	35.1873	8.021315	17.55834
	In Wet salted ribbon fish											
0 Hours	69.6511	3.488656	10.2464	54.2899	4.619897	11.8064	65.6051	3.935396	9.622384	62.79327	3.519256	7.772908
After 4 hrs	64.5888	3.079234	9.294029	51.31248	3.290183	8.719885	45.87574	4.229937	10.33363	47.97759	3.1341	7.245316
After 8 hrs	63.181	2.899324	6.848097	46.88904	3.750432	8.658832	45.812	4.197382	11.01222	49.89701	3.089598	7.43598

Table – 7.3.Effect of sun drying on TVN & Urea (m / 100g) & NPN SSN (g/100g) in Shark

Dry salted shark																
	Lot 1				Lot 2				Lot 3				Lot 4			
	TVN	NPN	SSN	Urea	TVN	NPN	SSN	Urea	TVN	NPN	SSN	Urea	TVN	NPN	SSN	Urea
0 Hours	30.461	17.8	33.845	147.35	60.37	14.175	28.21	121.31	53.67	11.703	22.99	174.52	46.91	11.76	22.04	163.66
After 4 hrs	31.582	20.056	34.4	318.25	34.99	11.576	27.47	281	48.97	14.03	23.107	208.01	47.88	12.92	22.84	161.59
After 8 hrs	28.677	22.241	31.037	378.14	25.59	9.318	25.13	157.83	43.86	14.968	20.931	155.83	43.72	12.99	22.55	259.16
Wet salted shark																
0 Hours	44.055	15.394	22.153	322.53	41.02	13.319	12.53	92.444	60.17	14.17	14.8	83.734	50.49	10.74	19.98	121.93
After 4 hrs	39.626	16.327	22.732	325.99	39.646	16.077	11.913	104.75	58.604	17.862	14.41	78.829	48.614	12.11	20.82	124.58
After 8 hrs	39.033	16.357	22.886	345.96	36.452	16.662	11.138	105.67	54.7	17.581	13.316	79.265	43.783	13.643	21.72	130.97

ble 1 Result on TVN, NPN & SSN in D.S. mackerel in lot 1.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	6194.651	12	516.2209	2.196671	0.048715	2.183377
olumns	47953.72	2	23976.86	102.0285	1.85E-12	3.402832
rror	5640.036	24	235.0015			
otal	59788.41	38				

ble 2 Result on TVN, NPN & SSN in D.S. mackerel in lot 2.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	2500.58302	12	208.3819	2.18192894	0.050142427	2.183377035
olumns	40313.0993	2	20156.55	211.055543	5.87785E-16	3.402831794
rror	2292.08474	24	95.50353			
otal	45105.767	38				

ble 3 Result on TVN, NPN & SSN in D.S. mackerel in lot 3

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	2077.02	12	173.085	2.112	0.0575	2.1834
olumns	34178.63	2	17089.3	208.53	7E-16	3.4028
rror	1966.848	24	81.952			
otal	38222.5	38				

ble 4 Result on TVN, NPN & SSN in D.S. mackerel in lot 4.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	3838.019	12	319.8349	2.20394	0.048026	2.183377
olumns	38835.88	2	19417.94	133.8064	9.66E-14	3.402832
rror	3482.871	24	145.1196			
otal	46156.77	38				

Table 5 Result on TVN, NPN & SSN in D.S. mackerel in lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	35.606	1	35.60561	5.05975	0.153416	18.51276
Columns	2813.5	2	1406.74	199.9054	0.004977	19.00003
Error	14.074	2	7.037028			
Total	2863.2	5				

Table 6 Result on TVN, NPN & SSN in D.S. mackerel in lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	22.80497	1	22.80496855	7.5156355	0.111282043	18.51276
Columns	5276.037	2	2638.0184	869.388821	0.001148912	19.00003
Error	6.068673	2	3.034336692			
Total	5304.91	5				

Table 7 Result on TVN, NPN & SSN in D.S. mackerel in lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	12.05388124	1	12.05388124	2.111703	0.283353	18.51276
Columns	1583.216233	2	791.6081167	138.6807	0.007159	19.00003
Error	11.41626689	2	5.708133445			
Total	1606.686382	5				

Table 8 Result on TVN, NPN & SSN in D.S. mackerel in lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.100643	1	0.100643	0.006488	0.943135	18.51276
Columns	1880.839	2	940.4196	60.62769	0.016226	19.00003
Error	31.02277	2	15.51139			
Total	1911.963	5				

ble 9 Result on TVN, NPN & SSN in D.S. mackerel in lot 1 on storage.

NOVA

ource of Variation	SS	df	MS	F	P-value	F crit
ows	110.391	3	36.797	1.009012	0.451368	4.757055
olumns	3752.714	2	1876.357	51.45165	0.000167	5.143249
rror	218.8101	6	36.46835			
tal	4081.915	11				

ble 10 Result on TVN, NPN & SSN in D.S. mackerel in lot 2 on storage

NOVA

ource of Variation	SS	df	MS	F	P-value	F crit
ows	147.7732306	3	49.25774354	1.689609	0.26740873	4.757055194
olumns	4961.82765	2	2480.913825	85.0988	3.9487E-05	5.143249382
rror	174.9200027	6	29.15333379			
tal	5284.520883	11				

ble 11 Result on TVN, NPN & SSN in D.S. mackerel in lot 3 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	69.18974	4	17.29744	2.312214	0.145517	3.837854
olumns	2991.235	2	1495.617	199.9248	1.48E-07	4.458968
rror	59.84719	8	7.480898			
tal	3120.272	14				

ble 12 Result on TVN, NPN & SSN in D.S. mackerel in lot 4 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	89.9027	4	22.47567	0.846381	0.533673	3.83785
olumns	6218.743	2	3109.372	117.0916	1.19E-06	4.45897
rror	212.4402	8	26.55503			
tal	6521.086	14				

13 Result on TVN, NPN & SSN in W.S. mackerel in lot 1.

VA

urce of Variation	SS	df	MS	F	P-value	F crit
s	973.118	11	88.46527	3.441055	0.006568	2.258517
mns	37173	2	18586.5	722.9635	8.57E-21	3.443361
r	565.5929	22	25.70877			
al	38711.71	35				

ble 14 Result on TVN, NPN & SSN in W.S. mackerel in lot 2

OVA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	1581.034977	12	131.752915	3.8664043	0.002336645	2.183377035
umns	30605.10734	2	15302.5537	449.066796	9.6607E-20	3.402831794
or	817.8322051	24	34.0763419			
al	33003.97452	38				

ble 15 Result on TVN, NPN & SSN in W.S. mackerel in lot 3.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	1496.2	12	124.6834	3.646393	0.003383	2.183377
umns	29276.52	2	14638.26	428.0992	1.69E-19	3.402832
or	820.6468	24	34.19361			
al	31593.37	38				

ble 16 Result on TVN, NPN & SSN in W.S. mackerel in lot 4.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	1837.822	12	153.1518	3.340276	0.00575	2.18338
umns	36001.95	2	18000.98	392.6054	4.63E-19	3.40283
or	1100.401	24	45.85005			
al	38940.18	38				

Table 17 Result on TVN, NPN & SSN in W.S. mackerel in lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.116667	1	0.116667	0.021364	0.897195	18.51276
Columns	3611.961	2	1805.981	330.7059	0.003015	19.00003
Error	10.92198	2	5.460988			
Total	3623	5				

Table 18 Result on TVN, NPN & SSN in W.S. mackerel in lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.331612556	1	0.33161256	0.162176277	0.726127697	18.51276465
Columns	2578.85039	2	1289.42519	630.5978882	0.001583286	19.00002644
Error	4.089532233	2	2.04476612			
Total	2583.271534	5				

Table 19 Result on TVN, NPN & SSN in W.S. mackerel in lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.699267	1	3.699267	0.206367	0.694169	18.51276
Columns	3168.594	2	1584.297	88.38151	0.011188	19.00003
Error	35.85133	2	17.92566			
Total	3208.145	5				

Table 20 Result on TVN, NPN & SSN in W.S. mackerel in lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.010792	1	0.010792	0.000406	0.985747	18.5128
Columns	6336.725	2	3168.362	119.2955	0.008313	19
Error	53.1179	2	26.55895			
Total	6389.853	5				

21 Result on TVN, NPN & SSN in W.S. mackerel in lot 1 on storage.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	94.76556	3	31.58852	3.29854	0.099484	4.757055
umns	4905.147	2	2452.573	256.1029	1.55E-06	5.143249
or	57.4591	6	9.576516			
al	5057.371	11				

ble 22 Result on TVN, NPN & SSN in W.S. mackerel in lot 2 on storage.

NOVA

ource of Variation	SS	df	MS	F	P-value	F crit
ows	232.0170443	3	77.33901476	1.470619	0.31399854	4.757055194
olumns	7086.170724	2	3543.085362	67.37257	7.7474E-05	5.143249382
rror	315.536611	6	52.58943517			
tal	7633.724379	11				

ble 23 Result on TVN, NPN & SSN in W.S. mackerel in lot 3 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	137.6976	4	34.4244	1.939707	0.197211	3.837854
olumns	5852.361	2	2926.18	164.8811	3.15E-07	4.458968
rror	141.9777	8	17.74722			
tal	6132.036	14				

ble 24 Result on TVN, NPN & SSN in W.S. mackerel in lot 4 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	89.9027	4	22.47567	0.846381	0.533673	3.83785
olumns	6218.743	2	3109.372	117.0916	1.19E-06	4.45897
rror	212.4402	8	26.55503			
tal	6521.086	14				

ble 25. Result on TVN, NPN & SSN in D.S. ribbonfish in lot 1.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
s	1931.401	12	160.9501	2.209565	0.0475	2.183377
umns	16753.51	2	8376.754	114.9982	5.07E-13	3.402832
r	1748.219	24	72.84246			
al	20433.13	38				

ble 26 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 2.

OVA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	1756.777081	12	146.39809	1.29087056	0.285764332	2.183377035
umns	21313.61309	2	10656.8065	93.96678483	4.44772E-12	3.402831794
or	2721.848551	24	113.410356			
al	25792.23872	38				

ble 27 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 3.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	2092.246	12	174.3538	2.429932	0.030951	2.183377
umns	20018.94	2	10009.47	139.4999	6.1E-14	3.402832
or	1722.061	24	71.75254			
al	23833.25	38				

ble 28 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 4.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	2549.505	12	212.4587	2.469945	0.028656	2.18338
umns	16225.65	2	8112.826	94.31587	4.28E-12	3.40283
or	2064.423	24	86.01762			
al	20839.58	38				

Table 29 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.170985	1	0.170985	0.071269	0.814505	18.51276
Columns	2157.481	2	1078.74	449.6352	0.002219	19.00003
Error	4.798292	2	2.399146			
Total	2162.45	5				

Table 30 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	9.882706446	1	9.88270645	3.520650388	0.201423864	18.51276465
Columns	1854.454733	2	927.227366	330.3187649	0.003018241	19.00002644
Error	5.614136796	2	2.8070684			
Total	1869.951576	5				

Table 31 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.064496	1	3.064496	7.775339	0.108146	18.51276
Columns	2769.768	2	1384.884	3513.773	0.000285	19.00003
Error	0.78826	2	0.39413			
Total	2773.62	5				

Table 32 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	51.98941	1	51.98941	1.576312	0.336099	18.5128
Columns	2671.006	2	1335.503	40.49227	0.024101	19
Error	65.96336	2	32.98168			
Total	2788.959	5				

33 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 1 on storage.

VA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	132.3843	3	44.12811	4.885428	0.047382	4.757055
umns	3497.934	2	1748.967	193.6283	3.55E-06	5.143249
r	54.19559	6	9.032598			
al	3684.514	11				

ble 34 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 2 on storage.

NOVA

urce of Variation	SS	df	MS	F	P-value	F crit
ows	79.43212669	3	26.47737556	1.312253	0.35429916	4.757055194
olumns	3683.468097	2	1841.734049	91.27871	3.222E-05	5.143249382
rror	121.0622292	6	20.17703819			
tal	3883.962453	11				

ble 35 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 3 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	210.379	4	52.59476	3.242187	0.073602	3.837854
olumns	3062.297	2	1531.148	94.38715	2.73E-06	4.458968
rror	129.776	8	16.222			
tal	3402.452	14				

ble 36 Result on TVN, NPN & SSN in D.S. ribbonfish in lot 4 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	97.16548	4	24.29137	3.53855	0.060457	3.837854
olumns	4297.848	2	2148.924	313.0361	2.53E-08	4.458968
rror	54.91824	8	6.86478			
tal	4449.932	14				

Table 37 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 1.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1993.33	12	166.1108	3.083223	0.009105	2.183377
Columns	28050.95	2	14025.48	260.3302	5.36E-17	3.402832
Error	1293.017	24	53.87571			
Total	31337.3	38				

Table 38 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3294.835016	12	274.569585	2.727552327	0.017558386	2.183377035
Columns	20733.8925	2	10366.9462	102.9844161	1.6692E-12	3.402831794
Error	2415.964661	24	100.665194			
Total	26444.69217	38				

Table 39 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2081.523	12	173.4602	5.991346	0.000101	2.183377
Columns	37084.85	2	18542.43	640.4587	1.5E-21	3.402832
Error	694.843	24	28.95179			
Total	39861.22	38				

Table 40 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2060.467	12	171.7056	5.348731	0.000242	2.18338
Columns	32921.14	2	16460.57	512.7566	2.04E-20	3.40283
Error	770.4507	24	32.10211			
Total	35752.06	38				

Table 41 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 1 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.847927	1	0.847927	0.76112	0.47497	18.51276
Columns	4705.592	2	2352.796	2111.927	0.000473	19.00003
Error	2.228103	2	1.114052			
Total	4708.668	5				

Table 42 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 2 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2.699084047	1	2.69908405	0.750570907	0.477622526	18.51276465
Columns	2491.585403	2	1245.7927	346.4344725	0.002878241	19.00002644
Error	7.192082775	2	3.59604139			
Total	2501.476569	5				

Table 43 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 3 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3.266392	1	3.266392	2.136152	0.281349	18.51276
Columns	1933.101	2	966.5503	632.1036	0.00158	19.00003
Error	3.058202	2	1.529101			
Total	1939.425	5				

Table 44 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 4 on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.944369	1	1.944369	5.953094	0.134826	18.5128
Columns	2461.501	2	1230.751	3768.201	0.000265	19
Error	0.65323	2	0.326615			
Total	2464.099	5				

ble 45 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 1 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	242.4964	3	80.83213	2.018148	0.212943	4.757055
lumns	3897.644	2	1948.822	48.65653	0.000196	5.143249
rror	240.3158	6	40.05263			
tal	4380.456	11				

ble 46 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 2 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	67.61913996	3	22.53971332	1.373518	0.33797169	4.757055194
lumns	3714.576368	2	1857.288184	113.1788	1.7218E-05	5.143249382
rror	98.46123357	6	16.41020559			
tal	3880.656742	11				

ble 47 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 3 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	34.06964	4	8.517411	1.996822	0.187997	3.837854
lumns	5169.353	2	2584.677	605.9518	1.85E-09	4.458968
rror	34.12386	8	4.265483			
tal	5237.547	14				

ble 48 Result on TVN, NPN & SSN in W.S. ribbonfish in lot 4 on storage.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	15.34549	4	3.836371	1.738858	0.234195	3.837854
lumns	6038.092	2	3019.046	1368.401	7.22E-11	4.458968
rror	17.65007	8	2.206259			
tal	6071.088	14				

Table 49 Result on TVN, NPN & SSN in D.S. shark in lot 1.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4258.673	12	354.8894	3.511808	0.004262	2.183377
Columns	4805.918	2	2402.959	23.77848	2.03E-06	3.402832
Error	2425.345	24	101.056			
Total	11489.94	38				

Table 50 Result on TVN, NPN & SSN in D.S. shark in lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2082.13544	12	173.511287	11.10576286	4.62782E-07	2.183377035
Columns	18677.33215	2	9338.66607	597.730631	3.3769E-21	3.402831794
Error	374.9648657	24	15.6235361			
Total	21134.43246	38				

Table 51 Result on TVN, NPN & SSN in D.S. shark in lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	3179.387	12	264.9489	9.591348	1.81E-06	2.183377
Columns	11422.68	2	5711.342	206.7549	7.42E-16	3.402832
Error	662.9697	24	27.62374			
Total	15265.04	38				

Table 52 Result on TVN, NPN & SSN in D.S. shark in lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4340.331	12	361.6943	16.36116	1.02E-08	2.18338
Columns	12087.53	2	6043.766	273.3885	3.05E-17	3.40283
Error	530.565	24	22.10688			
Total	16958.43	38				

ble 53 Result on TVN, NPN & SSN in D.S. shark in lot 1 on drying.

OVA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	2.696791	1	2.696791	0.310696	0.633312	18.51276
umns	147.4621	2	73.73107	8.494521	0.105324	19.00003
or	17.35968	2	8.679838			
al	167.5186	5				

ble 54 Result on TVN, NPN & SSN in D.S. shark in lot 2 on drying.

OVA

urce of Variation	SS	df	MS	F	P-value	F crit
ws	8.755543796	1	8.7555438	0.371832067	0.604058109	18.51276465
umns	198.7187543	2	99.3593772	4.219612567	0.191585101	19.00002644
or	47.09407586	2	23.5470379			
al	254.568374	5				

ble 55 Result on TVN, NPN & SSN in D.S. shark in lot 3 on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	0.237343	1	0.237343	0.026828	0.88495	18.51276
umns	980.293	2	490.1465	55.40325	0.017729	19.00003
or	17.69378	2	8.846891			
al	998.2241	5				

ble 56 Result on TVN, NPN & SSN in D.S. shark in lot 4 on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.003301	1	0.003301	0.000389	0.986053	18.5128
olumns	988.6747	2	494.3373	58.27238	0.016871	19
ror	16.96644	2	8.483219			
tal	1005.644	5				

Table 57 Result on TVN, NPN & SSN in D.S. shark in lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	156.4077	3	52.13592	1.415906	0.32723	4.757055
Columns	605.7208	2	302.8604	8.225076	0.01909	5.143249
Error	220.9295	6	36.82159			
Total	983.0581	11				

Table 58 Result on TVN, NPN & SSN in D.S. shark in lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	59.01677392	3	19.67225797	1.011401	0.4504825	4.757055194
Columns	746.6868397	2	373.3434198	19.19454	0.00246959	5.143249382
Error	116.7029786	6	19.45049644			
Total	922.4065922	11				

Table 59 Result on TVN, NPN & SSN in D.S. shark in lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	110.0596	4	27.5149	3.720137	0.053823	3.837854
Columns	1715.625	2	857.8123	115.98	1.24E-06	4.458968
Error	59.16965	8	7.396206			
Total	1884.854	14				

Table 60 Result on TVN, NPN & SSN in D.S. shark in lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	122.4804	4	30.62009	1.14937	0.400061	3.837854
Columns	1459.314	2	729.6572	27.38876	0.000264	4.458968
Error	213.126	8	26.64076			
Total	1794.921	14				

Table 61 Result on TVN, NPN & SSN in W.S. shark in lot 1.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	6703.72	12	558.6434	2.715363	0.017966	2.183377
Columns	10297.59	2	5148.797	25.02643	1.34E-06	3.402832
Error	4937.625	24	205.7344			
Total	21938.94	38				

Table 62 Result on TVN, NPN & SSN in W.S. shark in lot 2.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4880.461523	12	406.7051269	13.37117	7.6926E-08	2.183377035
Columns	6956.198102	2	3478.099051	114.3488	5.3867E-13	3.402831794
Error	729.9978756	24	30.41657815			
Total	12566.6575	38				

Table 63 Result on TVN, NPN & SSN in W.S. shark in lot 3.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4781.249	12	398.4375	8.673595	4.5E-06	2.183377
Columns	18734.2	2	9367.098	203.9126	8.69E-16	3.402832
Error	1102.484	24	45.93683			
Total	24617.93	38				

Table 64 Result on TVN, NPN & SSN in W.S. shark in lot 4.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	5028.294	12	419.0245	9.009466	3.2E-06	2.183377
Columns	13499.41	2	6749.703	145.1257	3.94E-14	3.402832
Error	1116.225	24	46.50936			
Total	19643.92	38				

65 Result on TVN, NPN & SSN in W.S. shark in lot 1on drying.

NVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	6.277539	1	6.277539	0.642875	0.506798	18.51276
umns	912.3792	2	456.1896	46.71778	0.020957	19.00003
or	19.52959	2	9.764796			
tal	938.1863	5				

ble 66 Result on TVN, NPN & SSN in W.S. shark in lot 2 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	6.658239253	1	6.658239253	2.06026	0.28766528	18.51276465
lumns	1621.163123	2	810.5815617	250.8184	0.00397112	19.00002644
or	6.463492831	2	3.231746415			
tal	1634.284855	5				

ble 67 Result on TVN, NPN & SSN in W.S. shark in lot 3 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.683056	1	0.683056	0.690388	0.49343	18.51276
olumns	3280.233	2	1640.117	1657.721	0.000603	19.00003
rror	1.97876	2	0.98938			
otal	3282.895	5				

able 68 Result on TVN, NPN & SSN in W.S. shark in lot 4 on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	2.712326	1	2.712326	37.11629	0.0259	18.51276
olumns	1891.756	2	945.8778	12943.68	7.73E-05	19.00003
rror	0.146153	2	0.073076			
otal	1894.614	5				

Table 69 Result on TVN, NPN & SSN in W.S. shark in lot 1 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	161.9366	3	53.97888	1.586863	0.288077	4.757055
Columns	222.32	2	111.16	3.267866	0.109649	5.143249
Error	204.0965	6	34.01609			
Total	588.3532	11				

Table 70 Result on TVN, NPN & SSN in W.S. shark in lot 2 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	286.6470982	3	95.54903272	1.664309	0.27231625	4.757055194
Columns	160.6199633	2	80.30998164	1.398869	0.31720542	5.143249382
Error	344.4638423	6	57.41064038			
Total	791.7309038	11				

Table 71 Result on TVN, NPN & SSN in W.S. shark in lot 3 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	189.6923	4	47.42308	0.988153	0.466137	3.837854
Columns	822.8392	2	411.4196	8.572734	0.010245	4.458968
Error	383.9331	8	47.99164			
Total	1396.465	14				

Table 72 Result on TVN, NPN & SSN in W.S. shark in lot 4 on storage.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	72.17131	4	18.04283	0.551106	0.704168	3.837854
Columns	750.6373	2	375.3187	11.46386	0.004477	4.458968
Error	261.9143	8	32.73929			
Total	1084.723	14				

Table 73 Result of urea in shark during dry salting.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1447811.35	12	120650.9	300.0915	2.67E-32	2.032703
Columns	12616.31405	3	4205.438	10.46006	4.32E-05	2.866265
Error	14473.69668	36	402.0471			
Total	1474901.361	51				

Table 74 Result of urea in shark during wet salting.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1262378	12	105198.2	26.4115	2.89E-14	2.032703
Columns	707123.1	3	235707.7	59.17776	5.42E-14	2.866265
Error	143389.6	36	3983.045			
Total	2112891	51				

Table 75 Result of urea in 4 dry salted shark during drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	40.047	1	40.047	0.0078	0.9353	10.13
Columns	32763	3	10921	2.1192	0.2766	9.277
Error	15460.3	3	5153.4			
Total	48263.3	7				

Table 76 Result of urea in 4 wet salted shark during drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	96.033	1	96.03	2.317	0.2253	10.13
Columns	83092	3	27697	668.3	1E-04	9.277
Error	124.34	3	41.45			
Total	83313	7				

le 77 Result of urea in dry salted shark during storage in lot 1 & 2.

