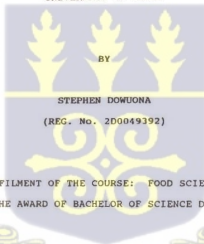


THE EFFECTS OF DIFFERENT METHODS OF  
SALTING ON THE QUALITY OF SALTED FISH

A DISSERTATION PRESENTED TO THE  
DEPARTMENT OF NUTRITION AND FOOD SCIENCE

UNIVERSITY OF GHANA



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(1)

DECLARATION

This research project was carried out by me in the Department of Nutrition and Food Science, University of Ghana, under the supervision of Mrs. Agnes Budu.

Signed .....

  
.....

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(ii)

DEDICATION

To my dear parents, my sisters, Cecilia and Maggie, my brothers, John and Francis whose love, encouragement and support have brought me this far.

(iii)

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to my supervisor, Mrs. Agnes Budu for her tolerance, guidance, constructive criticisms and useful suggestions, which made this work successful.

I am also grateful to Dr. E. Collison for his assistance in various ways.

Further thanks go to the entire workers in the Nutrition and Food Science Department, especially Mr. Salia, Mr. Kuma and Mr. Quansah.

My special thanks goes to Miss Cynthia Ayettey my dear cousin and Felix Nortey for their secretarial assistance.

My greatest thanks goes to my Lord Jesus for what He has made me.

(iv)

ABSTRACT

Samples of fresh Tilapia (Tilapia species) and Redfish (Sparidae species) were salted using the pickle and kench curing methods. The salted fish were then dried using solar and air-drying methods.

Standard methods were used to determine the effects of processing and drying methods on the chemical composition of the processed fish.

With the uptake of salt by the fish, the ash content increased significantly during processing, with resultant decreases in the fat, protein and moisture contents. Fat decrease was also partly attributed to dripping of liquified fat during drying as well as chemical oxidation of the fat. Protein losses were also partly due to proteolysis of the protein as well as denaturation. The extent of the differences in moisture, fat and protein between the pickled and kenched samples were not significant except for ash and salt contents.

Sensory evaluation using the rank method and analysed by Analysis of Variance (ANOVA) showed that the kench cured and air-dried samples are more acceptable, whiles pickle cured and solar dried samples are least acceptable with respect to texture, odour and appearance.

The salted dried Tilapia samples were also found to have a longer shelf-life than the similarly treated Redfish samples.

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CHAPTER 1

INTRODUCTION

Fish contributes significantly to the nutritional requirements of most people in Africa. Here, it is generally the major source of protein in most diets. This is because fish is relatively cheap as compared to meat. Also unlike meat, there is little or no religious rejection of fish.

However, the proteins present in fish are also rich nutrients from micro-organisms which causes spoilage. This makes fish a highly perishable food, hence the need for rapid processing after catch. Spoilage of fish soon commences after it is caught. The climatic conditions of high temperature and atmospheric humidity prevailing in Ghana contribute to spoilage and therefore makes it mandatory that fish is sold or cured without delay after catch.

The rapidity with which deterioration takes place depends upon the particular species of fish, the damage they suffer because of the methods for capture and handling and the conditions under which the fish are subsequently kept (Rawson, 1966). In nature, fish muscles are generally considered sterile. However, when fish dies, bacteria originally confined to the guts, liver and gills of the healthy live fish start to invade the surrounding sterile tissues by way of blood vascular system (James, 1977). Although the composition may vary somewhat with different species, fish generally comprises 70% water, 20% protein, 5% fat and 5% ash. (Rawson, 1966).

Water is essential to bacteria so that bacterial activity is minimized if the water content of the fish is reduced. Less than 3% water brings bacterial activity to a standstill (Rawson, 1966). In recent years, it has been shown that not only bacteria and their metabolic products are responsible for spoilage, but that enzymes that are inherent in the fish muscle and intestine are also involved. According to Bramstedt and Auerbach, (1977), the presence of certain fish muscle enzymes appear to be a prerequisite for an optimal growth of bacteria which causes spoilage. Autolysis due to the digestible action of tissue enzymes may alter the texture, flavor and appearance of the fish product.

Another important factor of fish spoilage is stiffening after death or rigor mortis. After death, Adenosine Triphosphate(ATP), the energy producing compound is no longer resynthesised. Its concentration in the cell therefore falls. At the same time, the pH is lowered by the accumulation of lactic acid as a product of glycolysis. These factors causes a contraction of the muscle and loss of mechanical properties, since ATP acts as a plasticisor (James 1977). The hydrolysing activity of some enzymes and the splitting of proteins are enhanced. Proteins are broken down to peptides and then to amino acids. The amino acids are subsequently broken down by hydrolysis and deamination, giving among other products, ammonia which is characteristic of badly spoiled fish.

Ammonia and other amines are also produced as breakdown products from trimethylamine oxide which is naturally present in fish flesh. According to (James 1977), trimethylamine and other

volatile acid components have been shown to be produced mainly by bacteria and enzymes. The degradation of nucleotides occurs quite rapidly after death. ATP is degraded to adenosine Diphosphate(ADP) and then to Adenosine monophosphate(AMP) by phosphorylase enzymes. Deaminase convert AMP to Inosine monophosphate(IMP) then to hypoxanthine.

Hypoxanthine can be estimated reasonably easily by a spectrophotometer. It forms a very convenient index of spoilage. Production of IMP is also important in relation to flavor enhancers (James, 1977). The methods used for fish processing in most African Countries are traditional because of their strong links with local traditions (Sefa-Dedeh 1993). Very simple methods have been used to convert the highly perishable fresh fish into shelf-stable forms. There are four main traditional methods of fish preservation in Ghana to enhance its keeping quality. These are;

- ◆ Drying
- ◆ Smoking
- ◆ Salting
- ◆ Fermentation

These techniques can be applied in a single process of preservation, or two or more process combinations can be used. For example, the production of salted smoked fish (locally called "Opoku") salted dried fish (Koobi) and salted fermented fish (locally called "Momoni"). Other methods involve cooking and

frying, but these are regarded as methods of preparation for home consumption than for preservation. The traditional fish processing trade spreads along the coastal towns and beaches and big lakes in Ghana e.g Chorkor, James Town, Shama, Elmina, Ada and certain areas in the Volta Region. The processing is done mostly by the women folk whose husbands are fishermen.

Smoking involves the deposition of wood smoke chemicals on the fish. Usually, fish with high fat composition are preferably smoked. Drying is done in the sun, in Ghana. The extent of drying is determined by feel. The process is always at the mercy of the weather, so the use of modern solar dryer is recommended. The essence of salting is to minimise the moisture content to a level so as to eliminate the growth and development of micro-organisms, especially the pathogenic and spoilage micro-organisms. Solar-salt, that is salt made from sea water evaporation in open ponds is the only salt available to most fish processors.

Commercial salt contains some amount of calcium(Ca) and magnesium(Mg). According to Cole and Greenwood-Barton (1973), fish salted with pure sodium chloride(NaCl) produce a flabby dried product which is pale yellow in colour and does not have the characteristic flavor of salted fish. Presence of small amounts of Ca and Mg salts whiten and stiffen the fish as well as impart a bitter flavor which most consumers of salted fish find palatable. Excessive amounts of Ca and Mg however hinder the penetration of the sodium chloride into the flesh of the fish. Salt penetration is also affected by the fat content of the fish and the extent of

spoilage (Cole and Greenwood-Barton 1973). All solar salts contain greater or lesser numbers of salt tolerant bacteria which cause "pink" in inadequately dried fish. These bacteria attack the protein of such fish so that the fish becomes covered with a pink slime.

