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GHANA/NETHERLANDS ARTISANAL FISH PROCESSING PROJECT

RESEARCH PROJECT #1

STUDIES ON THE HANDLING, MARKETING AND DISTRIBUTION OF FRESH LANDED FISH IN GHANA

EFFECT OF MARKETING PRACTICES ON THE QUALITY OF FRESH FISH IN GHANA

FOOD RESEARCH INSTITUTE LIBRARY

By

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EFFECT OF MARKETING PRACTICES ON THE QUALITY OF FRESH FISH IN GHANA

M. A. Hodari-Okae, L. Abbey and A. Osei-Yaw

ABSTRACT

Selected fresh fish retail markets in the District of Accra were surveyed to determine the fish marketing practices, available facilities and the general conditions of fish marketing. Samples of fish were collected from the markets and analysed for their physical, chemical, sensory and microbiological quality as related to the prevailing market conditions. Poor handling practices were observed to be the major contributory factor leading to early fish spoilage in the various fish markets surveyed. Display techniques carried out in either the open space or in stalls that are not fly-proof were found to further aggravate the spoilage problem. In addition, the practice of over-loading fish in boxes resulted in belly burst leading to contamination of the whole batch of fish, with gut contents serving as a good source of microbial inoculum.

Little or no ice was used to lower the temperature of fresh fish in order to preserve its freshness during sale. Thus, most of the fish species examined were found to be unfit for consumption, having lost most of the freshness attributes. Microoganisms involved in the spoilage include: *E. coli, Bacillus* spp., Micrococci, *Aeromonas* and *Corynebacterium*; with a maximum aerobic count per gram of 482×10^7 organisms. The presence of faecal coliforms was indicative of faecal contamination either from the batch of fish or from human source.

The texture and flavour of some of the cooked fish samples showed poor sensory qualities, although the odour of all the cooked fresh fish samples analysed were found to be acceptable. However, variability in scores showed that fish samples collected from landing sites had better sensory scores than those purchased from the fish markets (having been handled along the chain of distribution). Hence, fish reaching the consumer tend to be of poor quality. There was a steady correlation between free fatty acid content and the extent of spoilage. Higher values of over 18% were recorded for Grade C fish, while lower values of less than 3% were observed in Grade B fish samples.

INTRODUCTION

Fish is an important component of the diet of the majority of Ghanaians, and it is also the most significant of the non-traditional exports. In Ghana, fish and fishery products account for the major protein intake; and majority of the catch is contributed by local artisanal fishing which account for about 60% of the total fish catch. Fish being highly nutritious contains about 70-80 % water, 15-24 % protein, 0.1-22 % fat (depending on whether it is a lean or fatty fish), 1-2 % minerals, and from negligible to 2% carbohydrates (Clucas, 1985); in addition to its richness in fat-soluble vitamins especially Vit. A and D (Putro, 1990). The national annual fish output of Ghana is about 350,000 tonnes of which about 46,000 tonnes come from the Volta Lake and 58,000 tonnes produced by inland capture fisheries (MTADP, 1990).The commercially important pelagic fish of Ghana includes oil sardines (*Sardinella longiceps*), sea bream (*Pagrus pagrus*), baracudas (*Sphyraena* spp.), mackerel (*Rastrelliger kanagurta*), anchovies (*Anchoa guinnessis*), and tuna.

Fish is however highly perishable under the Ghanaian tropical conditions of high temperatures leading to rapid deterioration of the fresh fish catch. A substantial amount of fish landed at the beaches of Ghana is sold unprocessed as fresh fish under conditions as high ambient temperatures, poor handling facilities and inadequate marketing techniques. To maintain an overall quality of such highly perishable commodity like fish, it is of utmost importance to dispose of the catch as soon as possible before deterioration sets in. Landing sites are known to lack the necessary

basic infrastructure, such as cold room and refrigerated vans. This limitation is not only at the shores but also at the marketing sites as well. In the Ghanaian markets, unsold fresh fish at the end of the day are usually chilled, frozen or processed though deterioration might have begun. Refrigeration and ice making facilities at the marketing points are not available to the retailers for use to maintain a high quality product until it reaches the consumer. Added to these, the display methods employed by the retailers tend to have a degradatory effect on the cummulative quality of the fish. Immediately the fish is harvested from the water body, spoilage begins causing loss of freshness qualities of the fish. This occurs as a result of a series of complicated changes that develop in the dead fish mainly due to enzymatic and bacterial action.

Bacteria are natural inhabitants of the gills, gut and the slime covering the surface of the fish (Connell, 1980). So that during handling of the fish, these bacteria tend to grow and multiply, resulting in biochemical changes associated with spoilage. At every stage of handling, distribution, processing and marketing of the fish, spoilage continues to manifest itself mainly due to contamination from the hands of handlers, dust from the environment as well as exposure to surfaces in contact with the catch.