OVA

ource of Variation	SS	df	MS	F	P-value	F crit
ws	19395.05	3	6465.016	7.109349	0.070731	9.276619
umns	7429.99	1	7429.99	8.170497	0.064661	10.12796
r	2728.105	3	909.3682			
al	29553.14	7				

le 78 Result of urea in dry salted shark during storage in lot 3 & 4.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	5805	4	1451.2	9.497	0.0255	6.388
umns	66.641	1	66.641	0.436	0.5451	7.709
ror	611.21	4	152.8			
tal	6482.8	9				

ble 79 Result of urea in wet salted shark during storage in lot 1 & 2.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	66632.34	3	22210.78	8.328434	0.05763	9.276619
olumns	3910.676	1	3910.676	1.466396	0.312609	10.12796
ror	8000.585	3	2666.862			
tal	78543.6	7				

ble 80 Result of urea in wet salted shark during storage in lot 3 & 4.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	171694	4	42924	83.75	0.0004	6.388
olumns	2660.1	1	2660.1	5.19	0.085	7.709
ror	2050.1	4	512.52			
tal	176405	9				

Chapter 8

CHEMICAL CHANGES OF FISH DURING SALTING, DRYING AND STORAGE – LIPID FRACTIONS

1. Introduction

Fats are important nutritional component of fish meat. The fat content of the fish pends on species, size and season. Besides, fat content is also related to the habitual r food habit. Based on the fat content, the fishes are classified into three categories - s with less than 0.5% fat is called lean fish, 0.5% to 5% fat containing fishes are called ous fatty fish and above 5% is called fatty fish. The lipids from fish are characterised the presence of high degree of unsaturation because of the very reason that they ergo oxidation and hydrolysis than any other meat food. The oxidation is an aerobic cess and is promoted by free radical mechanism. During oxidation process the lipid acts with other food components particularly with protein and thereby affects quality vadasan, 1981). Similarly the products of hydrolysis, FFA reacts with proteins, aturing them, there by affecting the quality.

The formation of free fatty acid (FFA) in sardine stored in chilled seawater is orted by Krishnakumar *et al*, (1986). The FFA hydrolysis in heavy salted sample was od and is proportional to decrease of phospholipids (Lovern, 1961). The oxidation of A to Peroxide Value (PV) in salt solution in presence of dissolved oxygen in brine ution (Krishnakumar *et al* .1986). Viswanathan (2000) reported that two types of anges take place in the lipids during processing and preservation of fish - lipids drolysis and oxidation. Devadasan (1981 & 2000) narrated the changes taking palace meat on lipids. Koimumi *et al.* (1980) cited in Thomas & Iyer (2000) stated that the ated dried fish are susceptible to oxidative deterioration because the added sodium loride is known to have strong pro–oxidant effect on lipids. As salt concentration creases it was found to inhibit the formation of FFA.

1.2. Lipid Oxidation

Lipid oxidation is an important change, which occur during the storage of the red fish. The lipids in the fish react with oxygen in presence of sodium chloride and auses yellowish discolouration or brown colour on the surface of the fish affecting ppearance to fish. This type of discolouration is probably seen on the belly portion. eroxide is an important intermediate product of oxidation and rancidity. Anon. (1987) ported that the rancidity of the product causes two undesirable effects vizly, the utritive value of the oxidized fish oil is lower than that of the oils in the natural state and e consumption of rancid oil can produce toxicological problems. Govindan (1985) ported that fat oxidation due to atmospheric air or oxygen cause unpleasant rancid vour and colour and the meat change to the colour of rusted iron. Peroxides are rmed first by oxidation of fats, which are further broken down into simpler and doriferous compounds like aldehydes, ketones and hydroxy acids which impart the aracteristic odours. The presence of copper accelerates reaction.

12. Aims

is chapter aims to study:

- The FFA and PV content of Mackerel, Ribbonfish and Shark at fresh condition
- The changes in FFA in the above fish during dry and wet salting with different preservatives, drying and storage at different conditions
- The changes in PV in the above fish during dry and wet salting with different preservatives, drying and storage at different conditions

13. Materials and Methods

The processed fish prepared as in M.M in the chapter 4 and flow sheet Table no 4.1, 4.2 and 4.3 used to find the total lipids, free fatty acids (FFA) and peroxide value PV). The fresh fish before salting or dried fish were cleaned without bone or skin and hopped in to small pieces on a dried plastic board or wooden piece and then kept in a ned grinder. The meat was ground and this meat was used for the various experiments. he prepared sample was kept in the refrigerator until further use.

13.1. Total Lipids

This test was carried out only for fresh fish. A known quantity of the dried ample was taken in a cotton plugged extraction thimble and kept in the Soxhlet's action chamber. Petroleum ether (60 – 80^0 c) solvent was used as per AOAC, (1980).

$$\text{Lipids} = \frac{\text{Weight of lipids x 100}}{\text{Weight of sample}} = \text{-------- gm / 100 gm}$$

13.2. Free Fatty Acid

Before the appearance of oxidative rancidity on the meat, there is an increase lipid oxidation that leads to a build up of non-esterified fatty acid, which more readily xidise than the esterified fats. The fatty acids are derived primarily from the hydrolysis phospholipids by the action of lipase and phospholipase. The free fatty acids are not ontributing much undesirable flavours in fish muscle but they readily oxidise compared glyceride.

The FFA content of the fish was estimated following the method of AOAC (1980) nd Namboothri (1985) using anhydrous sodium sulphate.

alculation,

Equivalent weight of oleic acid = 280gm

ml of 0.1N Na OH = 0.28 gm of oleic acid in 1 litre

$$\text{of FFA} = \frac{\text{Volume of NaOH used x 0.01 x 0.28 x 100}}{\text{Weight of fat}} = \text{------ mg \% as oleic acid}$$

13.3. Peroxide Value

The oxidative rancidity is a major cause of flavour deterioration in stored fish. he unsaturated fish oils are susceptible to oxidation and peroxide found in storage. It is s an intermediate product, which further breaks down leading to the formation of cation process.

The chloroform extract prepared for FFA was added with 10ml glacial acetic acid as per AOAC. (1980) & Namboothri, (1985) and PV was estimated.

Calculation:

$$\text{Peroxide value} = \frac{\text{Volume of sodium thiosulphate used x N x 1000}}{\text{Weight of fat}} = \text{------- millimole / gm of fat}$$

14. Results

14.1. Total Lipids

The total lipids content of mackerel, ribbon fish and shark were 10.48 gm, 3.59 gm and 2.51 gm / 100gm respectively.

14.2. Free Fatty Acid changes during salting, drying and storage

14.2.1. Dry and wet salted Mackerel.

The fresh mackerel had 0.47 (oleic acid %) FFA. The dry salted lot one, had 725.53 and 87.23% more and 65.96% less and 91.49% more FFA and wet salted lot had 8.30% less and 82.98% more and 4.26% less and 23.40% more at 4, 8, 24 and 48 hours of salting than fresh fish. The dry salted lot two, had 757.45% more and 65.96, 65.96 and 29.79% less and wet salted lot had 17.02 and 2.13% less and 2.13% more and 6.38% in same salting period. The dry salted lot three, had 938.3% more and 72.31 and 72.34% less and 2.13% more and wet salted lot had 12.77, 93.62 and 17.03% more and 12.77% less in same salting period. The dry salted lot four, had 653.19% more and 74.47, 61.70 and 12.77% less and wet salted lot had 59.57, 23.40% more and 19.15% less and 6.38% more in same salting period (Figure – 8.1). In dry salted fish, there is significant difference between salting time ($p < 0.001$) and between FFA ($p < 0.05$).

ere is significance in lot 1 and 2, no significance in lot 2 and 3 and lot 3 and 4. There significance in column 1 and 2 at initial stage only and fully significant in column 2 and and no significance in column 3 and 4 (Table 1). In wet salted fish there is no nificance in salting hours between lot 1 and 2, lot 2 and 3 and lot 3 and 4 and in FFA and c2, c2 and c3 and c3 and c4 (Table 2)

Change in FFA after drying in dry salted lot one was 35.77% less and 204.55% re and wet salted sample was 29.31% more and 46.67% less after 4 hours at noon d after 8 hours at evening than salted fish. The dry salted lot two, had 15.15 and 16% more and wet salted lot had 4.55 and 2.38% less after same drying period. The salted lot three, had 35.42% more and 9.23% less and wet salted lot had 65.85% re and 55.33% less after same drying period. The dry salted lot 4, had 102.44% more d 3.61% less and wet salted lot had 150.01 and 28.01% more after noon and evening able – 8.1). There is no significance between lot 1 and 2, lot 2 and 3 and lot 3 and 4 ing hours and in FFA in 4 dry salted lots (Table 3). There is no significance between 1 and 2, lot 2 and 3 and lot 3 and 4 and in FFA in 4 wet salted lots (Table 4).

FFA content in unpacked dry salted lot had 42.32% less and 117.65 and 59% more and wet salted lot had 295.12% more and 50.62 and 28.75% less after 10, and 30 days than dried fish. The packed dry salted lot had 81.36 and 138.32% more d 30.59% less and wet salted lot had 200.0% more and 51.22% less but 85.00% more er same period. The refrigerator stored dry salted lot had 16.95, 5.80 and 50.68% re and 16.36% less at one to four months and wet salted lot had 2.44, 78.54 and 4.00% more after one to four months. The cold storage stored dry salted lot had 11.52 d 7.48% less and 150.01 and 8.33% more and wet salted lot had 19.51% and 12.24% ss and 25.58 and 125.93% more after one to four months (Figure – 8.2). In dry salted ackerel, there is no significance between lot one and two storage period but little nificance in FFA (Table 5). There is no significance between lot three and four in e period but little significance in column (Table 6). In wet salted mackerel, there is nificance between lot one and two in storage period but little significance in FFA e 7). There is no significance between lot three and four storage period and in FFA e 8).

2. Dry and wet salted Ribbonfish

The fresh fish had 0.66 FFA (oleic acid %). Four dry and wet salted lots showed st similar results as in dry and wet salted mackerel and high decrease observed in alted samples as in Figure – 8.3. In dry salted fish, the salting time ($p < 0.05$) and were significant ($p < 0.01$). There is significance between lots 1 and 2, lots 2 and 3 ally only and lots 3 and 4. The significance between column c1 and c2 was high ally and not significant subsequently, between c2 and c3 was significant but c3 and it was not significant (Table 9).). In wet salted fish, there is significance between FFA s 1 and 2, lots 2 and 3 and 3 and 4 ($p < 0.001$) and between salting time there were significance (Table 10).

The change in FFA content during drying, of each four dry and wet salted lots, d almost similar results as in dry and wet salted mackerel (Table – 8.2). In dry salted n, there is no significance in lots 1 and 2, lots 2 and 3 and lots 3 and 4 in rows or umns (Table 11). In wet salted fish, there is significance in lots 1 and 2, lots 2 and 3 d lots 3 and 4 ($p < 0.01$) but there is no significant difference in drying time (Table 12).

FFA content in unpacked dry salted lot had 60.96% less and 142.11% more and .61% less and wet salted lot had 71.30% less and 9.38 and 72.86% more in 10, 20 d 30 days than dried fish. The packed dry salted lot had 34.25% less and 31.11% re and 15.26% less and wet salted lot had 73.09% less but 15.00 and 62.32% more er the same period. The refrigerator stored dry salted lot had 40.41% and 56.32% less d 113.16% and 6.17% more after one to four months and wet salted lot had 29.15% d 66.49% less and 294.33% more followed by a decrease of 51.67% after one to four onth. Cold storage stored dry salted lot had 26.03 and 60.19% less and 16.28% and 32.00% more and wet salted lot had 43.05, 77.95% less and 100.00 and 46.43% more ter the same periods (Figure – 8.4). In dry salted fish, there is no significance between ts one and two and also between FFA (Table 13). There is significant difference etween storage period, lots three and four ($p < 0.05$) but FFA effects are not significant able 14). In wet salted fish, there is significant difference between lots one and two (p 0.001) but FFA effects are not significant (Table 15). The storage period effects (p < 01) and FFA effects are significant ($p < 0.05$) in lots three and four (Table 16).

4.2.3. Dry and wet salted Shark

The FFA content of fresh shark was 0.72 (oleic acid %). Each sample in four dry nd wet salted lots had almost similar results as in dry and wet salted mackerel in igure – 8.5). In dry salted shark there is significant difference between salting hours (p 0.001) and FFA columns ($p < 0.001$). There is significance between lot 1 and 2 at tial salting time, lots 2 and 3 and lots 3 and 4 had little significance. The significance in olumns c1 and c2 was more initially then decreased and c2 and c3 and c3 and c4 are gnificant (Table 17). In wet salted shark, there is significant difference between salting ours ($p < 0.001$) and between FFA ($p < 0.001$). There is significance in lots 1 and 2 but ecrease as salting period increase. There is significance between lots 2 and 3 and lots and 4. There is significance in columns c1 and c2 and no significance in c2 and c3 and 3 and c4 (Table 18).

Change after drying in FFA content in each four dry and wet salted lot had most similar result as in dry and wet salted mackerel (Table – 8.3). In dry salted shark, ere is no significance between lots 1 and 2, lots 2 and 3 and lots 3 and 4 and also in FA (Table 19). There is significance in wet salted shark between drying time and FFA < 0.05). There is significance in lots 1 and 2 and no significance between lots 2 and 3 nd lots 3 and 4 (Table 20).

FFA content in dry salted lot stored in unpacked condition was 19.94% less and 3.37% more but 15.21% less and wet salted lot was 60.28% more and 15.93% less and 33.95% more after 10, 20 and 30 days than dried fish. The dry salted lot stored in packed condition had 26.98 and 26.10% less but 214.67% more and wet salted lot had 1.38% more and 37.00% less and 39.15% more in the same storage period. The refrigerator stored dry salted lot had 47.51% less and 255.31% more and 11.95% less at 1 to 3 month and wet salted lot had 48.58% less 602.07% more and 27.60% less after one to three months storage. The dry salted lot, stored in cold storage had 5.87% less and 133.44 and 14.06% more and wet salted lot had 36.52 and 521.23% more and 5.90% less in the same period (Figure – 8.6). In dry salted shark, there is no significance between lot one and two in FFA and also in storage period (Table 21). There is significance between lots three and four ($p < 0.5$) in FFA and between storage period ($p < 0.01$) (Table 22). In wet salted shark, there is no significance in FFA in lots one and two and in storage period (Table 23). The storage period effects are significant ($p < 0.001$) but FFA effects are not significant (Table 24).

4.4.3. Peroxide Value changes during salting, drying and storage

4.4.3.1. Dry and wet salted Mackerel

Fresh mackerel had 108.11 millimoles / gm of fat. The dry salted lot one, had 5.94, 70.14, 60.44% less and 115.44% more and wet salted lot had 13.41 and 39.46% less and 166.40 and 200.92% more than fresh fish after 4, 8, 24 and 48 hours of salting. Dry salted lot two, had 3.39 and 28.08% less and 54.86 and 130.04% more and wet salted lot had 10.69% less but 88.99, 140.75 and 193.28% more in the same salting period. In dry salted lot 3, had 19.94, 74.81and 80.99% less and 42.47% more and wet salted lot had 25.04, 15.32, 292.42 and 350.60% more in the same salting period. Dry salted lot 4, had 57.97% more and 41.97 and 49.75% less and 90.44% more and wet salted lot had 98.34, 178.08, 259.31and 291.14% more after 4, 8, 24 and 48 hours of ing (Figure – 8.7). In dry salted fish, the salting time and PV effects are significant (p 0.001). There is significance between lots 1 and 2, 2 and 3 and 3 and 4 and also in columns c1 and c2, c2 and c3 and c3 and c4 (Table 25). In wet salted fish, there is significant difference between salting time and between PV ($p < 0.001$). There is significance in lots 1 and 2, 2 and 3 and 3 and 4 as salting time increase and is the same columns c1 and c2, c2 and c3 and c3 and c4 (Table 26).

PV content after drying in dry salted lot 1, was 29.26 and 9.21% more and wet salted lot 14.56 and 12.65% more after four hours at noon and after eight hours at evening than salted fish. Dry salted lot two had 6.90 and 8.32% more and wet salted lot 76 and 6.92% more in the same period. Dry salted lot three had 41.68% more and 25% less and wet salted lot 4.33 and 8.56% more in the same period. In dry salted lot four had 8.76 and 6.97% more and wet salted lot had 29.58 and 8.41% more at noon and evening (Table – 8.1). In dry salted fish, there is significance between lots 1 and 2, lots 2 and 3 and lots 3 and 4 as drying time increases ($p < 0.05$) but no significance in drying time (Table 27). In wet salted fish, the drying time and PV effects are significant (p 0.01). There is significance between lots 1 and 2, lots 2 and 3 and lots 3 and 4 and in columns (Table 28).

PV content in unpacked stored dry salted lot had 12.89% less and 11.32% more and 35.01% less wet salted lot had 18.76% more and 14.75 and 63.17% less after 10, 20 and 30 days than dried fish. The packed stored dry salted lot had 73.08% more but 2.99 and 36.12% less and wet salted lot had 22.33 and 16.63% more but 57.52% less same storage period. The refrigerator stored dry salted lot had 15.62, 7.91, 2.67 and .36% more and wet salted lot had 20.73% less and 25.45, 17.81 and 25.77% more after one to four months. The cold storage stored dry salted lot had 19.50% more and .30% less and 9.95 and 2.86% more and wet salted lot had 24.12% less and 10.55, .05 and 4.69% after one to four months (Figure – 8.8). In dry salted fish, there is no gnificance between storage period and between PV in lots one and two (Table 29). 'ere is significant difference between storage period ($p < 0.01$) and PV effects were not gnificant in lots three and four (Table 30). In wet salted fish, there is no significance etween lot 1 and 2 and in column c1 and c2 (Table 31). There is significant different etween rows ($p < 0.05$) lots 3 and 4 but column effects are not significant (Table 32)

14.3.2. Dry and wet salted Ribbonfish

PV content of fresh fish was 103.71 millimoles / gm of fat. The dry salted lot one, ad PV content 17.85, 16.28, 85.73 and 138.68% more and wet salted lot 30.45, 42.71, 1.20 and 216.44% more than fresh fish after 4, 8, 24 and 48 hours of salting. Dry salted t two, had 1.29, 8.17, 17.85 and 99.36% more and wet salted lot had 60.71, 130.08, 91.62 and 296.90% more in the same period. Dry salted lot had 20.65, 26.33, 190.59 nd 326.29% more and wet salted lot 64.88, 90.99, 118.50 and 191.12% more in the ame period. Dry salted lot four, had 94.47, 127.02, 289.83 and 371.67% more and wet alted lot 106.95, 133.10, 176.41 and 284.63% more after same hours of salting (Figure -8.9). In dry salted fish, the salting time and PV effects are significant ($p < 0.001$). There s significance between lots 1 and 2, 2 and 3 and 3 and 4 and also in columns c1 and c2, 2 and c3 and c3 and c4 (Table 33). In wet salted fish, there is significant difference etween salting hour and between PV ($p < 0.001$). There is significance in lots 1 and 2, 2 and 3 and 3 and 4 as salting time increase and is same in columns c1 and c2, c2 and 3 and c3 and c4 (Table 34).