The salt content is important mainly because of its effect on uptake of moisture. The more heavily salted a product, the more difficult it is to remove moisture by natural drying and the more rapid the wetting in humid air. Salt has some antiseptic properties and the growth of bacteria, other than the salt tolerant types, is inhibited in strong solutions. The main preservative action of salt is that it removes water from the flesh of the fish in contact with it by osmosis.

"Koobi" the Ghanaian salted and sun-dried fish is used locally for flavoring soups, stews or grilled and eaten with kenkey. "Koobi" processing is undertaken in fishing towns and villages such as Chorkor and James Town in Accra, Shama, Ada and Elmina. In all these areas the same principle is applied, the differences in the methods of processing are mainly found in the number of days of salting and the duration of drying. A large proportion of Ghanaian women use "Koobi" in their food preparations. Although this product is widely used, very little scientific work has been done on it. Processing is still done under the traditional unhygienic conditions. The process has not been characterized with respect to chemical changes.

The objectives of this project are therefore to:

1. To determine the effects of processing on the chemical composition of salted fish using wet and dry salting methods.
2. To determine the effects of processing on the sensory characteristics of the salted fish.
3. To determine the effects of processing in the shelf life of the salted fish.

These findings will help in the standardization of the process for industrial adaption.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 FISH PRODUCTION IN GHANA

Fishing has become a major, source of employment the world over. The introduction of modern fishing methods in West Africa has increased the catch considerably in recent years. (Amu Disney, 1973)

In Ghana, there has been a rapid development of fishing due to an increase in the operation of deep sea motor vessels. Almost all the towns and villages along the coast line engage in fishing. In addition, Lagoon and river fishing is wide spread.

However, the distribution of fresh marine fish is still restricted largely to the coastal areas. This restriction in fresh fish distribution is due to primarily the very perishable nature of the fish under the warm climatic conditions (Cole and Greenwood - Barton, 1973). Other factor such as lack of suitable transport facilities (Amu and Disney, 1973), development of new technology and availability of trained personnel are also relevant (Garm & Limpus, 1976).

It is unfortunate that in the tropics where animal proteins is in high demand to satisfy the dietary needs of the people, climatic conditions are such that spoilage of fish is more likely to occur. According to Borgstrom (1965) fish may start to deteriorate in a few hours in the tropics so any quick and simple steps to preserve a catch are beneficial. In contrast, fish can be held for a day or

two in temperate climate whiles in the Arctic, it rapidly becomes frozen (Rawson, 1966)

According to Talarczak (1977), in the majority of artisanal fishing centres, the fish is handled on the beach at landing places where even simple facilities are not available. The fish may or may not be chilled with ice at sea and at shore, it is not protected from the sun or other weather conditions and it is not cleaned or washed before sale. At landing, fish are often dumped on sandy beaches or foul grounds for sorting and marketing (Watanabe, 1982).

Talarczak (1977) further enumerated the procedure of handling and collection of fish at landing places as follows:

- (a) Landing of the canoe in beach.
- (b) Discussion between fishermen and fish mongers or buyers on the price of fish per basket according to the species caught.
- (c) Unloading of the fish in baskets from canoes by women or fishermen's relatives who carry the fish to the place where it is sold or near the beach, or directly into vehicles.
- (d) Supplying that part of the catch destined for curing before sale to the beach site, where this operation takes place.

The relatively high price of fresh fish and the limited supply of fish products as well as their poor keeping quality together with inadequate marketing systems have all hindered a larger consumption.

Although the development of industrial fisheries had been significant, the artisanal fishery is still the most important sector of the fishing industry in Ghana where its most valuable

role is to provide food for the home market (Talarczak, 1977)

Generally, the quality and freshness of the fish is very unsatisfactory both in coastal and inland towns because of the conditions under which it is handled, transported, sold and kept (Talarczak, 1977)

TABLE 1

TYPES OF FISH COMMONLY USED IN GHANA

<u>COMMON NAME</u>	<u>SCIENTIFIC NAME</u>
1. Trigate Mackerel	<u>Auxis thazard</u>
2. Long finned herrings	<u>Visha melanota</u>
3. Sardine	<u>Sardinella aurita</u>
4. Red mullet	<u>Upeneus Prayensis</u>
5. Redfish	<u>Sparidae species</u>
6. Sea bream	<u>Deutex species</u>
7. Club mackerel	<u>Scomber celias</u>
8. Tilapia	<u>Tilapia species</u>
9. Tiger fishes	<u>Hydrocon species</u>

Whereas fish types 1 to 7 are obtained from marine habitat, species 8 and 9 are obtained only from fresh water environments.

In Ghana, the main fishing season extends from August to October. The seasonal nature of fishery operations makes the supply of all types throughout the year rather difficult fishing is done mainly with the aid of nets and baskets (Rawson, 1966).

## 2.2 FISH SPOILAGE

Fish begins to deteriorate from the moment they are caught (James, 1977). It is such an extremely perishable commodity that it may have to be consumed immediately or preserved in one form or another without delay.

In the tropics, the situation is even worse and fish will spoil within 12-20 hours after a catch, depending on the species, method of catching, handling, the damage they suffer because of the method of capture and the conditions under which the fish are subsequently kept. A considerable proportion of fish landed during the glut season goes to waste accompanied by drastic reduction in prices. This is primarily due to improper handling and inadequate storage and processing conditions. There are two main causes of fish spoilage. The first involves the activity of endogenous digestive enzymes called autolytic spoilage. The second type of fish spoilage involves bacterial breakdown called bacterial spoilage.

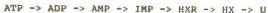
### 2.2.1 AUTOLYTIC SPOILAGE

Autolysis is a complex process whereby fish muscle is digested by proteolytic enzymes naturally present in the gut and living muscle (Tressler and Lemon, 1951). The healthy living gut is able to resist autodigestion but as soon as the fish dies, enzymes involved in the digestion of food attack and quickly breakdown the gut and belly wall as well as the flesh. In life, the cell is prevented from auto digestion because the proteolytic enzymes are

enclosed inside the cells in bag-like structures, the Lysosomes (James, 1977)

As the pH decreases, due to glucose breakdown to lactic acid, the proteolytic enzymes may be released from the lysosomes and degrade the tissues (Ihekoronye and Ngoddy, 1985). Proteins are broken down to peptides and then to amino acids. The amino acids are then broken down by hydrolysis and deamination giving among other products ammonia, which is a characteristic of badly spoiled fish. Other amines are also produced as breakdown products from trimethylamine oxide, which is naturally present in fish flesh. (James, 1977)

According to Watanabe et al, ATP decomposition proceeds along the following sequence;



Where:

ATP	=	Adenosine triphosphate
AMP	=	Adenosine monophosphate
ADP	=	Adenosine diphosphate
IMP	=	Inosine monophosphate
HXR	=	Inosine
HX	=	Hypoxanthine
U	=	Uric acid

These changes are mainly associated with the endogenous enzymes. At the same time, exogenous enzymes from bacteria are also reacting with substrates produced by these reactions (James, 1977).

The effects of autolytic breakdown of fish include,

- (i) Flavour development (James, 1977)
- (ii) Enhancing bacterial growth (Hess, 1960)
- (iii) Breakdown of tissue muscle resulting in textural changes in the fish (Ihekoronye, Ngoddy, 1985)

Autolysis is promoted by high temperature especially when the fish is un-gutted.

#### 2.2.2 BACTERIAL SPOILAGE

Although the flesh of freshly caught fish is considered to be sterile, the skin, the gills and intestines can carry considerable bacterial loads. Both quantitatively and qualitatively, the microbial flora is a function of the environment in which the fish is caught.

After death, the normal barrier preventing infection is broken and the micro-organisms start to attack. According to Hess (1960), the sources of bacterial contamination of the fish flesh are the intestine contents, the slime covering the fish and especially the gills, also dirty surfaces with which the fish comes into contact on the deck, in holds of fishing vessels and fish plants.