PV content change after drying in all four dry and wet salted lots, increased as in ry and wet salted mackerel (Table – 8.2). In dry salted fish, the drying time ($p < 0.05$) nd PV effects are significant ($p < 0.001$). There is significance in lots 1 and 2, 2 and 3 nd 3 and 4 and in columns c1 and c2, c2 and c3 and c3 and c4 (Table 35). In wet alted fish, drying time effects ($p < 0.05$) and PV effects are significant ($p < 0.01$). There significance in lots 1 and 2, 2 and 3 and 3 and 4 and in columns c1 and c2, c2 and c3 nd c3 and c4 (Table 36).

PV content in unpacked stored dry salted lot had 132.38% more and 19.17 and .62% less and wet salted lot 21.51% more and 1.50 and 39.81% less at 10, 20 and 30 ys than dried fish. The packed stored dry salted lot had 7.13% more and 5.21 and .74% less and wet salted lot 1.91 and 30.29% more but 8.16% less in the same riods. The refrigerator stored dry salted lot had 14.01 and 12.56% less and 113.08 d 1.73% more and wet salted lot 5.28% less and 33.83 and 35.53% more and 0.99% ss at one to four months. The cold storage stored dry salted lot had 21.82 and 30.67% ss and 56.74 and 11.55% more and wet salted lot had 0.30% less and 24.96 and .12% more which subsequently reduced to 4.34% in same period (Figure – 8.10). In y salted fish, there is no significance between storage period and between PV in lots 1 d 2 (Table 37). There is no significant difference between lots 3 and 4 and columns able 38). In wet salted fish, there is no significant difference between lots 1 and 2 and columns (Table 39). There is significant difference between storage time ($p < 0.001$) in s 3 and 4 but PV effects are not significant (Table 40).

.3.3. Dry and wet salted Shark

The PV content of fresh shark was 155.84 millimoles /gm of fat. The dry salted one, had 21.57% less and 14.08, 90.20 and 163.10% more and wet salted lot 25.25 d 46.15% less and 24.43 and 152.82% more after 4, 8, 24 and 48 hours of salting an fresh shark. Pattern of change in PV in other lots are given in Figure – 8.11. In dry ited fish, the salting time and PV effects are significant ($p < 0.001$). There is nificance between lots 1 and 2, 2 and 3 and 3 and 4 and also in columns c1 and c2, and c3 and c3 and c4 but the significance increase as the salting time increase able 41). In wet salted fish, there is significant difference between salting time and tween PV ($p < 0.001$). There is significance in lots 1 and 2, 2 and 3 and 3 and 4 as ing time increase and is same in columns c1 and c2, c2 and c3 and c3 and c4 (Table 43).

PV content change after drying, in all four dry and wet salted lots, increased as in dry and wet salted mackerel (Table – 8.3). In dry salted fish, the drying time effects ($p < 0.05$) and PV effects are significant ($p < 0.01$). There is significance between lots 1 and 2, 2 and 3 and 3 and 4 and in columns c1 and c2, c2 and c3 and c3 and c4 (Table 43). In wet salted fish, drying time effects ($p < 0.01$) and PV effects are significant ($p < 0.01$). There is significance in lots 1 and 2, 2 and 3 and 3 and 4 and in columns c1 and c2, c2 and c3 and c3 and c4 (Table 44).

PV content in unpacked stored dry salted lot had 37.67% more and 29.31 and 3.37% less and wet salted lot had 177.74% more and 6.59% less which subsequently increased by 0.56% at 10, 20 and 30 days respectively than dried fish. The pattern of change in P V contents in other samples of various lots are reflected in Figure – 8.12 and in Table 46. In wet salted fish, there is no significant difference between lots 1 and 2 and in PV (Table 47). There is significant different between storage period in lots 3 and 4 and PV effects are not significant (Table 48).

8.5. Discussion

Mackerel is a fatty fish; ribbonfish and shark are lean fishes. The lipid includes all type of fat available including tri-glycerides. The degradation of lipids into fatty acids are by hydrolytic rancidity and are caused by enzymes present in fish. Fish have unsaturated lipids (Olcott, 1961) which undergo various changes during salting, drying and storage. According to Cutting (1961) sodium chloride promotes lipolysis and rancidity during drying. The multi-bond free radical reacts with oxygen to give peroxy radical hence form peroxide value. According to Lovern (1961) lipid hydrolysis takes place during both light and heavy curing. Ackman (1974) stated that more subtle change takes place in frozen stored fish, which involves liberation of fatty acids from lipids. The emical constituent of *T.Indicus* shows that it has 10.9 mg% iron and 3mg / 100gm amin C (Swaminathan, 1993).

The results of dry salted lot showed that there was no steady increase or rease in FFA during dry salting in both control and preservative added lots. The FFA ue increased in the initial stage may be due to moisture loss. The FFA value reased in initial stage of wet salting and decreased as the salting time increased in ackerel. The FFA value increased continuously in sample one and two up to 48 hours dry salted ribbonfish. But the lots three and four have more value up to 24 hours only. e wet salted ribbonfish had the same effect as wet salted mackerel. The dry and wet ted shark showed an increase in FFA content initially but decreased as the salting riod increased. This may be due to the soluble low molecular weight acids partially ssed in to the solution from fish as reported by Kleimannov *et al.* (1958). But the rease of FFA was comparatively more in dry salted shark than wet salted shark. arks samples in both dry and wet salting were scored and salt penetration effect is ual and comparatively equal results were achieved in FFA.

According to Lovern (1961) effect of lipid hydrolysis is high at initial stage in eavy salting. The initial increase in FFA may be due to moisture loss and also due to eavy hydrolysis of lipids. He further stated that the phospholipids and glycerides ndergo hydrolysis to produce FFA depending on the conditions. Klaveren & Legendre 965) reported that the salt content exceeding 15.5 - 17% interfere into lipid hydrolysis nd unsaturated FFA liable to be oxidative decomposition at the double bond resulting in ostly ketones and aldehydes. Here salt content exceeds the range and lipids ydrolysis is fast and agrees with above. The lipid hydrolysis in seafood is catalyzed by ases, which cleave FFA from glycerol (Bligh *et al.*, 1988). Krishnakumar *et al.* (1986) eported the formation of FFA in sardine stored in chilled seawater. According to Sankar ar (1988) FFA development during frozen storage of fresh and iced pomfret showed formation of FFA and was temperature dependent and phospholipid hydrolysis.

Results in drying process showed that the FFA content decreased in some ses after four hours drying but increased after eight hours drying in dry and wet salted ackerel and ribbonfish. FFA content increased in dry salted shark and decreased in et salted shark for whole day. Sun drying causes oxidation and moisture loss so FFA ntent is more. The decreased level of FFA content is due less evaporation of moisture ter the initial four hours of drying. The results in the unpacked open air stored samples owed that the FFA content decreased initially but increased latter in dry and wet salted ackerel and wet salted ribbonfish. FFA decreased initially, then increased and again creased in dry salted ribbonfish and shark. It increased initially followed by a crease, which further increased in wet salted shark. Bligh *et al.* (1988) detailed that e lipolysis depends on the moisture and relative humidity on the product and storage ndition. Endogenous enzymes present in fish produce FFA as reported by Bligh et al. 988) and Pigott & Tucker (1990). It was further reported that lipid oxidation enhance in y food to cause browning reaction and decrease protein quality. An appreciable oduction of FFA was reported at 37.0^c (Lovern, 1961). As the fish was store at 32.3 to 5.0^{0}c the formation of FFA is possible.

The stored packed lot showed that the FFA content increased for 20 days then creased in dry salted mackerel. But it did not play a particular pattern in wet salted ackerel and shark and dry salted ribbonfish. The FFA decreased initially and increased ter in wet salted ribbonfish and dry salted shark. Nair & Gopakumar (1986) reported at the FFA increased and fall at room temperature in Jew fish and threadfin bream. alaimani *et al.* (1984) reported that FFA increased in 20 week in packed oil sardine and anumanthappa & Chandrasekhar (1987) in hot smoked mackerel and the present sults agree with earlier findings. The refrigerator stored lot showed that the FFA creased up to three months as reported by Hanumanthappa & Chandrasekhar (1987) hot smoked mackerel and then decreased in dry and wet salted mackerel. FFA was ss than the dried lots for two months and then increased in dry and wet salted bonfish. FFA was less initially than dried lots then increased and decreased in dry and et salted shark. Mallette *et al.* (1968) reported that sodium chloride reacts in solid state. e formation of FFA content in dry and wet salted ribbonfish and shark are slow initially nd increased latter followed by a decrease. This may be due to the conversion of FFA ketones and aldehydes as above. The cold storage stored lot showed that the FFA ntent increased initially for two months and decreased subsequently in dry salted ackerel, ribbon fish and shark and wet salted ribbonfish. The FFA content was high itially and decreased but increased in wet salted mackerel and shark. Lovern (1961) ported that the action of lipid hydrolysis under goes at – 5^{0}c and was limited.

Peroxide value decreased initially up to 24 hours but decreased as salting eriod increased in lot one to three. Lot four showed that it increased initially but ecreased at 8 and 24 hours and increased at 48 hours of salting in dry salted mackerel. he wet salted mackerel showed that the PV decreased initially but increased as salting eriod increased in lots one and two but increased as salting period increased in lots ree and four as reported by Krishnakumar *et al.* (1986) in chilled sea water storage of ardine and the results agree with earlier results. Dry salted ribbonfish showed that PV creased as salting period increased initially for 4 hours, but in lot 3 it increase at 8 hrs. he wet salted ribbonfish shoed that the lot 1 had steep increase initially then falls but ots increased gradually. PV content in dry salted shark showed that it decreased initially n lots 1 and 2 but increased in lots 3 and 4. The wet salted shark showed that PV ontent decreased initially for 8 hours then increased at 24 hours expect in lot 2. rishnakumar *et al.* (1986) reported that the oxidation of FFA to PV in salt solution is due o the presence of dissolved oxygen in brine solution. In lots selected for storage study, servative have good effect in reducing the formation of PV. During the initial stage, formation of PV was less and in the latter stage the oxidation of unsaturated FFA sults in the formation of PV in presence of sodium chloride. The chemical composition Tamarind showed that it has high content of iron in it (Swaminathan, 1993). Iron may sten the conversion process in wet salted fish and shark due to the haematin pigments increasing the susceptibility of oils to rancidity (Valle, 1974). In the drying process the sh undergoes moisture loss and FFA oxidation.

The formation of high PV during drying is due to many factors like light, oxygen nd high temperature, etc. In every dry and wet salted lots there were more PV content nd was more coloured at the end of drying time. The wet salted and sun dried lots had ore moisture content and more rancid (Valle, 1974) at 35^0c to 40^0c, than tunnel dried ample due to shorter time required in tunnel drier than sun drying. Valsan (1976) ported that PV content increased appreciably in cured dried mackerel products. Nair 993) stated that the process of lipid oxidation in fish muscle involves highly complex actions. Pan (1988) reported that the PV content increased in sardines during drying nd storage. The present results agree with earlier findings.

In unpacked lots one, PV was low initially than the dried sample, which further reased then decreased at 30 days in dry and wet salted mackerel. But it increased tially and decreased as storage period increased in dry and wet salted ribbonfish and ark. The fatty fish showed different value as the storage period increased due to the ature of the lipid content. The PV formed due to the break down of FFA as reported by eimannov *et al.* (1958). Bligh *et al.* (1988) reported that at low relative humidity lipids idized at a faster rate. The packed stored lots two showed that the PV content reased initially and then decreased in dry and wet salted mackerel and ribbonfish. imilar findings were reported by Chakrabarti *et al.* (1991) in prawn cake. PV was low tially and increased in dry and wet salted shark. Similar findings were reported in Jew and threadfin bream (Nair & Gopakumar, 1986). Kalaimani *et al.* (1984) reported the PV content increased in 8 weeks then decreased and subsequently increased in in sealed pack. Gupta & Chakrabarti (1994) reported that PV increased slowly and n decreased in samples and repetition of both increasing and decreasing was noticed ome packed samples. High degree of unsaturation, in from of multiple double bonds fatty acids, renders fish lipids highly susceptible to the development of oxidative cidity. Attack by molecular unsaturated fatty acid, by a free radical mechanism and is racterized by a slow initiation period, followed by an accelerating rate of hydrogen sorption with formation of hydroperoxides (Olcott, 1961). Shin *et al.* (1972) cited in cman (1974) stated that degradation of peroxides to malonaldehyde is another nplex aspect. Similarly little peroxide is likely to be absorbed by fish without alteration keuchi, 1972) cited in Ackman (1974). So the increase and decrease of the PV may due to the above factors.

Refrigerator stored lots showed that PV content increased as the storage period reased in dry salted mackerel and wet salted shark as reported by Hanumanthappa & andrasekhar (1987) in hot smoked mackerel. It was low initially then increased as rage period increased in wet salted mackerel and wet and dry salted ribbonfish. FFA itent increased, decreased and then increased in dry salted shark and this is a similar ding with Gupta & Chakrabarti (1994). The formation of PV is influenced by nperature and relative humidity as reported by Bligh *et al.* (1988). The formation of PV es more time at low temperature and relative humidity than at room temperature and h relative humidity (Nair, 1993). The cold storage stored lots showed that PV content s high at initial stage then decreased followed by an increase in dry salted mackerel. e low initial and increased values were observed in wet salted mackerel, dry salted bonfish and dry and wet salted shark. It was observed that PV formation is high at h temperature stored lots and low at low temperature stored sample (Nair, 1993) and ggested that storage temperature is a critical factor in determining the level of roxide value. Balachandran (2001) also reported that hydroperoxides change to ehydes and ketones.

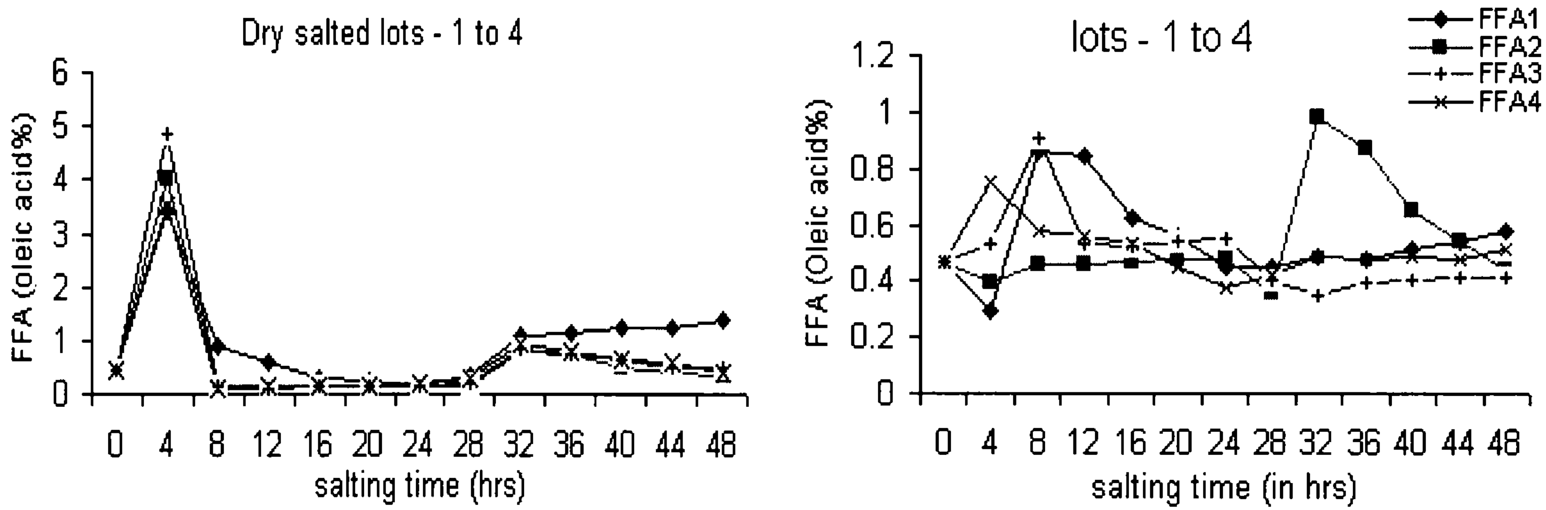

Figure – 8.1. Change in FFA during dry & wet salting of Mackerel

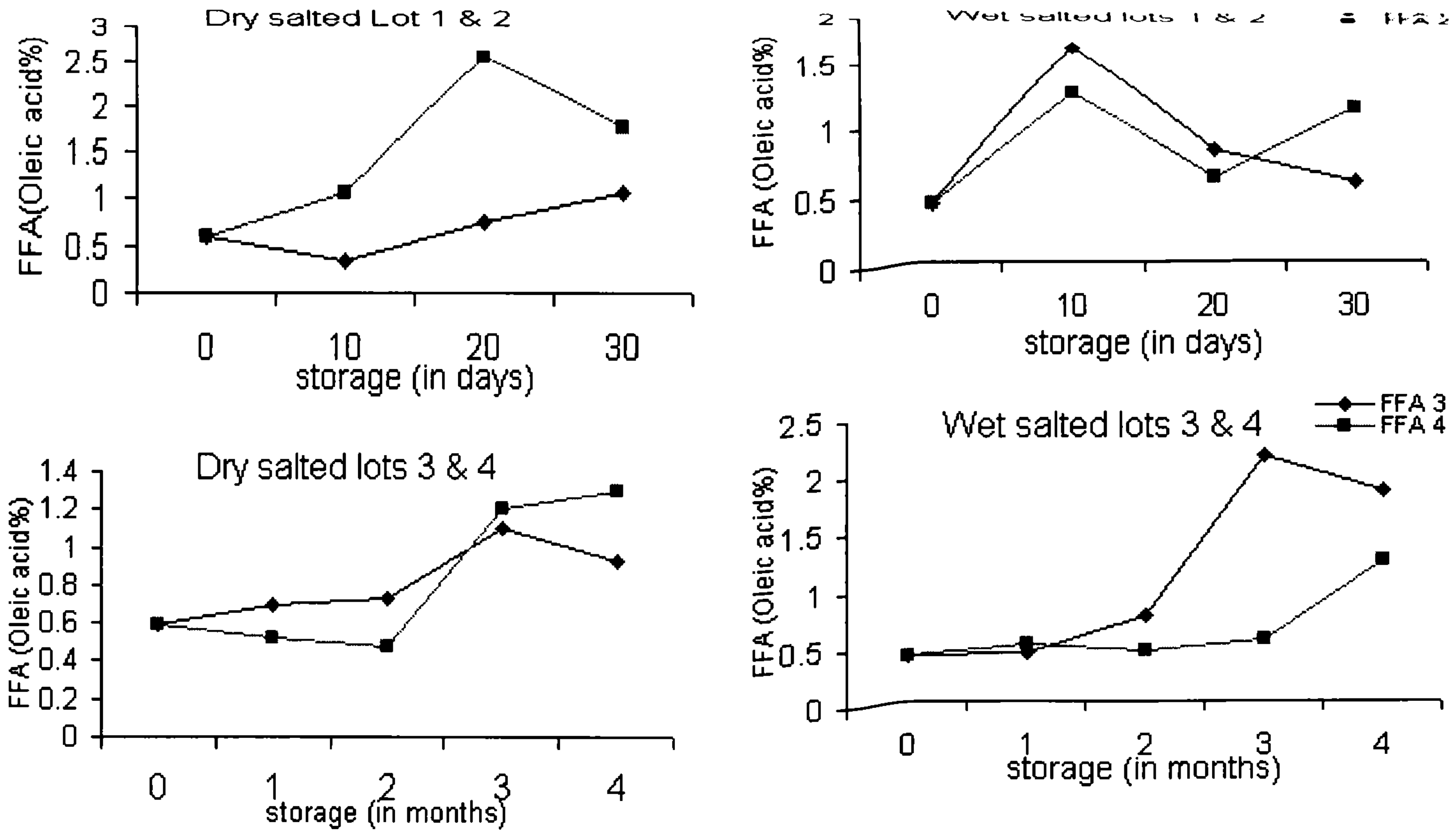

Figure – 8.2. Change in FFA in dry & wet salted Mackerel.

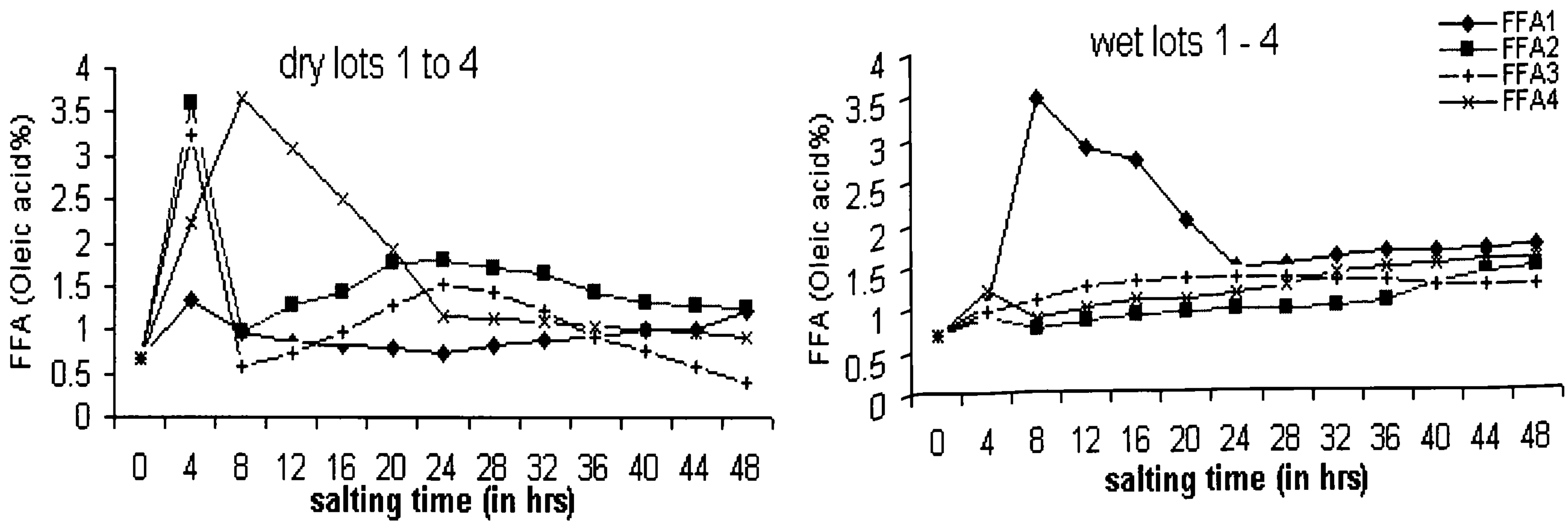

Figure – 8.3. Change in FFA during dry & wet salting of Ribbonfish.

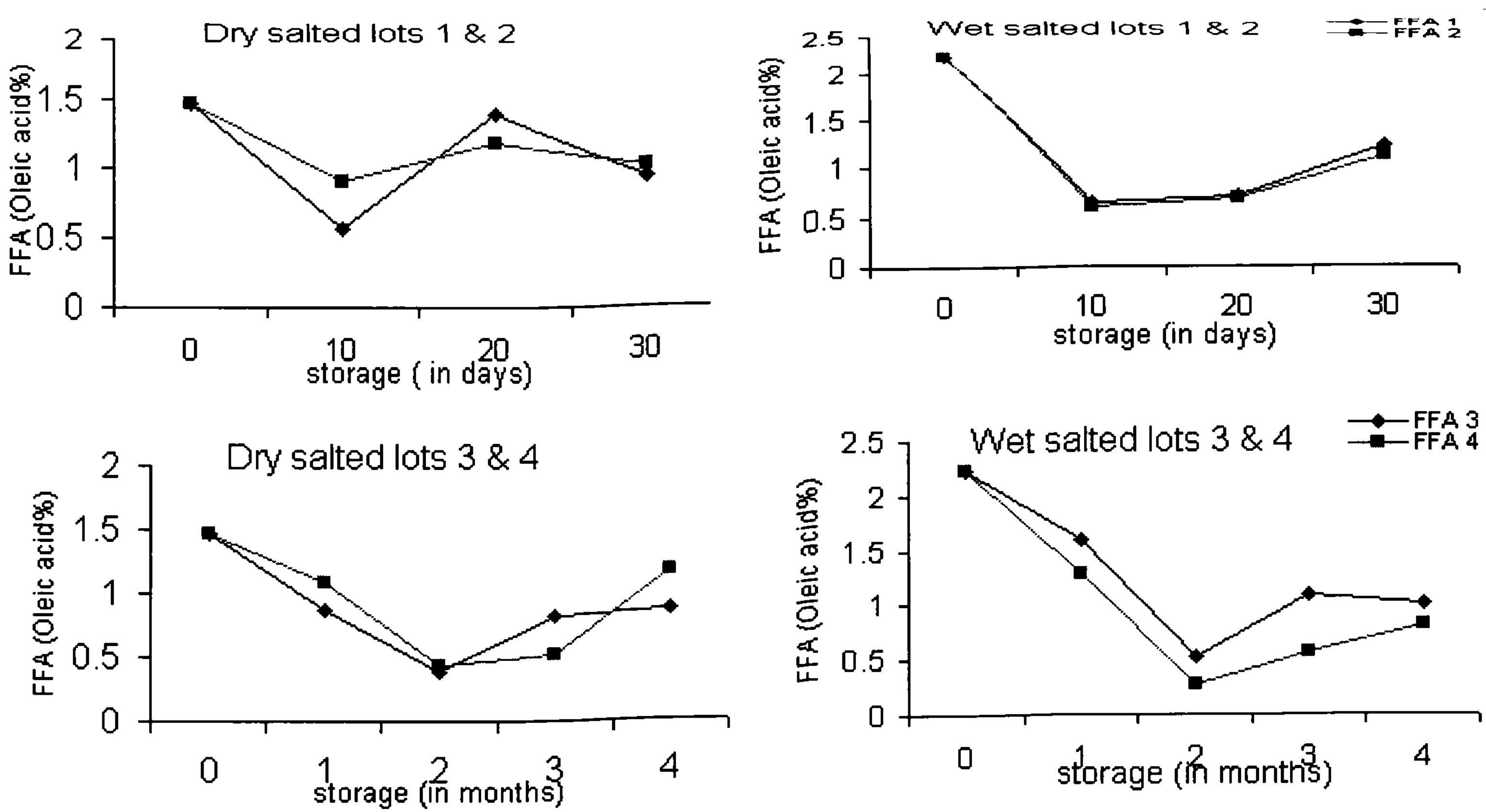

Figure – 8.4. Change in FFA in dry & wet salted Ribbonfish.

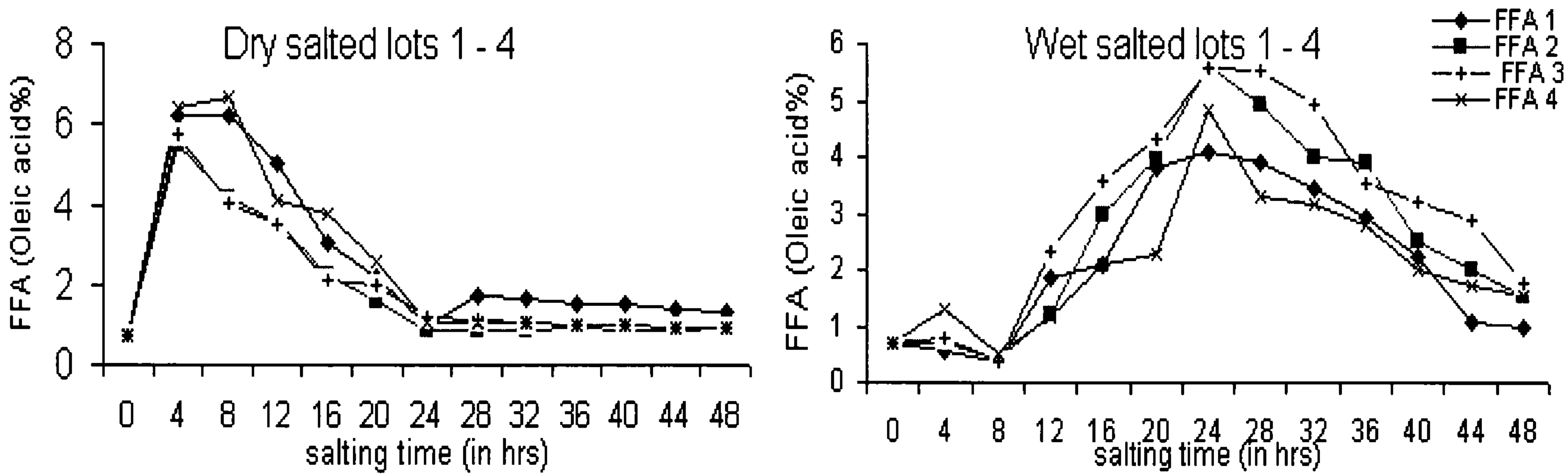

Figure – 8.5. Change in FFA during dry & wet salting of Shark.