Work done by Karthayani and Iyer (1968) on fish from temperate waters revealed that the bulk of the flora of skin muscle and gut consisted of gram negative asporogenous rods of the Achromobacter vibrio, pseudomonas, flavobacterium and cytophaga groups.

The relative percentages of these genera were at variance with those reported for fishes of temperate waters where pseudomonas predominated followed by achromobacter (Georgala 1958). Geographic location is known to cause such variations in generic distribution.

Thus Liston and Colwell (1963) reported greater abundance of Achromobacter species on fish caught in the warm waters areas than on fish from Northern pacific areas (Puget sound, off Washington Coast).

In temperate and Arctic waters, the micro-organisms found are mainly psychrophiles. In the warm waters of tropical countries, a greater percentage of gram positive mesophiles such as the Bacillus species, Coryneforms and micrococci are found.

Shewan (1970) suggested from data that fish can be infected and carry not only Salmonella but also possibly Staphylococcus aureus, even when caught in unpolluted waters.

Work done by Karthiayani and Iyer (1968) revealed that bacterial density is higher in the guts than on the skin and muscle. Bacterial growth is characterized but he production of slime, softening of the muscle tissues and also the production of offensive odours. Bacterial and autolytic spoilage usually occur simultaneously.

### 2.2.3 POST-MORTEM CHANGES IN FISH

When a fish dies, it stiffens almost immediately. The flesh becomes firm and elastic.

This condition is called rigor mortis (Borgstrom, 1965). According to Tressler and Lemon (1951), the state of rigor is a guarantee of perfect freshness. Although even under the most favourable storage conditions, rigor mortis gradually disappears in a short time, its absence does not indicate that the fish is not sufficiently fresh to be an excellent food.

Rigor mortis is the manifestation of a series of complex biochemical reactions that occur in animal tissue after death. The gradual hardening and stiffening of the carcass, observed, is brought about by the contraction of the various individual muscle.

Conversion of the muscle of a living animal to meat could be viewed as a simple mechanical disintegration of the carcass after the animal is killed (Ihekoronye and Ngoddy 1985).

According to Amano et al (1953) Noguchi (1957) and Jones et al (1965), the rigor period of fish is greatly influenced by the environmental conditions in which the fish dies, such as temperature. The duration of rigor depends upon the physical state of the fish. If the fish died suddenly and was not starving or spawning, rigor would start later and last longer than if the fish was starved or had struggled in the net before dying (Hess, 1960).

James (1977), outlined the biochemical changes associated with rigor mortis, or the post mortem period, as associated by lack of adenosine triphosphate (ATP) synthesis that is the energy producing compound. Its concentration in the cell therefore falls (Iwamoto, 1987).

At the same time there is a lowering of the PH to about 6.6-6.2 (Hess, 1960) due to the accumulation of lactic acid as a product of glycolysis. These factors cause contraction of the muscle and loss of mechanical properties since ATP acts as a plasticizer (James, 1977).

Rigor mortis among other factors retard the post mortem autolytic and bacterial decomposition of the flesh and its protein (Hess, 1960). Also fats are known to solidify (Ihekoronye and Ngoddy, 1985). After completion of the rigor mortis, the fish slowly returns to and often exceeds its pre rigor tenderness. This is due to the effects of various proteolytic enzymes that slowly degrade the muscle fibrous structure. This so-called "aging" is a very important step in fresh meat technology (Ihekoronye and Ngoddy, 1955).

Rigor index of fish can be measured and used as a parameter of rigor tensions using the equations.

$$\text{Rigor Index \%} = \frac{D_0 - D}{D_0} \times 100$$

where;

$D_0$  and  $D$  represent the distance of the base of the caudal fin from horizontal line of the table at the start (or in pre rigor state) and during storage respectively (Iwamoto et al 1987)

### 2.3 QUALITY ASSESSMENT OF FISH

Chemical compounds, such as volatile basic nitrogen and ATP related compounds which normally didn't exist in the living tissues of fish and are formed by autolysis and/or microbial actions are used as indications of fish freshness (Saito et al 1959)

A more accurate indicator of fish freshness results from over all enzymatic reactions attributed to the changes in fish freshness because the various reactions taking place in fish meat proceed at individual reaction rates (Watanabe et al, 1987)

**Table 2 FRESHNESS CHARACTERISTICS OF FISH**

	FRESH	SPOILED
1. Overall Appearance	Slimy, metallic wet sheen	Dull, dry, wrinkled
2. Skin tone	Elastic, firm	Inelastic, slack, bloated
3. Smell	fresh, seaweedy odour	sour, off-odour
4. Eyes	clear, projecting	Opaque, sunk in head
5. Gills	brightred/pink color fresh smell	dull, brownish in color off-odours
6. Mucous Coating on Skin	free flowing fine lubricant	coagulated mucous (slimy)

Source, Fish processing (1988) Food Cycle Tech. Source Book No 4 United Nation Development Fund for Women (UNIFEM)

Josephson and Lindsay (1987) have shown that certain volatile compounds responsible for the aromas of freshly harvested fish are the result of degradation of site specific (ie enzymatically-formed) hydroperoxides.

These enzymes mediated degradations are expressed in the formation of a variety of alcohols and carbonyls which are present in highest concentration in skin and slime fraction of flesh (Josephson et al 1987)

Production of trimethylamine (TMA) and total volatile basis (TVB) are the most commonly used tests for freshness (James, 1977). Puncture testing is an empirical method used in textural studies of food (Bourne, 1982). It measures the force required to push a metal probe into food to a depth that caused irreversible crushing or flow of the sample (Kronenberg and Hang, 1985).

#### 2.4 TRADITIONAL METHODS OF FISH PRESERVATION

The major portion of fish landed in Ghana is processed in one form or another with the aim of preserving it. the various methods of traditional processing of fish are;

- (i) smoking
- (ii) sundrying
- (iii) salting
- iv) fermentation
- (v) frying

The traditional fish processing trade spread along the coast of Ghana, near the fish landing beaches and around lakes, with bigger concentration in the coastal towns (Okraaku - Offei 1970).

Among the traditional methods, smoking is the most widely used, covering about 65 - 70% of the total fish per annum. Sundrying, salting, frying and fermentation account for about 10 - 15% of the catch and the rest is consumed fresh (Okraaku - Offei 1970)

Dry smoked fish is of low moisture content (10-15%) compared to fresh fish (75%water) and is done using smoking ovens (Rawson, 1966). Smoking is effected by both drying and deposition of smoke chemicals like aldehyde, ketones, phenols, organic acid. These have a preservative effect on the fish. There's also an antioxidant effect produced by phenolic compounds on the surface. The smoked product owes its storage life primarily to the drying and cooking processes, rather than the preservative value of the wood smoke chemical.

Sundrying of fish is one of the simplest and cheapest methods of curing fish. Sun dried fish plays an important role in Northern Ghana as the main source of protein. The quality of the product depends on climatic conditions since the product is at the mercy of the weather. However, the introduction of the solar dryer has eased a lot the problems encountered (Akuffo, 1976)

In hot humid climates, spoilage is not always arrested by dehydration methods as it is difficult to keep the product dry.

fermentation of fish is a method which inhibits spoilage changes within the fish by increasing the acidity. During fermentation, the use of salt inhibits the action of the spoilage bacteria and allows the fish enzymes or beneficial acid-producing

bacteria to break down the flesh. The use of fermentation as a low cost method of fish preservation is more commonly practised in South East Asia and West Aafrica (Food Cycle Tech. BK No 4)

#### 2.4.1 SALTING

Some big fishes are also salted before sundrying eg "koobi" (Okraku-offei, 1970)

The most important effect of the salt is the removal of water from the fish flesh to the point where microbial and enzymatic activities are retarded (Duere and Dryer, 1952)

Some spoilage bacteria cannot live in salty condition and a concentration of 6-10% salt in the fish tissue will prevent their activity. A group of micro-organisms known as halophylic bacteria are however salt loving and will spoil salted fish only.