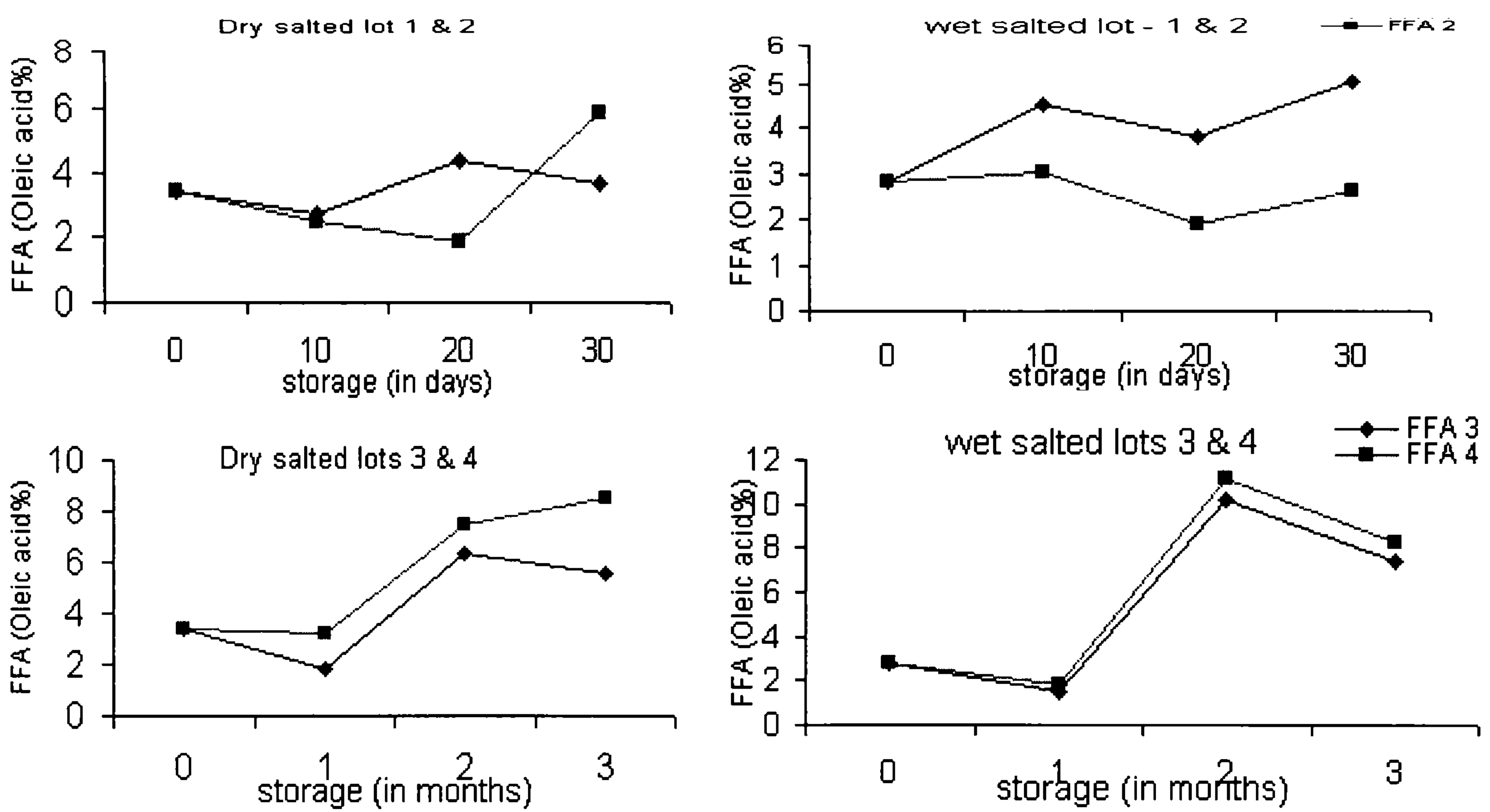

Figure – 8.6. Change in FFA in dry & wet salted Shark

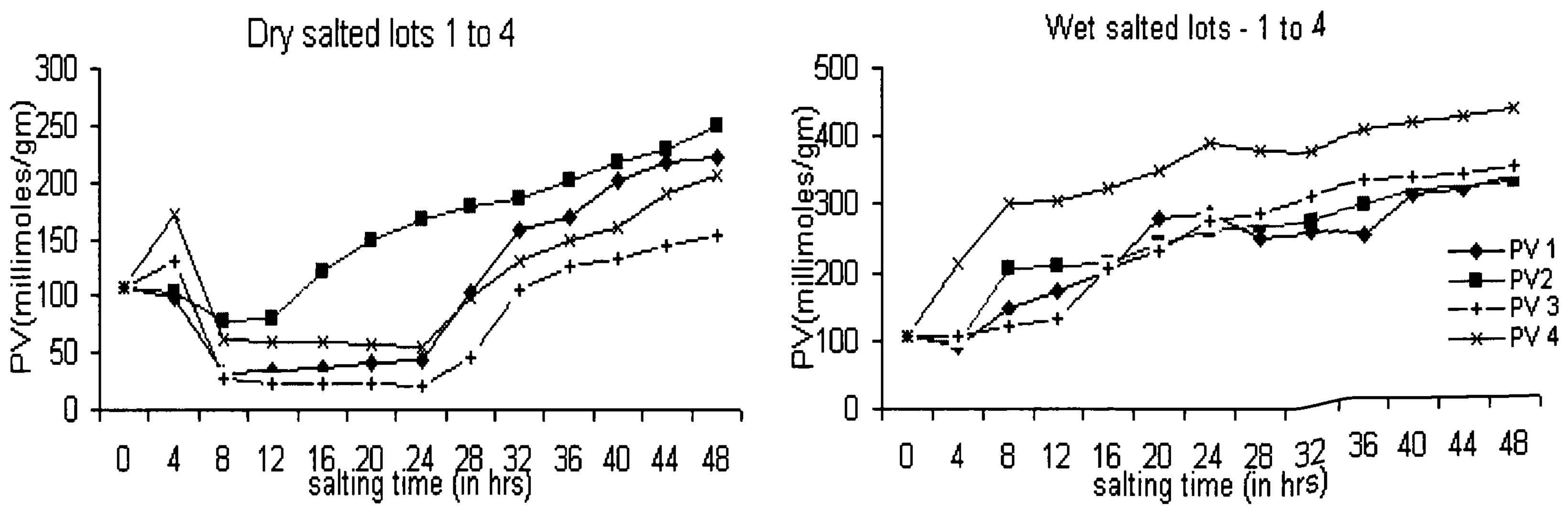

Figure – 8.7. Change in PV during dry & wet salting of Mackerel

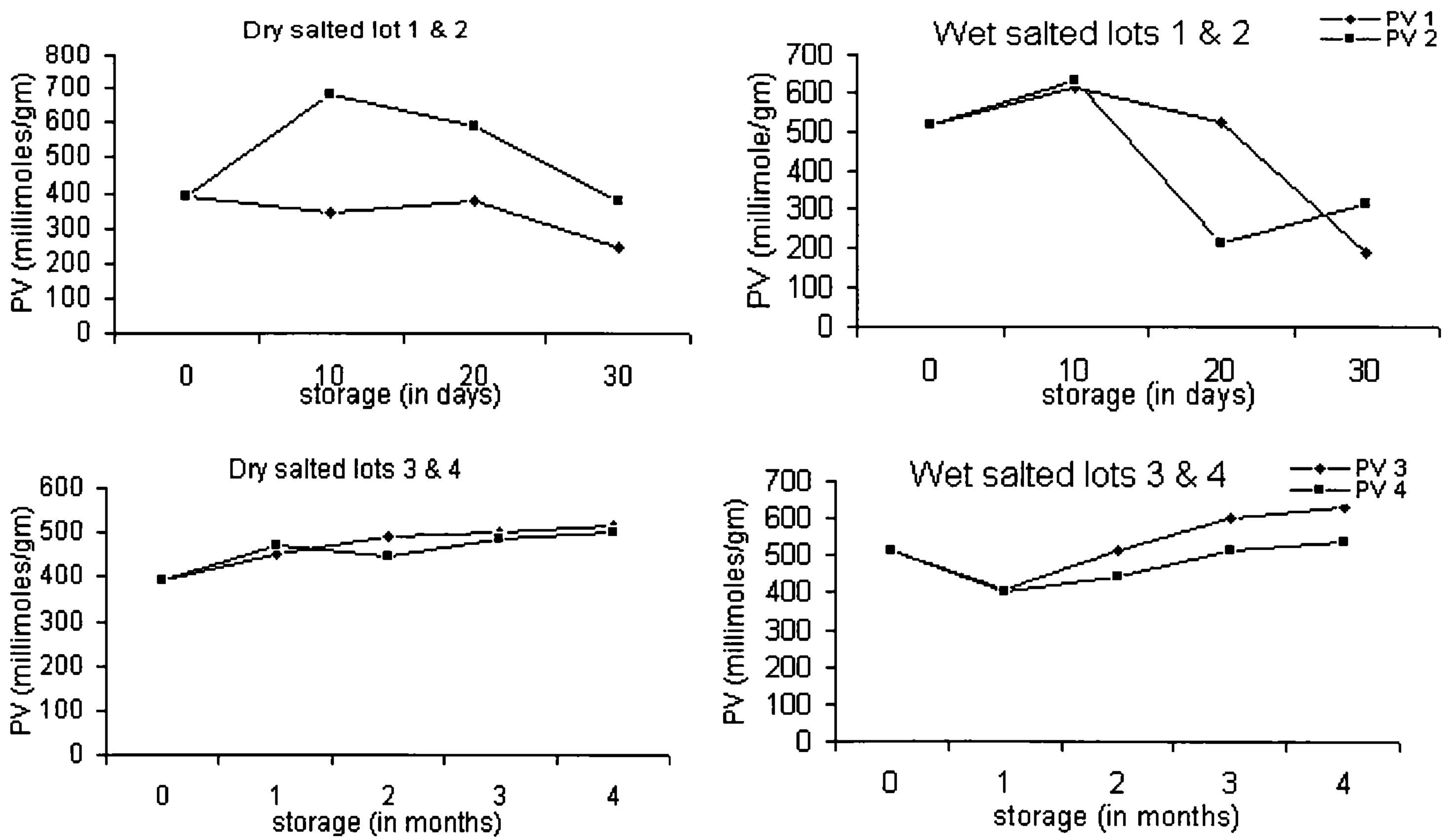

Figure – 8.8. Change in PV in dry & wet salted Mackerel

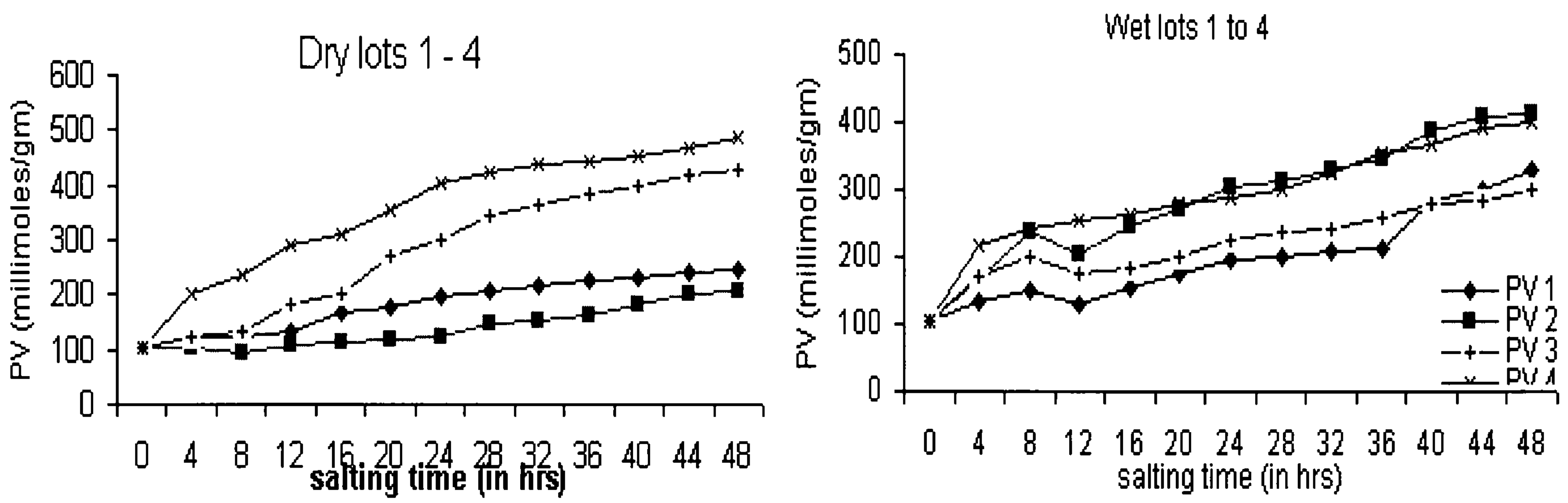

Figure – 8.9. Change in PV during dry & wet salting of Ribbonfish

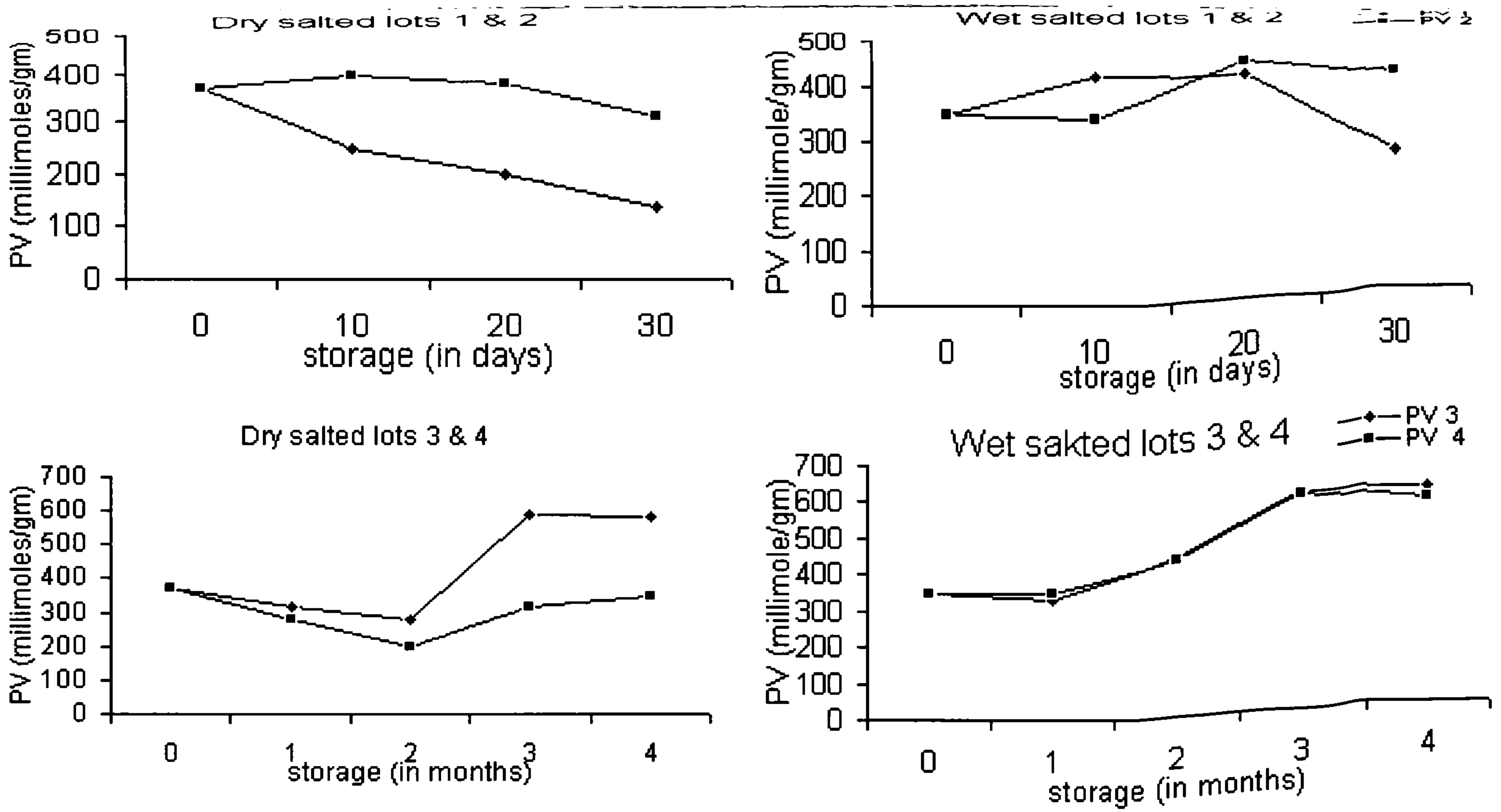

Figure – 8.10. Change in PV in dry & wet salted Ribbonfish

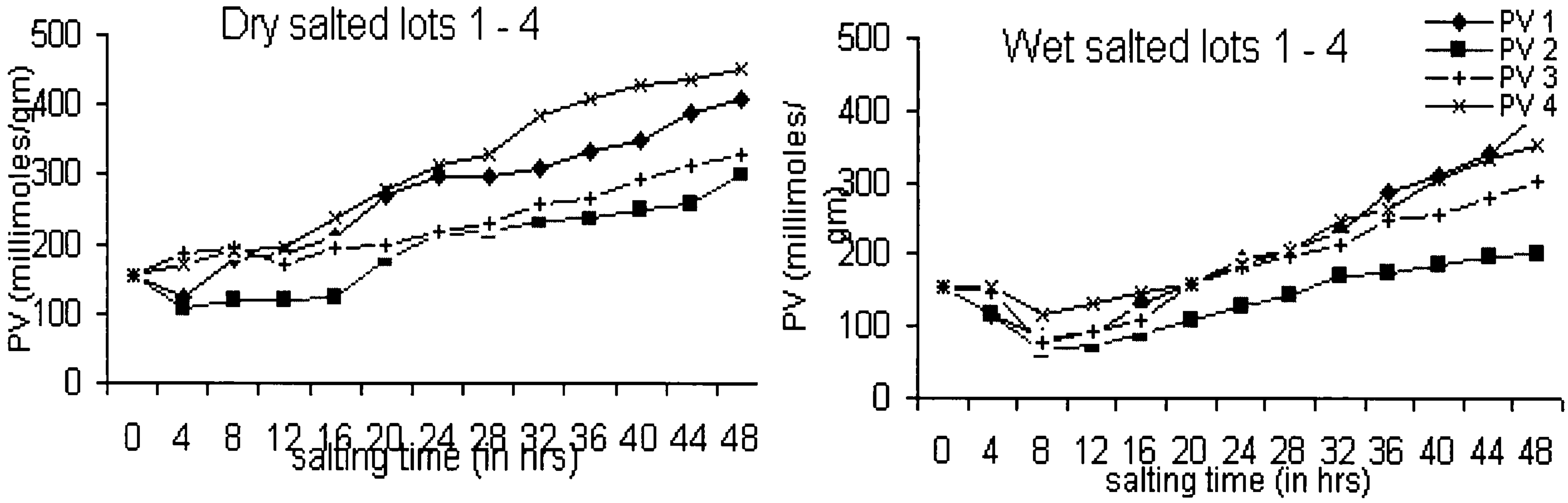

Figure – 8.11. Change in PV during dry & wet salting of Shark

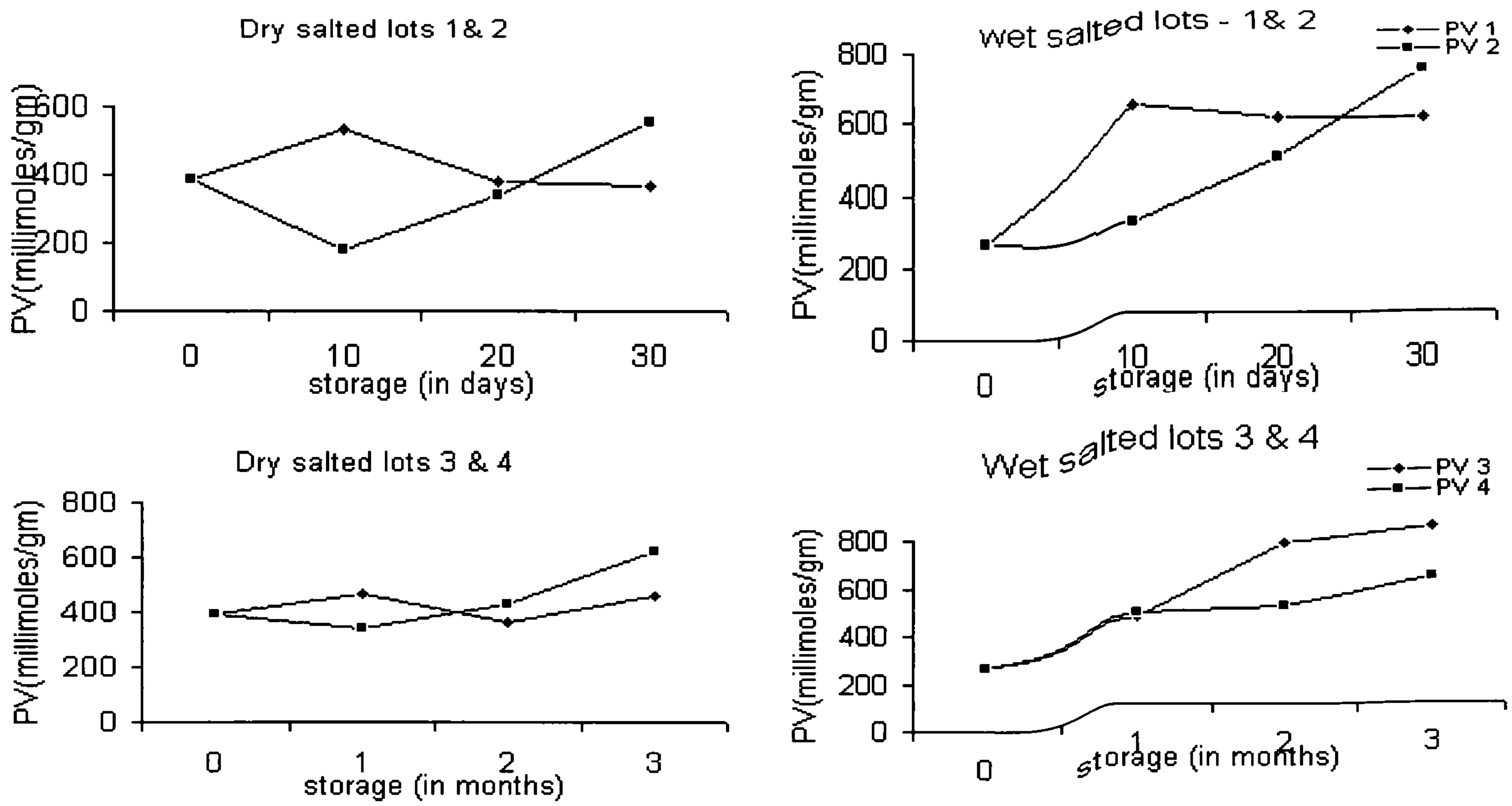

Figure – 8.12. Change in PV in dry & wet salted Shark able – 8.1. Effect of sun drying on FFA (Oleic Acid %) & PV (Millimole gm) in Mackerel

In dry salted Mackerel								
ge / fish	Lot - 1		Lot – 2		Lot - 3		Lot - 4	
Hours	FFA	PV	FFA	PV	FFA	PV	FFA	PV
0 hrs	1.37	222.91	0.33	248.7	0.48	154.02	0.41	205.91
4 hrs	0.88	301.05	0.38	265.88	0.65	218.22	0.83	223.95
8 hrs	2.68	328.78	0.43	288	0.59	202.4	0.8	239.56
In wet salted Mackerel								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
0 hrs	0.58	325.33	0.44	317.06	0.41	337.14	0.51	422.87
4 hrs	0.75	342.69	0.42	322.65	1.5	358.23	1.25	447.96
8 hrs	0.4	378.25	0.41	344.99	0.67	388.9	1.61	482.03

-8.2. Effect of sun drying on FFA (Oleic Acid %) & PV (Millimole/gm) in Ribbonfish

In dry Salted Ribbonfish								
e / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
	FFA	PV	FFA	PV	FFA	PV	FFA	PV
hrs	1.22	247.54	1.26	206.89	0.41	428.01	0.93	489.17
hrs	1.38	324.38	1.14	254	0.92	442.29	1.35	508.65
hrs	1.17	352.02	1.46	274.24	0.86	451.44	1.39	528.01
In wet Salted Ribbonfish								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
hrs	1.68	328.18	1.44	411.63	1.21	301.92	1.53	398.9
hrs	1.22	386.88	1.46	432.93	2.19	312.08	1.68	433.77
hrs	0.86	394.6	1.37	451.52	2.23	342.06	1.65	458.31

able – 8.3. Effect of sun drying on FFA (Oleic Acid%) & PV (Millimoles/ gm)

In dry Salted Shark								
e / fish	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
ours	FFA	PV	FFA	PV	FFA	PV	FFA	PV
hrs	1.34	410.02	0.92	301.01	0.93	328.02	0.92	453.04
hrs	3.33	455.48	3.11	366.66	3.33	351.43	2.5	477.14
hrs	2.43	472.02	2.15	382.87	3.41	389.76	4.02	489.84
In wet Salted Shark								
	Lot - 1		Lot - 2		Lot - 3		Lot - 4	
hrs	0.97	394.01	1.52	202.09	1.78	302.02	1.52	352.72
hrs	1.08	417.01	2.43	255.01	2.09	359.73	2.33	378.01
hrs	1.87	438.67	2.82	266.67	2.24	372.01	2.71	389.13

'able 1 Results of FFA in 4 lots of dry salted Mackerel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
'ows	48.55652	12	4.046377	53.93018	2.56E-19	2.032703
'olumns	0.896498	3	0.298833	3.982847	0.015061	2.866265
'rror	2.701077	36	0.07503			
'otal	52.1541	51				

'able 2 Results of FFA in 4 lots of wet salted Mackerel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
'ows	0.260942	12	0.021745	1.000885	0.467732	2.032703
'olumns	0.02879	3	0.009597	0.44172	0.724587	2.866265
'rror	0.782135	36	0.021726			
'otal	1.071867	51				

'able 3 Results of FFA in 4 lots of dry salted Mackerel during drying

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
'ows	0.3872	1	0.3872	0.939578	0.403885	10.12796
'olumns	2.2099	3	0.736633	1.787511	0.322568	9.276619
'rror	1.2363	3	0.4121			
'otal	3.8334	7				

'able 4 Results of FFA in 4 lots of wet salted Mackerel during drying

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
'ows	0.086112	1	0.086112	0.671988	0.472423	10.12796
'olumns	1.307438	3	0.435812	3.40091	0.170786	9.276619
'rror	0.384438	3	0.128146			
'otal	1.777988	7				

Table 5 Results of FFA in lots 1 & 2 of dry salted Mackerel on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.6303	3	0.543433	1.947092	0.298991	9.276619
Columns	1.3122	1	1.3122	4.701541	0.118645	10.12796
Error	0.8373	3	0.2791			
Total	3.7798	7				

Table 6 Results of FFA in lots 3 & 4 of dry salted Mackerel on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.67606	4	0.169015	5.517056	0.063409	6.388234
Columns	0.00036	1	0.00036	0.011751	0.918896	7.70865
Error	0.12254	4	0.030635			
Total	0.79896	9				

Table 7 Results of FFA in lots 1 & 2 of wet salted Mackerel on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.093338	3	0.364446	4.526575	0.123327	9.276619
Columns	0.000312	1	0.000312	0.003881	0.954242	10.12796
Error	0.241538	3	0.080513			
Total	1.335188	7				

Table 8 Results of FFA in lots 3 & 4 of wet salted Mackerel on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.701438	3	0.567146	2.258233	0.260411	9.276619
Columns	0.750313	1	0.750313	2.987557	0.182352	10.12796
Error	0.753438	3	0.251146			
Total	3.205188	7				

Table 9 Results of FFA in 4 lots of dry salted ribbonfish.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	10.39615	12	0.866346	2.412113	0.020582	2.032703
Columns	4.728223	3	1.576074	4.388167	0.009887	2.866265
Error	12.92993	36	0.359165			
Total	28.0543	51				

Table 10 Results of FFA in 4 lots of wet salted ribbonfish.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	2.692492	12	0.224374	1.321254	0.249478	2.032703
Columns	5.065483	3	1.688494	9.942892	6.49E-05	2.866265
Error	6.113492	36	0.169819			
Total	13.87147	51				

Table 11 Results of FFA in 4 lots of dry salted ribbonfish on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.001012	1	0.001012	0.040588	0.853222	10.12796
Columns	0.280638	3	0.093546	3.749958	0.153206	9.276619
Error	0.074837	3	0.024946			
Total	0.356488	7				

Table 12 Results of FFA in 4 lots of wet salted ribbonfish on drying.

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.0242	1	0.0242	1.581699	0.297506	10.12796
Columns	1.44585	3	0.48195	31.5	0.009078	9.276619
Error	0.0459	3	0.0153			
Total	1.51595	7				

Table 13 Results of FFA in lot 1 & 2 of dry salted ribbonfish on storage.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.622485	3	0.207495	8.596039	0.05529	9.276619
Columns	0.005565	1	0.005565	0.23055	0.663953	10.12796
Error	0.072415	3	0.024138			
Total	0.700466	7				

Table 14 Results of FFA in lot 3 & 4 of dry salted ribbonfish on storage.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.26786	4	0.316965	11.90032	0.017095	6.388234
Columns	0.00676	1	0.00676	0.253801	0.640892	7.70865
Error	0.10654	4	0.026635			
Total	1.38116	9				

Table 15 Results of FFA in lot 1 & 2 of wet salted ribbonfish on storage.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	3.30305	3	1.101017	1348.184	3.42E-05	9.276619
Columns	0.00245	1	0.00245	3	0.18169	10.12796
Error	0.00245	3	0.000817			
Total	3.30795	7				

Table 16 Results of FFA in lot 3 & 4 of wet salted ribbonfish on storage.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	3.9148	4	0.9787	52.93131	0.001019	6.388234
Columns	0.16384	1	0.16384	8.861006	0.04087	7.70865
Error	0.07396	4	0.01849			
Total	4.1526	9				

ble 17 Results of FFA in 4 lots of dry salted shark.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	152.5492	12	12.71244	68.84405	4.1E-21	2.032703
umns	4.8808	3	1.626933	8.810638	0.000163	2.866265
or	6.6476	36	0.184656			
al	164.0776	51				

ble 18 Results of FFA in 4 lots of wet salted shark.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	105.4658	12	8.788813	40.98723	2.46E-17	2.032703
umns	7.696038	3	2.565346	11.96367	1.39E-05	2.866265
or	7.719412	36	0.214428			
al	120.8812	51				

ble 19 Results of FFA in 4 lots of dry salted shark on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ws	0.00845	1	0.00845	0.012576	0.917793	10.12796
umns	0.7018	3	0.233933	0.348158	0.795356	9.276619
or	2.01575	3	0.671917			
al	2.726	7				

ble 20 Results of FFA in 4 lots of wet salted shark on drying.

OVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	0.365513	1	0.365513	10.34104	0.048742	10.12796
olumns	1.619638	3	0.539879	15.2742	0.025376	9.276619
rror	0.106037	3	0.035346			
otal	2.091188	7				

Table 21 Results of FFA in lots 1 & 2 of dry salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4.975038	3	1.658346	0.933361	0.521939	9.276619
Columns	0.049612	1	0.049612	0.027923	0.877918	10.12796
Error	5.330238	3	1.776746			
Total	10.35489	7				

Table 22 Results of FFA in lots 3 & 4 of dry salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	37.46566	4	9.366415	13.14538	0.014286	6.388234
Columns	6.561	1	6.561	9.208098	0.03861	7.70865
Error	2.8501	4	0.712525			
Total	46.87676	9				

Table 23 Results of FFA in lots 1 & 2 of wet salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.877638	3	0.625879	1.159366	0.453059	9.276619
Columns	4.248613	1	4.248613	7.870048	0.067552	10.12796
Error	1.619537	3	0.539846			
Total	7.745788	7				

Table 24 Results of FFA in lots 3 & 4 of wet salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	110.3299	4	27.58247	300.9051	3.28E-05	6.388234
Columns	0.51984	1	0.51984	5.671085	0.075873	7.70865
Error	0.36666	4	0.091665			
Total	111.2164	9				

Table 25 Results of PV in 4 lots of dry salted Mackerel

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	152132.9	12	12677.74	18.27065	8.02E-12	2.032703
Columns	39474.46	3	13158.15	18.963	1.51E-07	2.866265
Error	24979.88	36	693.8855			
Total	216587.2	51				

Table 26 Results of PV in 4 lots of wet salted Mackerel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	304555.4	12	25379.62	38.09806	8.14E-17	2.032703
Columns	103260.5	3	34420.17	51.66908	3.99E-13	2.866265
Error	23981.96	36	666.1656			
Total	431797.9	51				

Table 27 Results of PV in 4 lots of dry salted Mackerel on drying

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	308.0162	1	308.0162	1.626618	0.291972	10.12796
Columns	13120.51	3	4373.504	23.09625	0.014172	9.276619
Error	568.0797	3	189.3599			
Total	13996.61	7				

Table 28 Results of PV in 4 lots of wet salted Mackerel on drying.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1880.071	1	1880.071	107.5755	0.001912	10.12796
Columns	19476.58	3	6492.195	371.4757	0.000236	9.276619
Error	52.4303	3	17.47677			
Total	21409.09	7				

ble 29 Results of PV in lots 1 & 2 of dry salted mackerel on storage

IOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ws	49472.5	3	16490.83	1.642193	0.346805	9.276619
lumns	57611.45	1	57611.45	5.737073	0.096288	10.12796
'or	30125.88	3	10041.96			
tal	137209.8	7				

ble 30 Results of PV in lots 3 & 4 of dry salted mackerel on storage

IOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ws	16231.16	4	4057.79	16.22647	0.009718	6.388234
lumns	303.2705	1	303.2705	1.212731	0.332603	7.70865
ror	1000.289	4	250.0723			
tal	17534.72	9				

able 31 Results of PV in lots 1 & 2 of wet salted mackerel on storage

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	156662.3	3	52220.78	3.110784	0.188106	9.276619
olumns	3561.68	1	3561.68	0.212169	0.67641	10.12796
rror	50361.05	3	16787.02			
otal	210585.1	7				

able 32 Results of PV in lots 3 & 4 of wet salted mackerel on storage

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	40566.91	4	10141.73	9.991859	0.023324	6.388234
olumns	6694.121	1	6694.121	6.5952	0.062103	7.70865
rror	4059.996	4	1014.999			
otal	51321.02	9				

able 33. Results of PV in 4 lots of dry salted ribbonfish.

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	308802	12	25733.5	11.79172	3.91E-09	2.032703
olumns	362780.1	3	120926.7	55.41157	1.44E-13	2.866265
rror	78564.13	36	2182.337			
otal	750146.3	51				

able 34. Results of PV in 4 lots of wet salted ribbonfish

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	260566.5	12	21713.87	41.94353	1.68E-17	2.032703
olumns	86118.84	3	28706.28	55.45039	1.42E-13	2.866265
rror	18636.95	36	517.693			
otal	365322.3	51				

able 35. Results of PV in 4 lots of dry salted ribbonfish on drying.