Futher removal of water by drying will inhibit these bacteria. The removal of water which takes place during the salting of fish, is due to the fact that the salt solution outside the fish is of a higher concentration than the residual water in the fish flesh. As water is removed from the fish flesh salt will penetrate into it. If the salt concentration outside the fish is equal to that inside the fish flesh, no movement of water or salt will occur. Once this happens, more salt will have to be added to the solution so that the salting can continue.

The rate of water movement out and salt movement in depends on,

- the concentration of the salt solution
- the fat content of the fish
- the thickness of the fish
- temperature
- time that the salting is allowed to continue.

The type of salting operation used will depend, on;

- consumer preferences
- availability of salt and costs
- fish type, that is, lean or oily

Salt is variable in its properties, as it is produced in several ways

The main types are:

- sea salt from the sea or lake waters
- brine evaporated salts from underground sources
- rock salts

These salts differ in their chemical composition, their microbiological purity and their physical properties which will affect the salted fish quality.

Apart from contamination such as dust, sand, mud and moisture, salt intended for use on fish should have a low content of magnesium and calcium salts to avoid the bitter tastes and toughness imparted by these salts although the whiter colour effect may be a consumer preference.

Salt comes in different sized crystals or particles depending on whether or not it has been grounded and how it has been ground. Coarse grain more suitable (Large in size) will not penetrate into fish flesh as quickly as possible as fine grain (small in size) nor will it dissolve in water rapidly. Although fine grain salt will be suitable for making brines, coarser grains is more suitable for dry salting as a condition known as "salt burn" may occur if fine grain salt is used. That is, the surface of the fish becomes hardened due to too rapid a removal of water from the fish surface in a similar way to case hardening. The hard surface then prevents both salt penetration and water removal.

Salting as a traditional processing method has taken two forms;

- ◆ Dry salting
- ◆ Wet salting

#### 2.4.2 DRY SALTING

Dry salting is also known as "kench" salting. In this process the fish are mixed with dry crystalline salt, usually by rubbing it into or sprinkling it on the fish surface, and then stacking the fish making the middle higher than the sides. The water is removed from the fish by the action of the salt, and osmotic draining away as brine.

Non-fatty fish are usually dry salted. Salting fatty fish in this way will allow for extensive breakdown of oils, giving characteristic rancid flavours and smell, due to exposure to the air, and thus is not recommended.

Kench salting has the advantage that water drains away from the stack of fish so leaving it fairly dry. The fish may not be left long enough for complete salt penetration and if the pile is not re-stacked to allow re-arrangement of the fish, those at the bottom will have been salted to a different degree to those at the top

(Food Cycle Technology source book No 4, 1988)

#### 2.4.3 WET SALTING OR SALT PICKLING

This process is ideal for oily fish such as herrings, sardines, anchovies, mackerals especially to help inhibit rancidity by excluding air.

Pickle curing starts as for the dry salting method in that the prepared fish are layered alternately with dry salt crystals. The fluids are not left to drain away as in "kench" salting but are allowed to accumulate to cover all the fish. Often, weights are kept or placed on the top to keep the fish immersed in the brine, and assist in the removal of water

(food cycle technology source book No 4 1988)

2.5 EFFECT OF SALTING AND DRYING ON LIPIDS

Koizumi et al (1980) found out that dried-salted fish products are more susceptible to oxidative changes than freeze-dried fish flesh, because the added salt functions as a pro-oxidant.

Cutting (1962) has stated that although salt promotes rancidity in frozen fatty fish where cured fish are covered with a saturated salt brine, oxygen is rendered almost insoluble and rancidity develops extremely slowly. Other evidence exists that salt has a protective effect on lipids.

Nambudiry(1980) stated that it is a pro-oxidant in fatty species at lower concentrations, but as concentration increases, salt inhibits lipid oxidation. In addition to its effects on oxidation, salting also exerts an osmotic effect on fish flesh, thus oil and other constituents may be lost from the fatty fish (cuttings, 1962)

Rao et al (1983) studied lipid composition of commercial samples of salted sundried mackerel. Compared to fresh fish, these mackerel have a decreased glyceride content and higher free fatty acids indicating hydrolytic cleavage. Therefore sundrying causes considerable loss of polyunsaturated fatty acids.

2.6 EFFECT OF SALTING AND DRYING ON PROTEIN QUALITY

Evidently, the impact of salting and drying on the protein quality may be assessed from known effects of physical and chemical parameters employed in the production such as dehydration, temperature, time and added compounds, but only tests on the actual

products can provide reliable data on their protein quality.

The effects of drying temperature and salting on protein quality of dried cod were investigated by Aitken et al (1967) using the accelerated mechanical drying (AMD) system.

Unsalted fish have  $NPU_{st}$  (net protein utilisation - standardised) values of 96 when dried with a maximum temperature of  $100^{\circ}C$  compared with 87 when dried with a maximum temperature of  $115^{\circ}C$ .

Lightly salted (10.8% NaCl) and heavily salted (28.9% NaCl) fish have  $NPU_{st}$  values of 94 and 90 for undried, lightly salted fish.

El-Wakeil (1975) studied the protein quality of fresh water fish (Lates niloticus). Drying of the salted fish was done in air over 10-30 days depending on fish size. Thereafter, the fish was stored at room temperature for 30 days. The final product contained 10-12% moisture about 12% of fat and about 80% protein.

The effects of drying regimes on the invitro digestibility by Lee and Ryce (1987) shows that drying in the sun for a long time causes a slow but only slight lowering of digestibility due to protein damage and to the formation of enzyme indigestible substrate.

From these results and others, drying per se may not have any adverse effects on protein quality. As long as the drying temperature is kept below  $100^{\circ}C$  losses in protein quality are moderate. When drying temperatures are in excess of  $100^{\circ}C$ , losses in protein quality increase progressively with temperature.

## CHAPTER 3

### MATERIALS AND METHODS

#### 3.1 SAMPLE COLLECTION AND PREPARATION

Twenty pieces each of fresh Tilapia species and Redfish species (sparidae species) were purchased at the Kaneshie market and brought back into the laboratory.

In the laboratory, all of the fish samples were eviscerated, scaled and washed clean with tap water.

#### 3.2 SALTING PROCEDURE

##### 3.2.1 PICKLE SALTING (WET METHOD)

Ten pieces of the prepared Tilapia spp were weighed. This was accordingly salted using a 3:1 ratio by weight of the fish to the salt. The salting was done by placing and rubbing salt into all opened areas of the fish as well as on the surface of the fish.

The salted fish were then placed in a basket which was in turn placed in a bowl in such a way that the liquid exudate will form around the fish. A jute sack was placed on top of the fish in the basket and then weighed down with stones.

The same procedure was used for the Red fish samples. Salting was allowed to continue for 48 hours for both varieties.

### 3.2.2 KENCH SALTING (DRY METHOD)

The other ten pieces of both the Tilapia and Redfish varieties were weighed and salted in a 3:1 ratio by weight of fish to salt as was done for the pickle salting.

The fish samples were then placed in baskets which were returned placed on top of smaller bowls in such a way that the bottom of the basket was not in contact with the bottom of the bowl. In this way, the liquid exudate will not form around the fish but flow out into the bowl. Again, the baskets were covered with jute sacks and weighed down with stones. Salting was allowed to continue for 48 hours.

### 3.3 DRYING

Two (2) methods of drying were employed. These were solar drying and open-air drying. For the Tilapia species, the ten(10) pieces that were pickle cured were divided into two batches. Five pieces were solar dried while the other five pieces were air-dried.

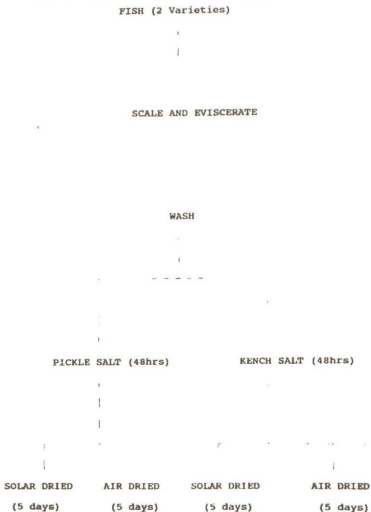
Five pieces each of the other ten pieces of Tilapia which were kench cured were also solar dried and air-dried. For the Redfish samples, the ten pieces that were pickle salted were also divided into two batches. Five pieces were solar dried and five pieces air-dried.

The same thing was done for the ten pieces which were kench salted.

Five pieces were solar dried while the other five pieces were air-dried. In all the above cases, drying was allowed to continue for 5 days.

Samples of both the Tilapia spp and the Redfish species were also both air-dried and solar dried without salting to serve as control. After drying, all the samples were milled into fine flour for proximate analysis.

Figure 1 FLOW DIAGRAM FOR SALTING AND DRYING PROCEDURE



### 3.4 PROXIMATE ANALYSIS OF PROCESSED FISH SAMPLES

#### 3.4.1 MOISTURE CONTENT DETERMINATIONS

Moisture was determined using Air-oven method of the Association of Official Analytical Chemists (AOAC method 14004, 1975). The moisture content was determined using 2 grams samples of the fish. These were weighed accurately into tarred moisture dishes and heated in an oven (Gallenkamp Oven) at 105° C to constant weight. The dishes were cooled in a dessicator and weighed to obtain the moisture loss.

#### 3.4.2 TOTAL ASH CONTENT DETERMINATION

The total ash content for the samples were determined by ashing at 600°C in a muffle furnance to a constant weight (AOAC, 13.066, 1975)

#### 3.4.3 CRUDE PROTEIN DETERMINATION

The protein content was determined by analysing for total nitrogen using the macro-kjeldhal method, (AOAC 7.045, 1975).

2 grams of the samples were digested in a kjeldhal flask using 25 ml concentrated sulphuric acid and 10 grams Reese and William reaction mixture. This was then distilled over 150 ml and then titrated with 0.1 N sulphuric acid to a faint pink. The nitrogen determined was converted to protein using the conversion factor 6.25.

#### 3.4.4 CRUDE FAT DETERMINATION

The method used was the soxhlet extraction method. This method is based upon the extraction with petroleum ether and subsequent weighing of all ether-soluble material from a weighed sample (AOAC 18.023,1975) 2 grams samples were used in the determinations.

#### 3.4.5 SALT CONTENT (SODIUM CHLORIDE) DETERMINATION

10 grams samples were weighed into a 250 ml erlenmeyer flask and then an excess of 0.1 N  $\text{AgNO}_3$  solution was added to precipitate all the chloride as silver chloride. This was boiled gently on a hot plate until all solids except  $\text{AgCl}$  dissolved. This was cooled and then 50ml water and 5ml indicator were added and then titrated with 0.1 N  $\text{NH}_4\text{SCN}$  solution to a permanent light brown.

The difference in volume between 0.1N  $\text{AgNO}_3$  added and 0.1N  $\text{NH}_4\text{SCN}$  used for the titration was used to calculate for sodium chloride ( $\text{NaCl}$ ) (AOAC 18.031, 1975)

#### 3.4.6 SENSORY ANALYSIS OF PROCESSED SAMPLES

Twenty(20) in-house panelists evaluated each of the processed (Salted) fish samples with respect to texture, odour, appearance and general acceptability. The panelists assigned the sample with the most acceptable texture a rank value of 1, the next sample with the next acceptable texture a rank value of 2, the next 3 and the least acceptable texture a rank value of 4. The evaluation was repeated for odour, appearance and general acceptability.

The results were analysed using computer-aided Analysis of Variance (ANOVA).

#### 3.4.7 SHELF LIFE DETERMINATION

Samples of the two varieties of processed fish were stored in a dry, airy place. The samples were inspected at three day intervals to check for signs of spoilage.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

4.1 MOISTURE CONTENT

With the Tilapia samples which were solar dried, the moisture content decreased to 46.49% and 45.03% in the pickled and kenched cured samples respectively as compared to 64.25% in the unsalted sample (Table 3).

The decreased moisture content for the cured sample was due to the action of the salt which removed water from the tissues of the fish by osmosis. The main aim of reducing the moisture content of the fish is to concentrate the salt in the fish, thus create an environment resulting in a water activity that is unsuitable for micro-organisms that cause spoilage to survive.

The pickle cured sample had a higher moisture content than the kench cured Tilapia. This was because during the pickle curing, the pickle that was formed eventually covered all the fish. The net result is that some of the water in the fish is retained since a stage is reached where there is no movement of water molecules out of the fish. Since in kench curing, the liquid pickle that forms is allowed to drain, the salt had ample contact with the fish to cause removal of more water by osmosis, thus a lower moisture content.

A similar observation was made for the Redfish sample which were solar dried. The moisture content decreased to 52.50% and 51.80% in the pickled and kench cured samples respectively compared to 67.62% in the unsalted sample. The observed decreases in the moisture could be due to the same reasons attributed to the moisture changes in the Tilapia species.

These difference in the moisture content are not significant and shows that the moisture content of the fish samples after processing does not depend on the salt treatment given (Appendix 1)

The methods of drying also had statistically significant effects on the moisture contents. It was observed that samples which were solar dried had slightly lower moisture content than samples which were air-dried for the same method of salting.

For example, pickled Tilapia species which were solar dried had 46.49% moisture while those which were air-dried had 47.97% moisture. Also kench Redfish which were solar dried had a moisture content of 51.80% while those which were air-dried had moisture content of 53.04%.

These observed differences in moisture content between solar and air-dried samples are due to the fact that the average temperature in the solar dryer is comparatively higher than the ambient temperature. Because the solar dryer is enclosed, more heat is trapped inside the cabinet which causes further removal of water than that removed by air drying. During the drying period, the average temperature as recorded in the solar dryer was 46°C while the ambient temperature (average) was 34°C.

Air drying has many limitations; long periods of sunshine without rain are required, drying rates are low and in areas of high humidity, it is often difficult to dry the fish sufficiently.

TABLE 3

Changes In Moisture content of Salted-Dried  
And Unsalted-dried fish Samples

SAMPLE	MOISTURE(%)
Tilapia, pickled, solar dried	46.49
Tilapia, kenched, solar dried	45.03
Tilapia, pickled, air-dried	47.39
Tilapia, kenched, air-dried	46.97
Redfish, pickled, solar dried	52.50
Redfish, kenched, solar dried	51.80
Redfish, pickled, air-dried	53.38
Redfish, kenched, air-dried	53.04
Unsalted Tilapia, solar dried	64.25
Unsalted Tilapia, air-dried	65.74
Unsalted Redfish, solar dried	67.62
Unsalted Redfish, air-dried	69.23

The quality of the sun dried fish is likely to be low due to slow drying, insect damage and contamination from air-borne dust, and it is difficult to obtain a uniform product (Clucas and Satchiffe, 1981). Thus in the search for improved drying techniques, the use of the solar dryer have been investigated as an alternative to the traditional open air-sundrying (Trim and Curvan, 1983).