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	729.429	1	729.429	25.25414	0.01518	10.12796
olumns	76434.23	3	25478.08	882.0965	6.47E-05	9.276619
rror	86.65064	3	28.88355			
otal	77250.31	7				

able 36. Results of PV in 4 lots of wet salted ribbonfish on drying.

NOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
ows	816.6861	1	816.6861	17.96057	0.024051	10.12796
olumns	18595.88	3	6198.626	136.3203	0.001053	9.276619
rror	136.4131	3	45.47105			
otal	19548.98	7				

Table 37 Results of PV in lots 1 & 2 of dry salted ribbonfish on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	22662.44	3	7554.145	2.21487	0.265282	9.276619
Columns	29997.8	1	29997.8	8.795333	0.059273	10.12796
Error	10231.95	3	3410.65			
Total	62892.19	7				

Table 38 Results of PV in lots 3 & 4 of dry salted ribbonfish on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	76023.01	4	19005.75	2.520978	0.19617	6.388234
Columns	38845.3	1	38845.3	5.152553	0.085735	7.70865
Error	30156.16	4	7539.039			
Total	145024.5	9				

Table 39 Results of PV in lots 1 & 2 of wet salted ribbonfish on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	11760.81	3	3920.27	0.799051	0.570961	9.276619
Columns	1359.551	1	1359.551	0.277111	0.635039	10.12796
Error	14718.48	3	4906.159			
Total	27838.83	7				

Table 40 Results of PV in lots 3 & 4 of wet salted ribbonfish on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	118981.2	4	29745.29	229.7615	5.62E-05	6.388234
Columns	64.11024	1	64.11024	0.495207	0.520419	7.70865
Error	517.8465	4	129.4616			
Total	119563.1	9				

able 41 Results of PV in 4 lots of dry salted shark

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	297538.2	12	24794.85	26.85805	2.22E-14	2.032703
olumns	91987.33	3	30662.44	33.21389	1.8E-10	2.866265
rror	33234.52	36	923.1812			
otal	422760.1	51				

able 42 Results of PV in 4 lots of wet salted shark

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	258488.6	12	21540.71	31.56067	1.72E-15	2.032703
olumns	43585.49	3	14528.5	21.28663	4.19E-08	2.866265
rror	24570.64	36	682.5177			
otal	326644.7	51				

able 43 Results of PV in 4 lots of dry salted shark on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	877.3861	1	877.3861	12.77615	0.037436	10.12796
olumns	20784.82	3	6928.275	100.8868	0.001646	9.276619
rror	206.0212	3	68.67375			
otal	21868.23	7				

able 44 Results of PV in 4 lots of wet salted shark on drying.

NOVA

Source of Variation	SS	df	MS	F	P-value	F crit
ows	402.1448	1	402.1448	32.05431	0.010912	10.12796
olumns	30048.18	3	10016.06	798.3638	7.51E-05	9.276619
rror	37.6372	3	12.54573			
otal	30487.96	7				

Table 45 Results of PV in lots 1 & 2 of dry salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	13666.91	3	4555.637	0.179348	0.904049	9.276619
Columns	5661.012	1	5661.012	0.222865	0.669081	10.12796
Error	76203.17	3	25401.06			
Total	95531.09	7				

Table 46 Results of PV in lots 3 & 4 of dry salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	37279.47	4	9319.868	1.631522	0.323468	6.388234
Columns	3340.487	1	3340.487	0.584781	0.487068	7.70865
Error	22849.51	4	5712.377			
Total	63469.46	9				

Table 47 Results of PV in lots 1 & 2 of wet salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	127675	3	42558.34	2.140462	0.273998	9.276619
Columns	11119.13	1	11119.13	0.559234	0.508852	10.12796
Error	59648.35	3	19882.78			
Total	198442.5	7				

Table 48 Results of PV in lots 3 & 4 of wet salted shark on storage

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	210524.2	4	52631.05	6.625843	0.047078	6.388234
Columns	36984.64	1	36984.64	4.656081	0.097129	7.70865
Error	31773.2	4	7943.299			
Total	279282.1	9				

Chapter 9

QUALITY CHANGES OF FISH DURING SALTING, DRYING, STORAGE AND HACCP

!. Introduction

There are various factors associated with quality control of fish. According to ss (1994) the word 'quality' embraces a lot of meaning such as safety, gastronomic ights, purity, nutrition, consistency, honesty, value and product of excellence. ISO 02 defined quality as " the totality of features and characteristics of a product or rvice that bear on its ability to satisfy as stated or implied needs." The earlier initions of quality were " Fitness for use", "value for money", "Degree of Excellence." cording to Zugarramurdi *et al.* (1993) quality production starts with an investment in ality.

The basic principle of the HACCP system was first published in 1971. Various stitutions like International Commission for Microbial Specifications for Foods (ICMSF), orld Health Organization (WHO), Food and Agriculture Organization (FAO, 1991), uality Management Programme (QMP) of Canada had developed various quality andards for seafood industry (Anon.1988b). The United Kingdom follows quality stems as British standards (B.S). European Economic Community (EEC), Australian uarantine and Inspection Service (AQIS), Australia had laid down their own quality ntrol system (Anon., 1993b). India follows Indian Standards (IS) and In-plant Quality ontrol (IPQC), the quality system as lay down by FAO, the HACCP manual (Anon., 92, FAO. 1992). At present HACCP has been adopted as a standard system of ocess control in seafood processing world over including India. In India this is now eing practiced in the entire freezing plants and exporting units. There are no clear uidelines in the case of cured fish or dried fish products produced in India and other eveloping countries. According to the Council Directive (Anon, 1991) salting process ay be done in the unpolluted area, but the consumer satisfaction of dried fish is not oted.

The HACCP system has not been applied in the cured / dried fish quality control :is an outlook of the fish processing plant. The HACCP is a progressive planning e the processors as well as the traders equally have to plan their own needs to up their product in a better way to control spoilage to a minimum. This is to achieve a uct with good quality, long storage life and better revenue. The processors can t each program for each type of fish to keep high standard but the same shall be ded for future reference, verification and inspection on demand. So these records jive a good idea of understanding to identify how and what are the drawbacks of the ty in preparing the earlier products. So it will become a systematic study for oving the quality of the product.

FAO (1999) defined that critical limits may be set for factors such as erature, time, physical product dimensions, water activity, moisture level, etc. These meters, if maintained within boundaries, will confirm the safety of the product. A ird is a biological, chemical or physical agent to cause harm to the consumer. Food ty risk analysis is an emerging discipline, and the methods used for assessing and aging risks associated with food hazard. So minimizing of risk and health hazards important. The identification of the risk is important to minimize hazard. So the ess of long or short term planning of risk analysis process helps to reduce the ee of hazard. This may be applied either to every type of fish or products prepared. is applicable in every aspect of fish processing and storage and sales (FAO, 1999; ji, 1993). The main elements of HACCP (Huss, 1994) are to Identify the potential irds, determine the Critical Control Points (CCPs), establish the criteria that must be to ensure that CCP is under control, establish a monitoring system, establish the rective action when CCP is not under control, establish procedure for verification and tablish documentation and record keeping. The risk is the estimated possibility and verity of adverse health effects in the exposed populations consequential to hazards in

d. It is essential to note that there is no "zero risk" food. So the risk really needs the sideration of quality of the product. The quality analysis programme needs the CCP tree developmental process in every process control for each product elopment process.

'1. Application of ISO - 9000 Series and Certification

Based on the good experience gained with British standards (BS) 5750 series lished in 1979 were adopted by ISO and the ISO series were published in 1987 ing at providing an international acknowledgement of quality efforts. It is a well-ined quality system and organization having equal responsibility to the management d workers and also the consumer right from the manufacturing point to selling point. ther this system defines all standards needed for the good quality product including e personal hygiene and health factors.

According to FAO. (1999), the sources of critical limits included are scientific lications and research data, regulatory requirements and guidelines, expert's opinion d experimental studies. The food hazard and risk analysis are the same subject but ferent matters. According to HACCP programme, the sequence of application of ACCP and checklist of the same are essential. Every rise in temperature and the delay processing cause spoilage of fish and products and results in an adverse effect. The int at which the fish and fishery product get the chance of spoilage has to be checked n the interest of better production in future. So the actual record keeping and other data elp to recheck the process control of the product to avoid the chances of spoilage of sh. The process of HACCP in a complete manner may be useful to the processor for he betterment of product as well as the customer. There is a necessity to adopt the HACCP system in the process control of dried and cured fish processing and product evelopment. While doing so, all the relevant factors are to be taken in to mind so that a ull quality control system can be adopted

2. **Quality changes in the dried fish**

FAO (1953) reported the standards for dried fishes in various countries. The orts showed that there is a need to improve the quality standards of the cured and d fish because most of the fishes are dried at beach without any safety measures to product. Srinivasan & Joseph (1966) reported on the products from Kanyakumari t the level of spoilage increased as storage period increased at normal condition. rther, the degree of spoilage depends on the absence of sufficient salt. The other ctors suggested were, due to salting of spoiled raw fish, imperfect washing and aning of the fish, inadequate curing and drying and handling under unhygienic ndition. The quality changes of the dried fish and cured fish along the Maharashtra ast was reported by Joseph *et al.* (1988a), along the Saurashtra Coast by Solanki & nkar (1988) Kalaimani *et al.* (1988) and along West Coast by Muraleedharan *et al.* 989), Malabar and Kanara coasts (Joseph *et al.*, 1983). Quality changes in Baracuda is reported by Joseph *et al.* (1987) with reference to moisture and salt content. Prasad *al.* (1994) reported the chemical and microbiological quality of dried fish from kinada.

1.3. **Pink formation**

The formation of pink or red discolouration on surface of the cured or salted oduct adversely affects the appearance. Species of the genus Halo bacterium and lococcus (Anon., 1981) attack dried fish and a pink or red discolouration is formed. It is two groups as *Sarcina littoralis, Pseudomonas salinaria* (Klaveren & Legendre, 65). It survives but not grows in salt water. They have a strong proteolytic action and e latter cause indole and hydrogen sulphide and they require 25 to 30% salt. Anon. 987) stated that on fish they very rapidly react and soften the flesh and has putrid nell and flavour and become unfit for consumption. Klaveren & Legendre (1965) ggested that the red halophiles grow on moist surface. Prasad & Rao (1994) stated at the red or pink formation is the major factor followed by rancidity and fungal rmation. The better quality fish can be obtained if better quality salt is used (Joseph *et a*l, 1986). Prasad and Rao (1995) reported that the pink formation can be better prevented if the salt is sterilized before salting. Both have suggested that salt tolerant acteria are found in salt itself.

The moisture content is another factor, which control the growth of pink forming acteria and also inadequate drying of the product. Kalaimani *et al.* (1988) and uraleedharan *et al.* (1989) reported that the dried sample had 35.4 to 40% moisture nd 20 to 25% salt on dry weight basis. Minimum recommended moisture content cepted to the dried fishes (thread fin bream, Jew fish, horse mackerel) is 40% as in S.I. (1974, 1967a) and minimum required salt content in the said fishes are 25%. The y salted mackerel should have a recommended moisture content of 35% and salt 25% nd acid insoluble ash 1.5% (ISI, 1967b). The recommended level to dry salted shark is oisture 40% salt 25 to 30% and acid insoluble 1.5% (I.SI., 1969). Govindan (1985) ported that the growth of a halophilic mould called *Sporendonema epizoum* has timum growth condition at salt concentration 10 to 15%, relative humidity 75% and nperature 25^{0}C. Anon. (1981) reported that the halophilic bacteria grow at a_w 0.75 at gh salt environment. The pink formation can be better removed by washing the same the initial stage in clean water or brine solution and re-drying. But this cannot be opted for highly contaminated fishes.

FAO (1991) suggested that keeping the fish at low temperature of 10^0 C check e growth of red halophiles. Syme (1966) reported that the dry fish should be stored at ^{0}F (5^{0}C) so that the red halophiles do not grow. The maximum growth occurs during e storage at 77^{0}F (25^{0}C). The growth of red halophiles is due to the proteolytic action the meat at 25^{0}C (Klaveren & Legendre, 1965). Anon. (1965) suggested that salted fish stored at low temperature will not encourage the growth of red halophiles. Rubbi al. (1983) reported that the fish stored at 13^0C is of superior quality in all cases than t fish stored at room temperature. Camu *et al.* (1983) suggested that the dried ackerel stored at 18^0C is acceptable for 12 weeks. Tressler & Lemon (1951) commended low temperature for fatty fishes. Ramachandran & Solanki (1991) ported the formation of red discolouration in semi - dried products of shark.

1.4. Dun formation

Klaveren & Legendre (1965) reported that the dun is brown or chocolate in olour, pepper like spot and grows at 10 to 15% salt. Anon. (1965) suggested that the alt constituent first absorbs moisture and wet surface helps the growth of pink and dun acteria and mould respectively. The growth depends upon the hygienic condition of the lant, curing yard and storage premises (Sukumar *et al.,* 1995). Anon. (1981) reported hat it is common at a_w 0.75 and 10 to 15% sodium chloride and at high glucose level. It s black, brown or fawn spot on the surface and caused by the growth of halophilic or alotolerant fungi. *Wallemia spora, Wallamia sabi*, appears chocolate in colour. The ost common species are *Aspergillus* species and *A. glaucus* species, which cause an bjectionable flavour and textural changes in fish. The metabolism causes the release of moisture and increase a_w around the affected parts. It rapidly spread over at the surface nd spoils fish depending on moisture level. The maximum growth is at 30^0C and grows p to 40 to 45^0C and the growth is less at low temperature - 10 to -15^0C. Syme (1966) eported that dun forms at 5% salt and does not grow below 41^0F (5.0^0C) the optimum rowth is at 77^0F (25.0^0C). FAO. (1957) reported that moulds are harmless, do not amage the flesh and growth is very slow. It grows only, if fish absorbs moisture from he atmosphere. It can be prevented by good hygienic method in and around the rocessing plant. Anon. (1982) reported that the presence of mould on the surface of the ish makes the product unacceptable to the consumer besides having the risk of cotoxin produced by some type of moulds on fish. The fish may be re-dried and red or damp the fish to prevent the contamination.

Gupta & Samuel (1985) reported that fungal infestation causes mycotoxin by *pergillous* sp. of cochin market. Joseph *et al.* (1986) reported that no pathogenic teria were identified in Tamilnadu coast,.but contaminated with halophilic bacteria. akrabarti & Varma (1997) reported that fungi are dominated during rainy season ng Kakinada coast. Chakrabarti & Varma (1999) stated that halotolerent fungi are ilable in salted dried fish along Visakkhapatnam coast. Prasad *et al.* (1994) reported t the dried fish from Kakinada had *coliforms, E.coli, faecal streptococci* and *coagulase sitive staphylococci.* Sanjeev & Surendran (1993 & 1996) reported the distribution of terial count in cured fish. They noted that *S.aureus* can not grow after 48 hrs salting l decrease further after sun drying. As the present study deals with more chemical nges in fish, the bacteriogical study was not deeply dealt with.

. Aim

s chapter aims to study:

- The Total Plate Count of the fishes at fresh condition
- The quality aspects of the fishes during dry and wet salting in different preservatives, drying and storage in different conditions
- To prepare a new HACCP system in relation to dry and wet salted fishes
- To prepare a new HACCP system in relation to semi – dried cured products

. Materials and Methods

The samples prepared as in M.M in the chapter 4 and flow sheet Table no 4.1, and 4.3 are used to find the Total Plate Count (TPC) The sample portion of fresh fish ore and after salting and after drying and storage were separated and used for the dy. The log graphs were prepared during salting and storage period and table was pared for the lot during drying.

. **Relative Humidity (RH)**

The relative humidity of drying yard and storage room are measured using a ve humidity meter and noted at morning, noon and evening. The temperature of the g yard and storage room were measured using a digital thermometer in the ing, noon and evening and noted. The studies were carried out during March to

. **Total Plate Count**

TPC was determined as per the method described by Namboothri (1985) and ɔated at 37^0c for 48 hours. The total bacterial load was counted and calculated with dilution factor.

3. **HACCP**

The processing and salting method of the fishes like mackerel, ribbonfish and rk described in chapter 4 was adopted here as tool. The salting of the fish passes ugh various stages and all the stages are considered in this chapter for HACCP lysis. The important stages are brought under CCP and discussed the chances and sibility of occurrence of hazards, to be controlled with suggestion and appropriate nt in Table 9.2, 9.3 and 9.4.

. **Results**

.1. **Relative humidity**

The relative humidity at morning and evening are high and low at noon. The nperature at noon is high and low at morning and evening. It showed that the both are r connected and changes according to the temperature and vice verse (Figure – 9.1).

.2. **Changes in TPC during salting, drying and storage**

.2.1. **Dry and wet salted Mackerel**

TPC in fresh fish was $5.5x10^3$. In dry salted lot 1, TPC decreased to $3.8x10^3$, $x10^3$, $3.9x10^3$ and $3.5x10^3$ and in wet salted lot $4.5x10^3$, $4.0x10^3$, $4.5x10^3$ and $2.5x10^3$

ɜr 4, 8, 24 and 48 hours of salting than fresh fish. In dry salted lot 2, TPC decreased 2.4x10^3 and increased 2.5x10^3, and decreased 2.2x10^3 and 1.8x10^3 and in wet salted 3.5x10^3, 3.7x10^3, 3.0x10^3 and 1.4x10^3 in same hours. In dry salted lot 3, TPC creased 2.5x10.^{3}, 2.3x10^3 and increased 2.8x10^3 and 2.1x10^3 and wet salted lot ix10^3, 3.2x10^3, 3.4x10^3 and 1.1x10^3 in same hours. In dry salted lot 4, TPC decreased arply 2.1x10^3, 2.9x10^3, 2.2x10^3 and 1.5x 10^3 and in wet salted lot 3.8x10^3, 2.9x10^3, ɜx10^3 and 1.2x10^3 in same hours (Figure – 9.2). In dry salted fish, the salting hours d TPC effects are significant ($p < 0.001$). There is significant difference between lot 1 d 2, and no significance between lot 2 and 3 and lot 3 and 4 also there is significance tween columns c1 and c2 but little significance between c2 and c3 and c3 and c4. In t salted fish, the salting hours and TPC effects are significant ($p < 0.001$). There is gnificance between lot 1 and 2, and little significance between lot 2 and 3 and lot 3 and also there is significance between columns c1 and c2 is higher than others (Table 2).

After drying, dry salted lot one, the TPC increased to 4.4x10^3 after 4 hours at on and decreased to 3.4x10^3 after 8 hours at evening and in wet salted lot it creased to 4.6x10^3 and 3.4x10^3 at noon and evening than salted fish. In dry salted lot o, TPC increased at noon 3.2x10^3 and decreased 2.5x10^3 and in wet salted lot creased to 4.2x10^3 and 3.3x10^3 in the same period. In dry salted lot three, the trend of ᴾC were 3.5x10^3 and 2.2x10^3 and in wet salted lot 4.01x10^3 and 3.2x10^3 in the same riod. In dry salted lot four, TPC increased to 3.61x10^3 and subsequently decreased to 8x10^3 and in wet salted lot 4.2x10^3 and 1.5x10^3 at noon and evening (Table – 9.1). In y salted fish, there is significant difference between drying hours and TPC ($p < 0.05$) able 3). In wet salted fish, there is no significant difference between drying hours and tween TPC (Table 4).

TPC in unpacked stored dry salted lot one, had 0.6x10^3, 0.2x10^3 and 0.3x10^3 d wet salted lot were 1.5x10^3, 1.1x10^3 and 0.3x10^3 at 10, 20 and 30 days than dried sh. TPC in packed stored lot two, dry salted lot increased to $3.1x10^3$, $3.4x10^3$ and .6x10^3 and wet salted lot to $3.5x10^3$, $4.01x10^3$ and $4.52x10^3$ in the same period. TPC in frigerator stored dry salted lot three had $1.3x10^3$, $1.2x10^3$, $1.35x10^3$ and $1.4x10^3$ and et salted lot had $3.5x10^3$, $3.41x10^3$, $3.62x10^3$ and $3.6x10^3$ after one to four months. PC in cold storage stored dry salted lot four had $2.4x10^3$, $1.8x10^3$, $1.5x10^3$ and .56x10^3 and wet salted lot $3.4x10^3$, $3.2x10^3$, $2.8x10^3$ and $2.5x10^3$ in the same period Figure – 9.3). In dry salted fish, there is no significant difference between storage period nd between TPC columns in lots one and two and storage period and between TPC ffects are not significant in lots three and four (Table 5 & 6). In wet salted fish, there is o significant difference between storage period and between TPC columns in lot one nd two and storage periods and TPC effects are not significant in lot three and four Table 7 & 8).

4.2.2. Dry and wet salted Ribbonfish

The TPC in fresh fish was $2.8x10^3$. The results in each four lots of dry and wet alted ribbonfish are almost similar with the mackerel during salting and are in Figure – 4. In dry salted fish, the salting hours and TPC effects are significant ($p < 0.001$). here is significance between lot 1 and 2, and no significance between lot 2 and 3 and t 3 and 4 also there is significance between columns c1 and c2 but little significance etween c2 and c3 and c3 and c4 (Table 9). In wet salted fish, the salting hours and PC effects are significant ($p < 0.001$). There is significance between lot 1 and 2, and it ecreased as salting period advanced. But no significance between lot 2 and 3 and lot 3 nd 4 also there is significance between columns c1 and c2 is higher than others (Table 0).