The advantages of the solar drying over the traditional sun drying of fish are well known.

- Faster drying
- Better quality
- Protection from dirt, insects and other predators

Generally, it was observed that irrespective of the methods of salting and drying, the Redfish samples had a higher moisture content than the Tilapia samples, possibly due to the differences in species, size or differences in initial moisture contents.

#### 4.2 CRUDE FAT CONTENT

The fat content of the fish samples decreased with salting. For the Tilapia samples which were solar dried, the fat content decreased from 15.47% in the unsalted sample to 7.68% and 7.36% in the pickled and kenched samples respectively. (Table 4)

Similarly, air-dried Tilapia samples had moisture contents which decreased from 16.93% in the unsalted sample to 8.14% and 7.98% in the pickled and kenched samples respectively.

TABLE 4

Changes In Crude fat Content of Salted-Dried  
And Unsalted-Dried fish samples

SAMPLE	CRUDE FAT (%)
Tilapia, pickled, solar dried	7.68
Tilapia, kenched, solar dried	7.36
Tilapia, pickled, air-dried	8.14
Tilapia, kenched, air-dried	7.98
Redfish, pickled, solar dried	9.62
Redfish, kenched, solar dried	9.27
Redfish, pickled, air-dried	9.78
Redfish, kenched, air-dried	9.43
Unsalted, Tilapia, solar dried	15.47
Unsalted, Tilapia, air-dried	16.93
Unsalted, Redfish, solar dried	17.42
Unsalted, Redfish, air-dried	17.82

Values are means of duplicate determinations expressed on dry matter basis.

The same trend was observed for the Redfish samples; Unsalted Redfish, Solar dried (17.42%) Redfish, pickled and solar dried (9.62%), kenched Redfish, solar dried (9.27%).

Also unsalted Redfish which was air dried had 17.82% fat whiles pickled and kenched redfish which were also air dried had 9.78% and 9.43% fat respectively.

The apparent decrease in the fat content from the unsalted samples to the salted samples may be largely due to the addition and uptake of salt during curing. The values of fat contents were recorded on dry matter basis, as such any imposed increase in one component will result in apparent decreases in the other components such as protein, ash and fat.

When salt is added to the sample, it goes to increase the ash content. Hence the fat content should decrease accordingly to accommodate the increases in percentage ash observed. In this respect, the decrease could be apparent.

It was observed that for both the Tilapia and Redfish samples, those that were kench cured had slightly lower crude fat content than those which were pickled. However analysis of variance for fat shows that the differences in fat content are statistically significant. (Appendix 2)

Multiple range analysis for fat by species shows that the Redfish samples have higher fat content than the Tilapia species. Also the same analysis for fat by salt treatment shows that changes in fat content caused by pickle and kench curing are not significant. (Appendix 2)

It was also observed that samples which were solar dried had lower crude fat content than those which were air-dried for the same method of salting (Table 4).

This observation could be due to the high temperatures within the solar dryer tent which could have liquified some of the fat and be lost through exudation during the period of drying.

Decreases in the fat content could also possibly be due to lipid oxidation. Loss in the fat content may cause a decrease in nutritive value of the salted dried fish product. On the other hand, decreasing the fat content imparts better storage potential.

According to Clucas and Jutcliffe (1981), spoilage of fish products is partly due to chemical oxidation of fat which causes rancidity. The higher the fat content, the more rancid the product can become.

As fish oil goes rancid, malonaldehyde is produced, which reacts with 2-thiobarbituric acid to yield a pink or red compound, the intensity of which is a measure of the degree of rancidity (Amu and Disney, 1973).

#### 4.3 CRUDE PROTEIN

The protein content was determined by analysing for total nitrogen. As with the fat content, protein decreased from the unsalted dried samples to the salted dried samples (Table 5).

Unsalted Tilapia which was solar dried recorded a protein content of 74.15% while pickled and kench cured Tilapia which were also solar dried had 59.9% and 58.83% protein respectively.

Unsalted Tilapia which was air-dried had 74.92% protein as against 60.47% and 59.81% for pickled and kench cured Tilapia which were air-dried.

Similarly, for the Redfish samples, the unsalted ones which were solar dried had 75.75% protein while the pickled and kench cured Redfish samples which were also solar-dried had 62.43% and 61.13% respectively. Further more, unsalted Redfish (air-dried) had 76.04% as against 63.46% and 62.08% for the pickled and kench cured samples respectively, also air-dried.

The apparent decreases in the level of protein in the salted samples may be largely due to the uptake of salt in the course of curing. As was discussed earlier, the crude protein was also recorded on dry matter basis. The uptake of salt results in a corresponding decrease in protein in order to accommodate the increased amount of salt.

**TABLE 5**

Changes In Crude Protein Content of Salted-Dried  
And Unsalted Dried fish Samples

SAMPLES	CRUDE PROTEIN (%)
Tilapia, pickled, solar dried	59.91
Tilapia, kenched, solar dried	58.83
Tilapia, pickled, air-dried	60.47
Tilapia, kenched, air-dried	59.81
Redfish, pickled, solar dried	62.43
Redfish, kenched, solar dried	61.13
Redfish, pickled, air-dried	63.46
Redfish, kenched, air-dried	62.08
Unsalted, Tilapia, solar dried	74.15
Unsalted, Tilapia, air-dried	74.92
Unsalted, Redfish, solar dried	75.75
Unsalted, Redfish, air-dried	76.04

Values are means of duplicate determinations expressed on dry matter basis.

Another probable reason for the observed decrease in the protein content of the salted sample could be due to proteolytic action of bacterial enzymes, converting the proteins into volatile nitrogenous compound.

The high temperatures associated with drying especially in the solar dryers could also have denatured the protein hence the decreased protein content.

Analysis of variance for protein shows that the differences in protein with respect to species and drying condition is not significant. This means that changes in protein does not depend on the species or drying condition.

However, changes in the protein content with respect to one salt treatment are statistically significant. The protein content of the processed fish depends very much on the salt treatment given. (Appendix 3).

#### 4.4 ASH AND SODIUM CHLORIDE (SALT) CONTENT

The ash content increased markedly from the unsalted sample to the salted samples (Table 6).

Ash is an expression for the inorganic components of the sample which include all the minerals. The high ash content of the salted samples is due to the uptake of salt during the salting process. The higher the amount of salt uptake, the greater the percentage total ash.

It was observed that generally, for fish samples that were kenched cured, salt uptake was higher than for the samples that were pickled cured and therefore samples that were kenched cured had higher percentage total ash than the samples that were pickled cured.

The reason is that for pickled curing, as water exudes from the fish as a result of salt uptake, a pickle forms around the fish. The rate of water removal depends on the concentration of solutes (salt) inside the fish and in the surrounding pickle.

As salting continues, a stage is reached where the concentration of salt inside the tissues of the fish is the same as the concentration of salt in the surrounding pickle. When this equilibrium stage is established, there would be little or no further uptake of salt and hence little or no water is removed.

However, with the kenched or dry salting, a pickle does not form around the fish. The pickle is allowed to drain away. In this way, salt uptake is higher because no equilibrium is established.

The salt goes to remove most of the water from the fish tissues. This is why salt uptake is higher in the kenched cured samples than in the pickled cured samples. This also explains why the moisture content of the kenched samples is lower than that of the pickled samples. (table 3)

For example, for the samples that were solar dried, pickled Tilapia had 5.28% salt and a corresponding 22.88% total ash, where as kenched Tilapia had 5.49% salt and a corresponding 23.27% total ash.

TABLE 6

Changes In Ash And Sodium Chloride Content of Salted-Dried  
And Unsalted-Dried fish Samples

SAMPLES	ASH (%)	Sodium Chloride (%)
Tilapia, pickled, solar dried	22.88	5.28
Tilapia, kenched, solar dried	23.27	5.49
Tilapia, pickled, air-dried	24.08	5.57
Tilapia, kenched, air-dried	24.75	5.78
Redfish, pickled, solar dried	25.82	6.53
Redfish, kenched, solar dried	26.43	6.78
Redfish, pickled, air-dried	26.03	6.67
Redfish, kenched, air-dried	26.65	6.84
Unsalted, Tilapia, solar dried	3.48	0.41
Unsalted, Tilapia, air-dried	3.92	0.46
Unsalted, Redfish, solar dried	5.61	0.59
Unsalted, Redfish, air-dried	5.84	0.64

Values are means of duplicate determinations expressed on dry matter basis.

Again for the Redfish samples, those that were pickle cured and air-dried had 6.67% salt and a corresponding 26.03% total ash, where as the kench cured samples also air-dried recorded 6.84% salt and 26.65% total ash.

Statistical analysis shows that the method of drying does not have any significant effect on the total ash content of the processed fish samples. However, the variety of fish as well as the salt treatment have significant effect on the salt content. The Redfish samples had higher amount of salt than the Tilapia samples. This difference is not surprising since the two varieties of fish come from different water environment. The Redfish comes from a marine habitat while the Tilapia is a fresh water fish. The marine environment has a higher amount of dissolved salts than fresh water and this could have contributed to the higher salt content of the Redfish as against the Tilapia. The high salt content of "koobi" enables it to keep for weeks, and it imparts to it a typical strong flavour much liked by the consumer (Okraku-Offei, 1970).

A probable disadvantage of salting is that essential water-soluble minerals can be lost through the water that exudes.

#### 4.5 SENSORY ANALYSIS

Twenty in-house samples with respect to acceptability using the variance was used to

There were significant differences with respect to texture, color and taste, as evaluated by the panel.

The extent of the plot which is a plot of the quality (Appendix 1) shows a rank value of 1.0 for the characteristic while the acceptable quality of the sample was 1.0.

This means that the samples are taken with the small sample with the small sample with the high

Similarly, all the Redfish samples which were kench cured and air-dried were the most acceptable in terms of texture, odour, appearance and general acceptability.

One striking finding was that for the samples that were least accepted, all were solar dried. For the Redfish samples, all the pickle cured and solar-dried were least accepted by the judge of panelists.

Tilapia samples which were kench cured and solar dried were least accepted for odour whiles pickle cured samples and solar dried were least accepted for appearance. However, both pickle and kench cured Tilapia which were solar dried were least accepted for texture.

It appears the high temperatures within the solar tent dryer affected the physical nature of the solar-dried samples and hence their least acceptability by the panel of judges.

ACCEPTABILITY OF PROCESSED FISH SAMPLES AS EVALUATED BY PANELISTSTABLE 7(1) Variety of fish: Tilapia Species

Quality Characteristic	Most Acceptable Sample	Least Acceptable Sample
1. Texture	Tilapia, pickled, air-dried	Both pickled and kenched Tilapia, solar-dried
2. Odour	Tilapia, kenched, air-dried	Tilapia, kenched, solar-dried
3. Appearance	Tilapia, kenched, airdried	Tilapia, pickled, solar-dried
General Acceptability	Tilapia, kenched, air-dried	Tilapia, kenched solar-dried

(2) Variety of fish: Redfish species

Quality Characteristic	Most Acceptable Sample	Least Acceptable Sample
1. Texture	Redfish, kenched, air-dried	Redfish, pickled, solar-dried
2. Odour	Redfish, kenched, air-dried	Redfish, pickled, solar-dried
3. Appearance	Redfish, kenched, airdried	Redfish, pickled, solar-dried
General Acceptability	Tilapia, kenched, air-dried	Redfish, pickled, solar-dried

Key To Means Plot

Sample 1 - Tilapia, pickled, solar-dried  
 Sample 2 - Tilapia, kenched, solar-dried  
 Sample 3 - Tilapia, pickled, air-dried  
 Sample 4 - Tilapia, kenched, air-dried  
 Sample 5 - Redfish, pickled, solar-dried  
 Sample 6 - Redfish, kenched, solar-dried  
 Sample 7 - Redfish, pickled, air-dried  
 Sample 8 - Redfish, kenched, air-dried

#### 4.6 Shelf-Life Determination

Samples of the two varieties of processed fish were stored in a dry, airy place in a bid to determine their shelf-life. At intervals of two(2) days, the samples were inspected to check for signs of spoilage such as production of slime on surface, discoloration, mould growth and ease of fragmentation.

The Tilapia samples were able to keep for more than three(3) months. The Redfish samples started deteriorating after five(5) weeks. The most visible sign of spoilage was mould growth. It also became easily fragmented. Rancidity of the Redfish fat could have enhanced its spoilage and therefore its shorter shelf-life as compared to the Tilapia samples.

CHAPTER

5.0 CONCLUSIONS

The two methods of salting em curing, resulted in decreased moisture degrees during processing, while the the addition of salt. Apart from loss the initial stages of processing, the content was expected, as a consequence involved in the process. The decrease (expressed on dry matter basis) could the uptake of salt. However, for f attributed to dripping of liquified f oxidation. For protein, proteolysis also be attributed to the observed decrease of the differences in moisture, protein and kenched samples are not significant contents.

Sensory evaluation by twenty ir the kench cured and air-dried samples terms of texture, odour and appearance were pickle cured and solar dried sensory evaluation panelists.

The Tilapia samples had a longer shelf-life than the Redfish samples probably because of the latter's high fat content. The Tilapia was able to keep for over three months whiles the Redfish deteriorated after five weeks.

5.1 RECOMMENDATION

It is recommended that micro-organisms especially moulds associated with deterioration of the processed sample be isolated and characterised in subsequent work.

CHAPTER 6

6.0

BIBLIOGRAPHY

- (1) Adjei-Boamah K. R. (1987), Mycotoxins in Ghanaian Foods Nutrition And Food Science Department, University of Ghana, Legon. Report No. NFS 87-05-F
- (2) Aitken a, Jason A. C., Ollay J., Payne P. R., (1967), Effects of Drying, Salting And High Temperature on the Nutrition Value of Dried Cod.
- (3) Akuffo S. (1976), The Development of New Fishery Product. (Intermediate moisture fish Products Datexi Spp and Salted Fish Cakes Balistes Spp). Nutrition And Food Science Department, University of Ghana, Report No. NFS 76-05-F.
- (4) Amu L. And Disney J. G. (1973), Quality Changes In West African Marine Fish During Iced Storage. Tropical Science 1973.
- (5) Amano k., Bito M., Kawabata T. (1953), Handling Effects on Biochemical Change In Fish Muscle Immediately After Catch. Bulletin of Japanese Society of Science, Vol. 19.
- (6) Borgstrom G. (1965), The Atlantic Fisheries of The U.S.S.R, pp. 282-315. Highway Publication, London.
- (7) Bransted F. and Auerbach M. (1977), The Spoilage of Fresh Water Fish. Academic Press London.