During drying, TPC content of each four dry and wet salted lots had similar ffect as in dry and wet salted mackerel and is shown in Table – 9.4. In dry and wet alted fish, there is significant difference between drying hours and TPC ($p < 0.05$)

between lot 1 and 2 and is nil in lot 2 and 3 and 3 and 4 and no significant difference between salting hours and TPC (Table 11 - 12).

TPC in unpacked stored dry and wet salted (lot one), decreased. The TPC in packed stored dry and wet salted lot two, increased during the period. The TPC in refrigerator stored dry and wet salted lot three, increased slowly after one to four months. The TPC in cold storage stored dry and wet salted lot four, increased but fast increase was in wet salted fish after same period (Figure – 9.5). In dry salted fish, there is no significant difference between storage hours and between TPC in lot 1 and 2 and TPC effects are significant ($p < 0.05$) in lot 3 and 4 but storage hours effects are not significant (Table 13 & 14), wet salted fish there is no significant difference between storage hours and between TPC in lot 1 and 2 and rows and columns effects are not significant in lot 3 and 4 (Table 15 &16).

9.4.2.3. Dry and wet salted Shark

The TPC in fresh shark was $3.8x10^3$. The TPC results in each four dry and wet salted lot were similar with dry and wet salted mackerel and are in Figure – 9.6. In dry salted fish, salting hours and TPC effects are significant ($p < 0.001$). There is significance between lot 1 and 2, and lot 2 and 3 and lot 3 and 4 also there is significance between columns c1 and c2, c2 and c3 and c3 and c4 (Table 17). In wet salted fish, the salting hours and TPC effects are significant ($p < 0.001$). There is significance between lot 1 and 2 and lot 2 and 3; it decreased as salting period advanced. But no significance between lot 3 and 4 also there is significance between columns c1 and c2 and is higher than others (Table 18).

After drying, TPC in each four dry and wet salted lot was decreasing as in dry and wet salted mackerel and are given in Table - 9.4. In dry salted fish, there is significant difference between drying hours and TPC ($p < 0.01$). There is no significance between lot 1 and 2 but significance between lot 2 and 3 and 3 and 4 (Table 19). In wet salted fish, there is no significant difference between lot 1 and 2 but significance between lot 2 and 3 and 3 and 4 and no significant difference between column TPC (Table 20).

TPC in unpacked dry and wet salted lot one decreased as storage days increased than dried fish. TPC in packed stored dry and wet salted lot two had similar results as in mackerel. TPC in refrigerator stored dry and wet salted lot three had little growth as in mackerel in four months. TPC in cold storage stored dry and wet salted lot four had little growth in dry salted one, where as it was more in wet salted shark (Figure 9.7). In dry salted fish, there is no significant difference between storage period and between TPC in lots 1 and 2 and there is significance ($p < 0.05$) between lot 3 and 4 but columns are not significant (Table 21 & 22), In wet salted fish there is no significant difference between storage period and between TPC, in lot 1 and 2 and storage periods and TPC effects are significant ($p < 0.05$) in lot 3 and 4 (Table 23 & 24).

9.5. Discussion

TPC content decreased as salting hours increased. But in some cases the TPC content decreases initially and increased as salting hours increased in lot four of dry salted mackerel. Minor increase was observed in wet salted lot as salting period increased as reported by Sanjeev & Surendran (1993) and agrees the same. Kochi being a tropical area, normal temperature was high which favour the growth of bacteria. Further, since the sterilized salt was used the availability of salt loving bacteria was also less. According to Valle (1974) bacterial contaminations decrease with increase of salt and decreasing moisture. The moisture loss influence a_w to retard the bacterial growth in the products. So the products are safe during the storage period. The preservatives had more effecting dry and wet salted ribbonfish. In lot 1 of the both dry and wet salted ribbonfish, TPC decreased initially then increased latter. But in remaining dry salted lot TPC not increased. The preservative added wet salted lot showed increased /

creased TPC level. In lot 1 of the dry and wet salted lot in shark, TPC showed a crease initially but increased subsequently and is same in preservative added lots. uring drying, wet salted lots had more bacterial load than dry salted lots. The initial acterial load of the dry and wet salted fishes including shark was higher as the bacteria at favorable temperature and condition (Anon., 1956) but decreased as drying time and emperature increased.

The unpacked stored lots one, showed that the bacterial growth was very less ue to high temperature and less relative humidity. Moisture content of the products creased during the storage and fishes are stiffened and a_w increased to retard the rowth of the bacteria. This resulted the product to increase salt and the TPC content as less in the product and agrees with (Valle, 1974) but this is against report by Joseph *et al.* (1986) from the products of Tamilnadu Coast as the product was contaminated aving more moisture. The result agrees with the findings of Anon. (1956). The packed stored lot two, showed that the TPC content in the wet salted lot is more than in the dry salted lot in later stage. In the dry salted lot, the bacterial load was high initially and ecreased latter. The increase in bacterial loads during the initial stage and agrees with Abraham *et al.*, 1993) in anchovies. But further storage shows that the bacterial content ecreased (Nair & Gopakumar, 1986) as the moisture content evaporated during storage and agrees with results. The same moisture accumulated in the sealed packet may be reabsorbed by the sample in presence of salt might have caused to increase the growth of bacteria. The relative humidity also had some effect with moisture in growth of acteria in open stored products (Anon, 1956).

The refrigerator stored lot three, showed that the TPC content increased as storage period increased up to three months as reported by Camu *et al.* (1983) in 18^0C stored lot and agrees with same. But slight increase observed during the 4^{th} month in dry and wet salted mackerel and wet salted ribbonfish and dry salted shark as reported by anumanthappa & Chandrasekhar (1987). But the TPC content increases as the orage period increases in dry salted ribbonfish. The TPC content decreased as the orage period increased in wet salted shark and this could be due to the high content of rea. No spoilage was observed in the product. The lot kept in cold storage four, showed at the TPC decreased as storage period increases in dry and wet salted mackerel. The PC content slowly increased in dry and wet salted ribbonfish and nominal change was oserved in dry salted shark and it decreased as storage period increased in wet salted nark. The decrease of TPC was due to unfavorable condition and low temperature, hich reduce the bacterial activities. The increase of TPC was very little during long orage

Hazard analysis critical control points were identified and corrective points were valuated, as it is necessary for the fish curing industry. As the fish is an easily spoiling od, it is very important to preserve the same at every point and period. Fresh fish have e risk of spoilage by bacteria after catch, landing, during transportation and ontamination of filth, etc till processing. So fish should be prevented from the above and ould be monitored from increase in temperature during processing, cleaning, etc. uring drying, fish may be contaminated by dust or sand particle or fly or rodent these ould be avoided and drying be carried out at unpolluted area. Packing and storage at w temperature are good elements of protection of products for long life. The products ould be distributed as first come first out basis to avoid storage loss.

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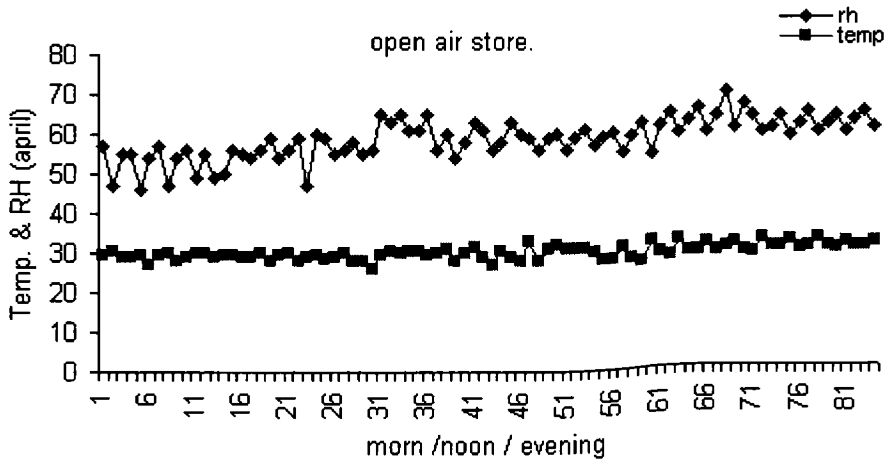