- (8) Clucas J. J. and Sutcliffe P. J. (1981), An Introduction of Fish Handling And Processing Depart. of Tropical Product Institute pp. 88.
- (9) Cole J. and Greenwood Barton (1973), Problems Associated with The Development of Fisheries In Tropical Countries III. The Preservation of The Catch By Simple Processes Tropical Product Institute, London W.C.
- (10) Cuttings, C. L. (1962), the Influence of Drying, Salting And Smoking On The Nutritive Value of Fish. In "Fish In Nutrition", Fishing News, London.
- (11) Duere J. D. and Dryer W. J. (1952), J. Fish Res. Bd. Canada 8, pp. 325-331.
- (12) El-Wakeil (1975), Chemical And Biological Evaluation of Fresh And Preserved Lake Nassers Fish. Journal of Food Science Technology.
- (13) Fish Processing (1988), Food Cycle Technology Source Book No. 4, United Nation Development Fund For Women (UNIFEM).
- (14) Fish Technology News (January, 1982), Issue No. 3
- (15) Garm R., Limpus L. (1976), Organisation Of Fish Inspection Programmes In Developing Countries. Tropical Products Institute. Conference Proceedings 5-9, July 1970.
- (16) Geogala J. (1958), The bacterial flora of The Skin of North Sea Cod In Journal of General Microbiology 18 pp. 84-91

- (17) Hess E. (1960), Bacterial Fish Spoilage And Its Control  
FAO, Rome, Italy.
- (18) Iwamoto M., Yamanaka H., Watanaba S., Hashimoto K. (1987)  
Effect of Storage Temperature On Rigor Mortis And ATP  
degradation In Paralichthys olicaceus muscle. Journal of  
Food Science Vol. 52, pp. 1514-1517.
- (19) James D. (1977), Fermented Fish Products CIDA/FAO/CEDAF.
- (20) Josephson D., Lindsay R., Stuibler D., (1987), Enzymatic  
Hydroperoxide Initial Effects In Fresh Fish. Journal of  
Food Science, May - June 1987.
- (21) Jones N. R., Murray J., Livingston E. I., and  
Murray C. K. (1965), Rapid Estimation of Hypoxanthine  
Concentrations as Indices of the Freshness of chill-  
stored Fish. Journal of Food Science, Vol. 15.
- (22) Koizumi F. L. (1980), Lipid Oxidation of Salted Freeze-  
Dried Meats At Different Equilibrium Relative Humidities  
Soc. Sci. Fisheries.
- (23) Kronerheng T., Hang B. (1985), A Puncture Testing Method  
For Monitoring Solid Substrate Fermentation. Journal of  
Food Science, Volume 50.
- (24) Liston J., Colwell R. R. (1963), Host and Habitat  
Relationship of Marine Commensal bacterial, In "Symposium  
on Marine Microbiology". Academic Press, London.
- (25) Nambudiry, D. D. (1980), Lipid Oxidation In Fatty Fish, The  
Effects Of Salt Content In The Meat.

- (26) Noguchi E. (1957), A Study Of The Freshness Of Fish Meat With Special Reference To The Determination Of Rigor Mortis Bulletin Of Japanese Society Of Science, Volume 5.
- (27) Okraku-Offel G. (1970), Processing Andd Preservation Of Fish In Ghana A Food Research
- (28) Rawson C. G. (1966), A short Guide To Fish Preservation, FAO of United Nations, Rome.
- (29) Rao B. G. (1983), Lipid Composition Of Salted Sundried Indian Mackerel. Journal Of Food Science Technology, Volume 21.
- (30) Saito J., Matsuyoshi M. (1959), A New Method For Estimating The Freshness Of Fish. Journal Of Fisheries Research Board
- (31) Shewan J. M. (1970), The Microbiology of Fish And Fishery Products. A progress Report, Highway Publication, London
- (32) Talarczak C. K. (1977), Small Scale Fisheries; The Method of Handling, Processing, Collection, Distribution And Marketing CIDA/FAO/CECAF.
- (33) Trim D. S., Curran (1983), A Comparative Study Of Solar And Sundrying Of Fish In Ecuador, In Tropical Products Institute.
- (34) Watanabe E., Nagumo A., Hoshi M., Konagaya S., Tanaka M., (1987) Microbial Sensory for The Detection Of Fish Freshness In Journal of Food Science Technology, Volume 13.

- (35) Yamada K., Harada K., Kawahara T., Tsukamoto S., (1983), Comparative Rates of ATP Degradation In Rested And Exhausted Young Yellow Tail Seriola quinqueradiata In Relation To Rigor Mortis, Bulletin of Japanese Society of Science, Volume 31.
- (36) AOAC (1975) Association Of Official Analytical Chemists, Approved Methods, 12 edition.

Analysis of Variance for moisture

Multiple range analysis for moisture by species

Multiple range analysis for moisture by salt treatment

Multiple range analysis for moisture by dry condition

### Analysis of Variance for fat

Source	df	SS	MS	F	P
Species	2	10.00	5.00	1.00	0.37
Salt treatment	2	10.00	5.00	1.00	0.37
Dry condition	2	10.00	5.00	1.00	0.37
Species * Salt treatment	4	10.00	2.50	0.50	0.80
Species * Dry condition	4	10.00	2.50	0.50	0.80
Salt treatment * Dry condition	4	10.00	2.50	0.50	0.80
Species * Salt treatment * Dry condition	8	10.00	1.25	0.25	0.98
Error	24	10.00	0.42		
Total	38	50.00			

### Multiple range analysis for fat by species

Species	Mean	SE	LS
1	1.00	0.20	0.60
2	1.00	0.20	0.60
3	1.00	0.20	0.60

### Multiple range analysis for fat by salt treatment

Salt treatment	Mean	SE	LS
1	1.00	0.20	0.60
2	1.00	0.20	0.60
3	1.00	0.20	0.60

### Multiple range analysis for fat by dry condition

1.00 0.20 0.60

### Analysis of Variance for protein

### Multiple range analysis for protein by species

### Multiple range analysis for protein by salt treatment

### Multiple range analysis for protein by dry condition

### Analysis of Variance for ash



Source	SS	df	MS	F	Prob > F
Species					
Salt treatment					
Dry condition					
Error					

### Multiple range analysis for ash by species



Species	Mean	SE	LS	LSL	LSU

### Multiple range analysis for ash by salt treatment



Salt treatment	Mean	SE	LS	LSL	LSU

### Multiple range analysis for ash by dry condition



Dry condition	Mean	SE	LS	LSL	LSU

### Analysis of Variance for salt



### Multiple range analysis for salt by species



### Multiple range analysis for salt by salt treatment



### Multiple range analysis for salt by dry condition

## Analysis of Variance for Y

Source of Variation	Sum of Squares	d.f.	Mean	F	p	Partial $\eta^2$
<b>TOTAL EFFECTS</b>	<b>25.962500</b>	<b>26</b>				
<b>Model</b>	<b>6.568750</b>	<b>10</b>				
<b>Sample</b>	<b>19.393750</b>	<b>7</b>				
<b>RESIDUAL</b>	<b>164.98125</b>	<b>133</b>	<b>1.239999</b>			
<b>TOTAL CORRECTED</b>	<b>190.94375</b>	<b>159</b>				

Missing values have been excluded.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Sig.
Model	27.700000	26	1.0653846	1.897	.000
Corrected Total	8.100000	19	.4263158	1.359	.000
Sample	19.600000	7	2.8000000	2.358	.000
Residual	157.90000	133	1.1872180		
Total (Corrected)	185.60000	159			

Missing Values have been excluded.

## ANALYSIS OF VARIANCE

Source	Sum of Squares	d.f.	Mean Square	F-ratio	Sig.
Between Groups	30.400000	26	1.169231	1.030	
Within Groups	9.625000	19	.506579	.446	
Total	20.775000	7	2.967857	2.617	
SIGMA	150.97500	133	1.135154		
TOTAL SCORE	181.37500	159			

MISSING VALUES have been excluded.

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## Analysis of Variance for appearance

	Sum of Squares	d.f.	Mean Square	F-ratio	Sig.
Corrected Total	41.900000	26	1.61153846		
Between Groups	3.625000	19	.19078947	1.174	.1
Within Groups	38.275000	7	5.46785714	4.999	
Total	145.47500	133	1.0937970		
RETCORE	187.37500	159			

Missing Values: 200 have been excluded.