Figure - 9.1. Changes in Temperature & R.H during open-air storage

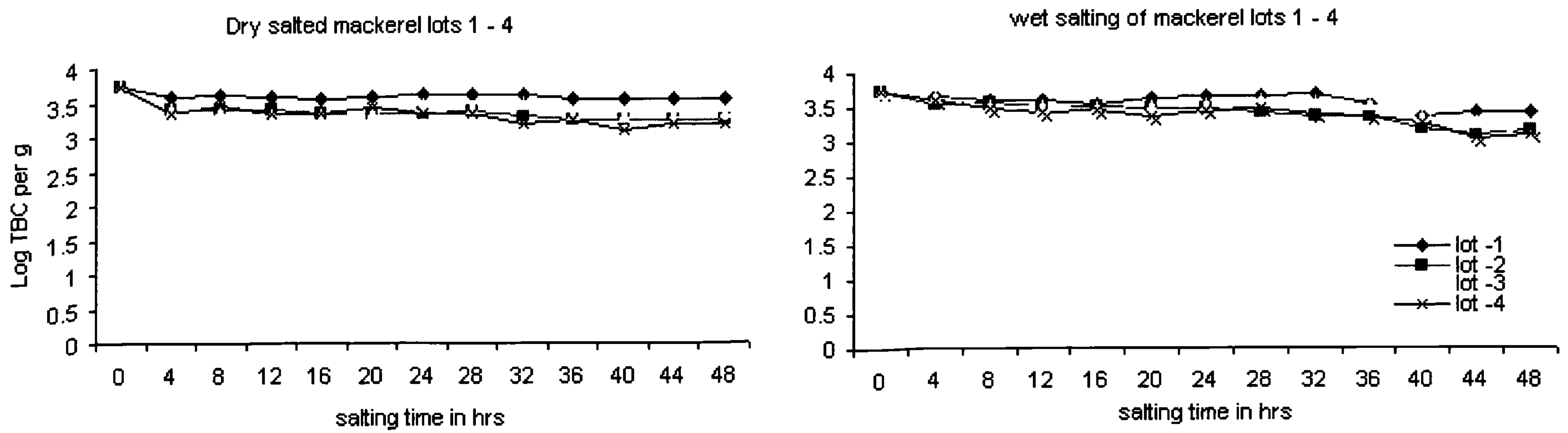

Figure 9.2 Change in TPC during dry and wet salting of Mackerel

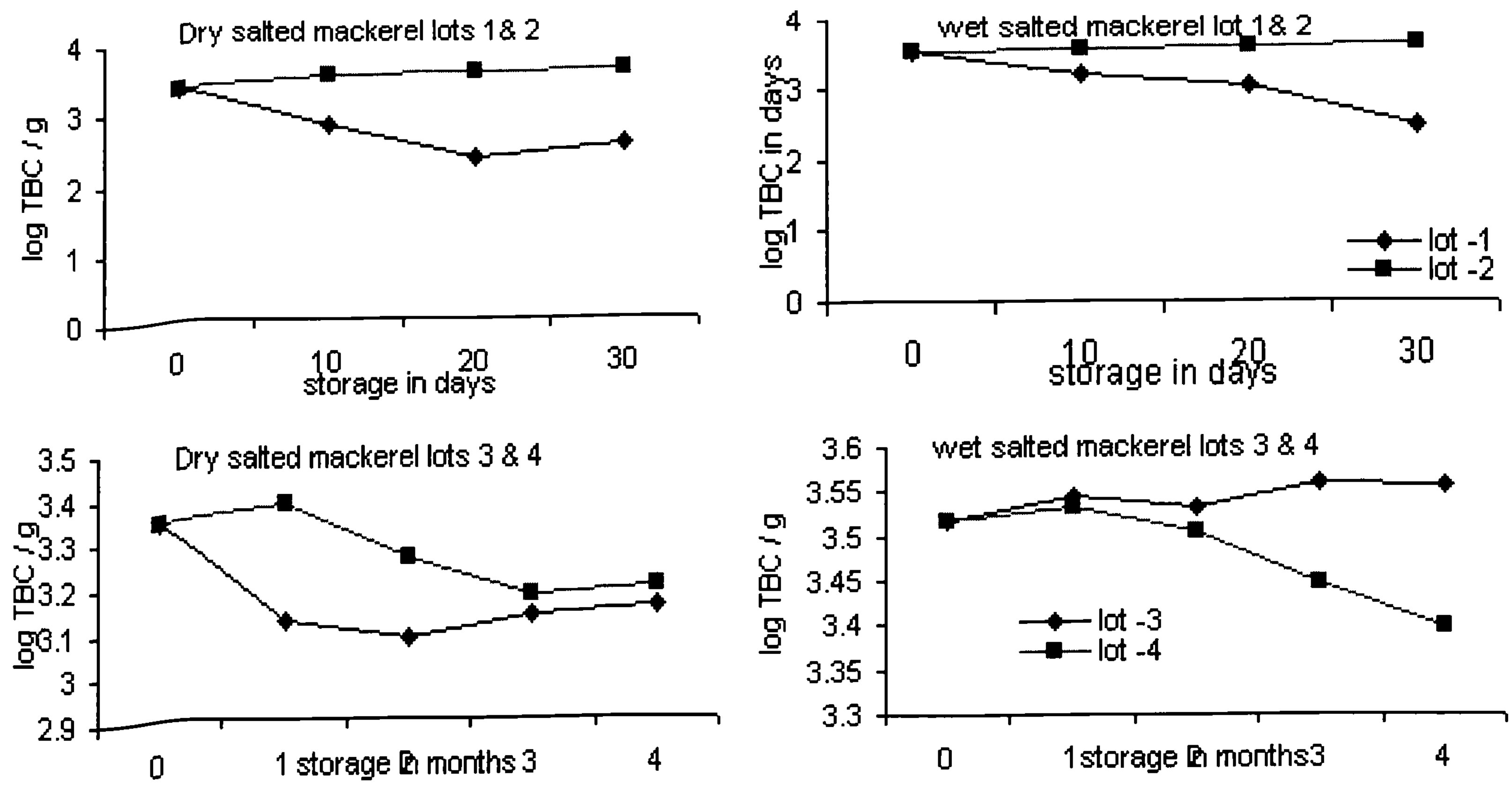

Figure 9.3. Change in TPC in dry and wet salted Mackerel during storage

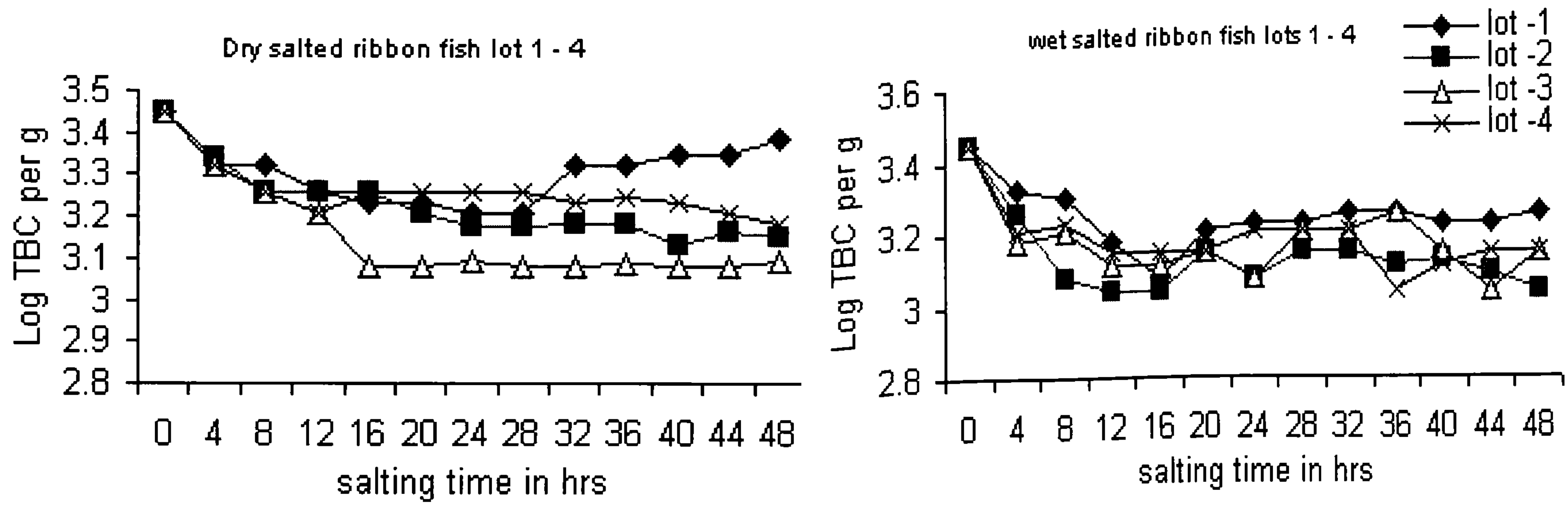

Figure 9.4 Change in TPC during dry and wet salting of Ribbonfish

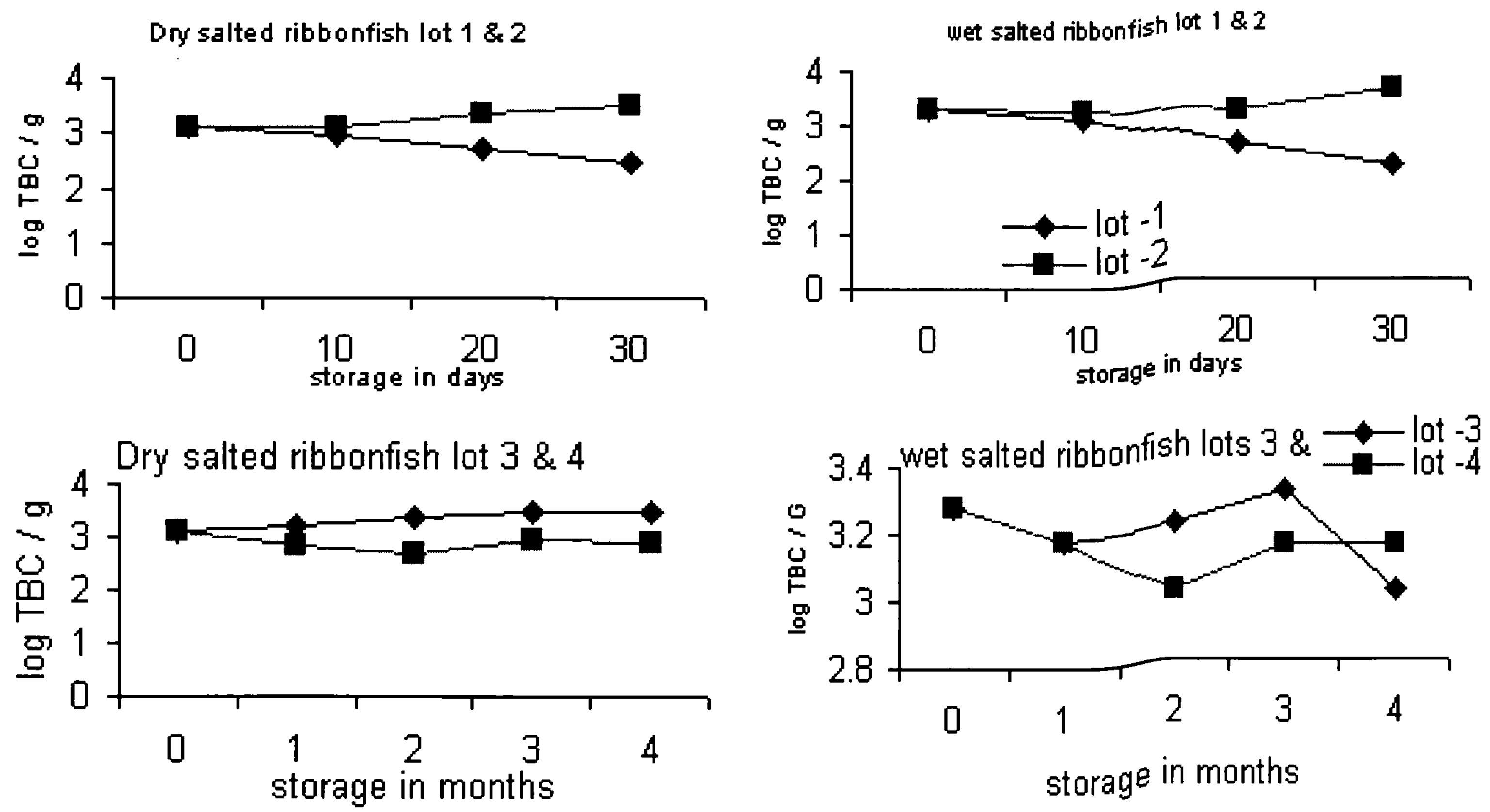

Figure 9.5. Change in TPC in dry and wet salted Ribbonfish during storage

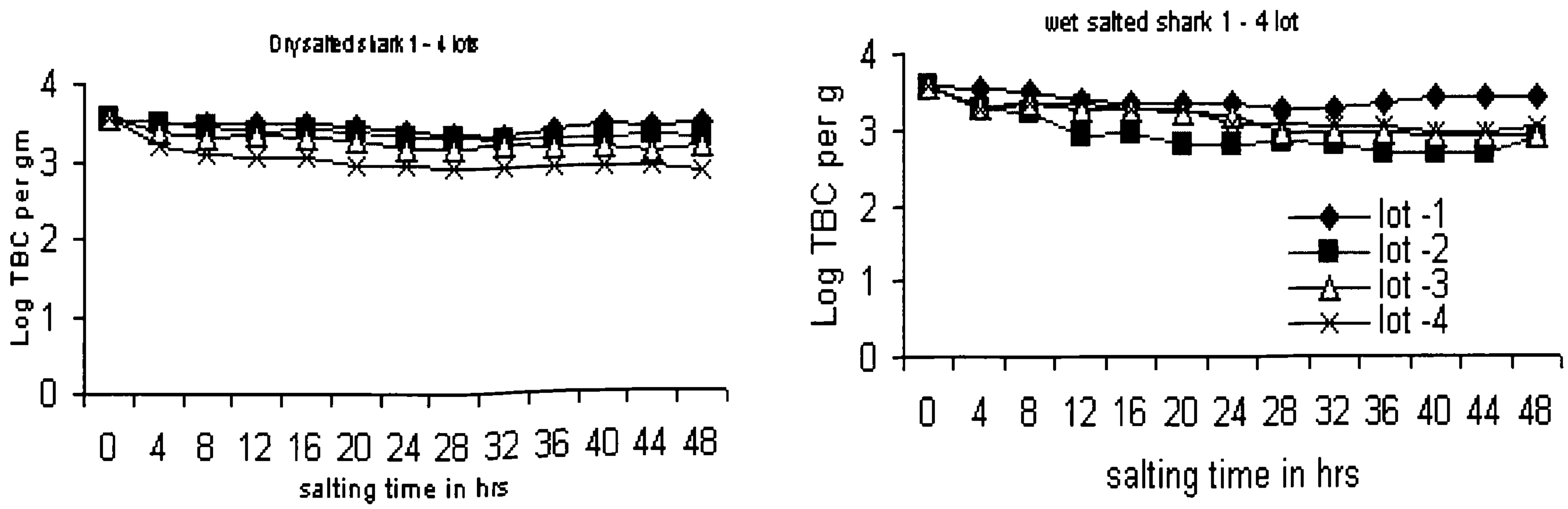

Figure 9. 6. Change in TPC during dry and wet salting of Shark

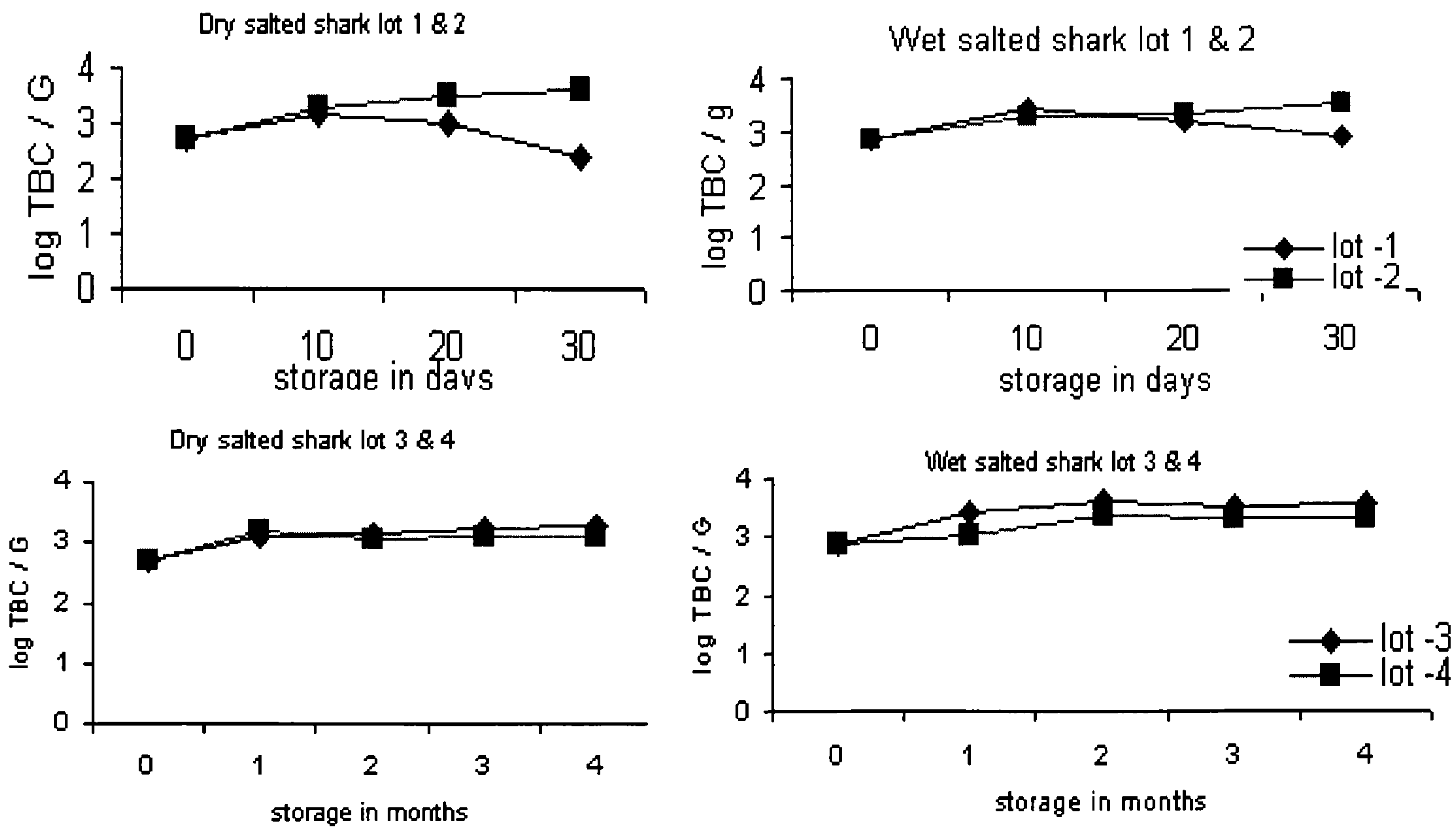

Figure 9. 7. Change in TPC in dry and wet salted Shark during storage

Table – 9.1. Effect of Sun drying on TPC

	In dry salted mackerel				In wet salted mackerel			
Stage	Lot -1	Lot -2	Lot -3	Lot -4	Lot -1	Lot -2	Lot -3	Lot -4
0 hrs	$3.5x10^3$	$1.8x10^3$	$2.1x10^3$	$1.5x10^3$	$2.5x10^3$	$1.4x10^3$	$1.1x10^3$	$1.2x10^3$
4 hrs	$4.4x10^3$	$3.2x10^3$	$3.5x10^3$	$3.61x10^3$	$4.6x10^3$	$4.2x10^3$	$4.01x10^3$	$4.2x10^3$
8 hrs	$3.4x10^3$	$2.5x10^3$	$2.2x10^3$	$2.8x10^3$	$3.4x10^3$	$3.3x10^3$	$3.2x10^3$	$1.5x10^3$
	In dry salted ribbon fish				In wet salted ribbon fish			
0 hrs	$2.43x10^3$	$1.41x10^3$	$1.23x10^3$	$1.51x10^3$	$1.8x10^3$	$1.1x10^3$	$1.4x10^3$	$1.4x10^3$
4 hrs	$3.9x10^3$	$3.8x10^3$	$3.8x10^3$	$3.1x10^3$	$2.6x10^3$	$2.6x10^3$	$2.8x10^3$	$1.1x10^3$
8 hrs	$2.1x10^3$	$1.3x10^3$	$2.2x10^3$	$2.2x10^3$	$1.9x10^3$	$1.5x10^3$	$1.9x10^3$	$1.02x10^3$
	In dry salted shark				In wet salted shark			
0 hrs	$3.1x10^3$	$2.5x10^3$	$1.5x10^3$	$0.67x10^3$	$2.6x10^3$	$0.78x10^3$	$0.85x10^3$	$1.1x10^3$
4 hrs	$3.5x10^3$	$2.1x10^3$	$0.9x10^3$	$2.1x10^3$	$2.1x10^3$	$1.5x10^3$	$1.62x10^3$	$0.5x10^3$
8 hrs	$1.8x10^3$	$0.81x10^3$	$0.5x10^3$	$1.01x10^3$	$1.52x10^3$	$0.7x10^3$	$0.22x10^3$	$0.21x10^3$

TABLE --- 9.2

Hazard and preservative measure for dry salted fish

Stage /product flow	Hazard	Preventive measure	Degree of control
Raw materials	Contaminated with pathogenic bacteria.	Monitoring the environments	CCP—2
Catch and handling	Growth of bacteria	(T*t) control	CCP --- 1
Chilling	Growth of bacteria	(T*t) control	CCP --- 1
Landing	Excess contamination / growth of bacteria	(T*t) control	CCP --- 1
Arrival to the processing center	Substandard quality enter for processing	Ensure reliable source sensory evaluation	CCP – 1 & CCP – 2.
Storage of raw material	------	-------	-----
Washing	------	-------	-----
Sorting	-------	Separation of spoiled fish	CCP --1
Cleaning	Gills and gut are carefully removed	Avoid the mixing of pathogens to flesh	CCP --- 2
Salting (dry salting) 1:4 salt to fish	Prevent spoilage	Each fish may have contact with salt	CCP -- 1
Washing	Excess salt	Washing	CCP -- 1
Drying	Excess moisture	Drying for 5 to 7 hrs.	CCP --- 1
Packing	Easy spoilage	Prevent spoilage	CCP -- 1
Storage	Give long storage time	Store the product at low temperature etc	CCP -- 1
Distribution	--------	Encouraging the products	------

The hazard and preventive measure for wet salted fish. Here, all the process same as in the table – 9.3. Except in the wet salting process. It detailed in the table below.

TABLE --- 9.3

Hazard and preventive measure for wet salted fish

Stage / product flow	Hazard	Preventive measure	Degree of control
Wet salting	The conc.: of salt may decrease after some time	Fresh salt solution or salt may be added to reinstate the conc.:	CCP. --- 1
Moving the brine solution	Low salt penetration	The brine may be equal conc.	CCP --1

TABLE --- 9.4

Hazard and preventive measures in storage of cured / dried fish product.

Stage / product	Hazard	Preventive	Degree of control
Unpacked fish	Easy spoilage	Packing and sealing	Ccp --1
Packed & stored at room temperature	spoilage	Storing at low temperature	Ccp -- 1
Packed & stored at +13^{0}c or refrigerated	Slow spoilage	Keep at low RH.	-------
Packed & stored at -18^{0}c	Slow spoilage	-------	------

Table 1 TBC result during dry salting of mackerel in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.586762	12	0.048897	11.1361	8.37E-09	2.032703
Columns	0.551637	3	0.183879	41.87781	7.9E-12	2.866265
Error	0.15807	36	0.004391			
Total	1.296469	51				

Table 2. TBC result during wet salting of mackerel in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.251226	12	0.104269	20.98413	1.01E-12	2.032703
Columns	0.278688	3	0.092896	18.69536	1.76E-07	2.866265
Error	0.178882	36	0.004969			
Total	1.708797	51				

Table 3 TBC result during drying of dry salted mackerel in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.047224	1	0.047224	26.40577	0.014278	10.12796
Columns	0.060859	3	0.020286	11.34331	0.038182	9.276619
Error	0.005365	3	0.001788			
Total	0.113449	7				

Table 4 TBC result during drying of wet salted mackerel in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.076798	1	0.076798	4.686039	0.119045	10.12796
Columns	0.094035	3	0.031345	1.912593	0.303844	9.276619
Error	0.049166	3	0.016389			
Total	0.22	7				

Table 5 TBC result during storage of dry salted of mackerel in lots 1 & 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.32004	3	0.10668	0.991096	0.502847	9.276619
Columns	0.892616	1	0.892616	8.292725	0.063544	10.12796
Error	0.322915	3	0.107638			
Total	1.535572	7				

Table 6 TBC result during storage of dry salted mackerel in lots 3 & 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.250521	4	0.06263	5.006618	0.073921	6.388234
Columns	0.041474	1	0.041474	3.315413	0.14274	7.70865
Error	0.050038	4	0.01251			
Total	0.342033	9				

Table 7 TBC result during storage of wet salted mackerel in lots 1 & 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.707986	3	0.235995	5.36054	0.100689	9.276619
Columns	0.078808	1	0.078808	1.790084	0.273293	10.12796
Error	0.132074	3	0.044025			
Total	0.918868	7				

Table 8 TBC result during storage of wet salted mackerel in lots 3 & 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.425052	4	0.106263	2.267728	0.223632	6.388234
Columns	0.293337	1	0.293337	6.260026	0.066624	7.70865
Error	0.187435	4	0.046859			
Total	0.905825	9				

Table 9 TBC result during dry salting of ribbonfish in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.232623	12	0.019385	7.585412	9.84E-07	2.032703
Columns	0.071886	3	0.023962	9.376239	0.000102	2.866265
Error	0.092002	36	0.002556			
Total	0.39651	51				

Table 10 TBC result during wet salting of ribbonfish in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.371251	12	0.030938	12.87665	1.19E-09	2.032703
Columns	0.084308	3	0.028103	11.69669	1.69E-05	2.866265
Error	0.086494	36	0.002403			
Total	0.542053	51				

Table 11 TBC result during drying of dry salted ribbonfish in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.121039	1	0.121039	10.25075	0.049269	10.12796
Columns	0.046583	3	0.015528	1.315033	0.413636	9.276619
Error	0.035423	3	0.011808			
Total	0.203045	7				

Table 12 TBC result during drying of wet salted ribbonfish in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.170578	1	0.170578	11.06736	0.044827	10.12796
Columns	0.220777	3	0.073592	4.774794	0.115767	9.276619
Error	0.046238	3	0.015413			
Total	0.437593	7				

Table 13 TBC result during storage of dry salted ribbonfish in lots 1 &2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.014978	3	0.004993	0.044234	0.985389	9.276619
Columns	0.427415	1	0.427415	3.786812	0.146851	10.12796
Error	0.338608	3	0.112869			
Total	0.781001	7				

Table 14 TBC result during storage of dry salted ribbonfish lots 3 & 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.053884	4	0.013471	0.390648	0.807601	6.388234
Columns	0.458251	1	0.458251	13.28893	0.02186	7.70865
Error	0.137935	4	0.034484			
Total	0.650069	9				

Table 15 TBC result during storage of wet salted ribbonfish lots in 1 & 2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.194655	3	0.064885	0.327992	0.807818	9.276619
Columns	0.591922	1	0.591922	2.992147	0.182108	10.12796
Error	0.593475	3	0.197825			
Total	1.380052	7				

Table 16 TBC result during storage of wet salted ribbonfish in lots 3 & 4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.122468	4	0.030617	3.2041	0.14282	6.388234
Columns	0.004812	1	0.004812	0.503568	0.517113	7.70865
Error	0.038222	4	0.009556			
Total	0.165502	9				

Table 17 TBC result during dry salting of shark in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.682715	12	0.056893	11.87087	3.57E-09	2.032703
Columns	1.354079	3	0.45136	94.17745	4.18E-17	2.866265
Error	0.172535	36	0.004793			
Total	2.209329	51				

Table 18 TBC result during wet salting of shark in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.499165	12	0.12493	11.21784	7.6E-09	2.032703
Columns	1.402984	3	0.467661	41.99259	7.6E-12	2.866265
Error	0.400923	36	0.011137			
Total	3.303072	51				

Table 19 TBC result during drying of dry salted shark in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.203426	1	0.203426	87.49975	0.002587	10.12796
Columns	0.332069	3	0.11069	47.61086	0.004978	9.276619
Error	0.006975	3	0.002325			
Total	0.54247	7				

Table 20 TBC result during drying of wet salted shark in 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.367744	1	0.367744	7.672949	0.069568	10.12796
Columns	0.605064	3	0.201688	4.208206	0.134296	9.276619
Error	0.143782	3	0.047927			
Total	1.11659	7				

Table 21 TBC result during storage of dry salted shark in 1 & 2 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.396935	3	0.132312	0.808648	0.567227	9.276619
Columns	0.397462	1	0.397462	2.429165	0.216984	10.12796
Error	0.490863	3	0.163621			
Total	1.28526	7				

Table 22 TBC result during storage of dry salted shark in 3 & 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.31756	4	0.07939	11.07562	0.019437	6.388234
Columns	0.012864	1	0.012864	1.794657	0.251406	7.70865
Error	0.028672	4	0.007168			
Total	0.359096	9				

Table 23 TBC result during storage of wet salted shark in 1 & 2 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.283354	3	0.094451	1.812609	0.318662	9.276619
Columns	0.044655	1	0.044655	0.856969	0.422868	10.12796
Error	0.156324	3	0.052108			
Total	0.484333	7				

Table 24 TBC result during storage of wet salted shark in 3 & 4 lots

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	0.563479	4	0.14087	13.9759	0.012781	6.388234
Columns	0.112507	1	0.112507	11.16202	0.02881	7.70865
Error	0.040318	4	0.010079			
Total	0.716304	9				

Chapter 10

CONCLUSION AND RECOMMENDATIONS

10.1. Conclusion

The following are important suggestions and recommendations based on the study. The study reveals that quantity of dry fish production in the State is decreasing and dry fish processing industry should be encouraged by Central and State Governments. MPEDA may help the industry technically and financially in production and export. The quality control during processing and production are essential and be aided by both Central and State departments during production and sales. Grant-in-aid may be provided by Govt. or bank during peak season to purchase fish and remit the same in equal period with low interest. The State Fisheries Department or MATSYAFED may purchase cured and dried fish with a quality control check and sell at high range area at reasonable rate. This way both Government and people in high ranges are benefited. The Government or State Fisheries Department may arrange centralised low temperature godowns for storage of cured fish to increase shelf life.

The dry and wet salting may be carried out to a period of 4 to 8 hours respectively and time may depend on temperature, size, concentration of medium, etc. Further increase in salting time leads to weight and nutritional loss in dry and wet salting. But demand is an unavoidable factor for sale of fish. The use of preservative in dry salting had better effect than wet salting. The weight loss was more in wet salting. pH was lowered more by natural than chemical preservative. Though sun drying had more effect on both lots, the effect in dry salting was high than wet salting. The decrease in moisture content increase nutrition and it was more in dry salted fishes and shark. Moisture, salt, firmness, a_w and other factors of unpacked fishes were reduced during storage due to high relative humidity and temperature. The packed dry salted lots kept at room temperature are useful only for 20 days. The refrigerator-stored lots had more storage life and nutritional content are good up to 3 months. The cold storage stored dry salted lot had more storage life than the wet salted lot. Wet salted or dry salted fish can be better stored in refrigerator or in cold storage until the fish is sold out.

The above study encourages to lower the salting time to 8 and 4 hours in dry and wet salting respectively with good amount of nutritive value. The use of preservatives in salting is encouraged to reduce pH. The low temperature preservation maintains the nutritional value and quality for long period. It further encourages the labeling of nutritional value of dry fish as in tinned products.

10.2. Recommendations

The moisture loss during the initial period of dry salting is less and it increased as salting time increased. It had reverse action during long salting in controls. So dry salting may be done for 4 hours and wet salting for 2 to 3 hours depending on the thickness of fish. The fish may be scored.

The loss of nutrients in dry salted product is less than the wet salted product due to osmosis. The chemical and natural preservative penetrates and reduces the pH to acidity. The chemical preservative has better performance than the natural preservative. The natural preservative has less effect on wet salting, which causes loss in nutritional value in brine solution as the nutritive components dissolve. So dry salting is preferred or wet salting can be done for limited hours.

The wet salted lot showed heavy weight loss during sun drying than dry salted lots and the yield is little high in dry salted lot. So wet salting should be limited for 4 to 5 hours.

The products may be packed and sealed after drying in polythene bags for long storage, better appearance and protection.

The dry salted mackerel with 2%, ribbonfish with 1% and shark with 2% calcium propionate and the wet salted mackerel with 5%, ribbonfish 10% and shark 5 % tamarind juice preservative had good appearance than the others.

Most of the protein nutrients, FFA value and fat oxidation are in decreasing manner in all wet salted lot as they dissolve in salt solution rapidly. In the case of dry salted lots the nutrient loss as less as the salt penetration is slow in the flesh. So dry salting may be preferred or wet salting for 4 to 5 hours may be done.

The study showed that no colour change occurred on the fish during wet salting when Gorukha puli was used during salting. The preservative (*Tamarindus indica)* has high effect to reduce pH.

8. The fish stored in open air showed loss of moisture and loss is high in wet salted lot than dry salted lot. Packed stored lot had moisture in it and it easily spoils the products (20 days). So the products should be packed and stored at low temperature.

9. The sealed lot stored in refrigerator and cold storage have high content of nutrients and the lipids oxidation is less than the other two types of storages. So storage of the products at low temperature should be encouraged and practiced.

10. Drying may be done in protected area without entrance to animals and birds. The products may be packed in attractive packets for easy handling and storage without causing damage.

11. The society or Govt. may sell the product on "fist come first out" basis to avoid long storage and for easy movement. Quality of the fish may be checked at every stage.

12. The "lab to land" program is urgent to improve the quality of cured fish production for internal and export marketing with long storage period.

13. The HACCP system may be introduced in the curing units for safe fish production.

14. Salting may be carried out with good quality fish immediately after landing and hygienic production of cured or dried fish may be controlled by Govt. body and the Govt. may take measures to improve the facilities and provide grant in aid through recognized societies or qualified hands.

15. The workers may be trained for the hygienic handling of fishes. The Inspectors of the Fisheries Welfare Board or Fisheries Departments may be asked to verify the required facility and improve the same.
16. The Govt. may adopt the quality standards and purchase the cured fish from curing units at a standard rate on the basis of quality and may fix the standard price and sell the same in high range places to bring good revenue to Govt. and it is a boost to the people of high range region who really need fish.

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