Barnett (1989) observed that since temperature has a pronounced effect on the growth of contaminating microorganisms, the initial temperature of fish is of critical importance; so that the initial temperature of fresh seafood should be kept at about 0°C. By

reducing the temperature, the rate at which bacteria grow and the incidence of chemical changes that contribute to spoilage of fish are kept in check. Typical manifestations of these changes in fish caused by spoilage are intense odour development of the external surfaces and gills, and a gradual softening of the flesh. This results in modification of the flavour, aroma, colour or texture beyond limits acceptable to the consumer.

The decomposition of fish flesh may be the result of microbial or autolytic action, or a combinaton of both. Spoilage may result from decomposition of protein, urea, trimethylamine or fat. While a trained sensory evaluation panel may be the genuine test of incipient spoilage, there are a number of analytical methods that could be used to measure or quantitate early evidence of deterioration. These include:

1. Total bacterial count (TBC) particularly of mesophiles in the Ghanaian environment of high temperatures.
2. Free glucose which is low and limited in fresh tissue and its rapid disappearance is an indication of bacteria growth and activities.
3. Inosine monophosphate (IMP) which is a flavour enhancer; as it disappears the sensory score tends to decrease.
4. Hypoxanthine increases as IMP decreases so it is a useful measure of deterioration. It is found to accumulate and reaches a maximum after two weeks storage.
5. Bound ribose decreases as hypoxanthine increases.
6. Volatile acids tend to increase as bacterial count

increases.

7. Trimethylamine increases with storage and reflects a decrease in sensory quality. Trimethylamine oxide (TMAO) contained in the fish breaks down and stimulates anaerobic growth of bacteria (Raa, 1981).

The most obvious criterion, however, of spoilage of fresh fish for the potential consumer is the presence of offensive aromas. Borgstrom (1961-65) in assessing loss of freshness described a flavour that was both subtle and attractive as the first change in quality. These occurred between the elapsed period when the fish was out of the water and the onset of microbial changes. Factors which tend to have effect on the microflora include the type of fish, storage conditions, and even the mode of capture (Shewan, 1970). Clucas (1985) observed that microbial attack is the most important spoilage mechanism, generally starting in the gills and gut, then spreading to other parts of the fish. While fish may have relatively low microbial counts immediately after capture, subsequent handling can influence an increase in such counts to a marked degree.

Bacteriological methods are usually unable to provide rapid results as fresh fish may have unusually high loads due to contamination but still be acceptable. High microbial loads in fresh fish however are indicative of a poor storage life.

The most commonly used chemical methods are estimations of total volatile bases and trimethylamine. These characteristics increase with storage and are more useful indices of quality changes at an

earlier stage than sensory methods.

Economic losses of fish have been reported to be as high as 20 - 40 % of the annual catch. The reduction in losses can only be achieved through improvements in handling, processing, storage and distribution of fish. The absence of any meaningful quality standards for marketing of fresh fish to a large extent hampers the adoption of improved methods of fish handling and processing. Consequently, efforts to minimise the significantly high losses associated with the fish industry had been futile. Improvement in this sector would lead to much higher returns to the fisherman and consumers' satisfaction would be achieved.

The objectives of the present study are therefore to:

i. assess the handling and marketing techniques that lead to quality deterioration of fresh fish offered for sale at the market centers.

ii. identify the factors that influence the quality of fresh fish and to establish data for recommendation for quality control standards of market fresh fish.

iii. recommend appropriate merchandising techniques and to develop a fish freshness scheme to be adopted in order to ensure sale of good quality products over longer period of selling time under the prevailing environmental conditions.

With the adoption of better methods of handling and merchandising, losses in quality parameters would be minimised and finally good sales and benefits would be realized by both consumers and fishmongers.

2. MATERIALS AND METHODS

2.1. Survey of Fish Marketing Centers

A survey was carried out of major fish landing sites from where market samples of fish were obtained. By means of questionnaires (APPENDIX I), information was obtained on areas designed to highlight the following:

i. Location and description of marketing center and facilities available, i.e. storage and transportation, shed and display stands, availability of water, sanitation and general environmental conditions.

ii. Sources of supply or acquisition of fresh fish for sale.

iii. Handling, marketing and method of display of fish to consumers.

iv. Marketing skills of fish sellers.

Four main markets from which samples were purchased were:

1. Salaga fish market
2. Kaneshie fish market
3. Tema fishing harbour market
4. Labadi fish market.

Photographs were also taken where appropriate to give pictorial description of methods of fish handling, display, and facilities at the various markets.

2.2. Sampling

Subsequent to the survey exercise, fish samples of four commercially important tropical marine fish species, namely Sea bream (*Pagrus pagrus*), jack mackerel (*Caranx hippos*), barracuda (*Sphyraena spp*), and round sardines (*Sardinella aurita*) were purchased from all the centers surveyed. At least five batches of each species were obtained from each market so as to be able to determine any variations among same species in relation to the different places within the same or different marketing centers. In each batch of fish obtained, about 10 - 12 pieces of each fish type were purchased from each seller as the case may be. Sample groups were treated on the basis of their individual specie groupings; that is, five sample groups of each specie from each marketing center. Where a market had fish displayed under a shed as well as in the open sun, ten sample groups were taken. This sampling procedure helped to determine any quality variations between same specie of fish displayed under a shed and those exposed in the sun.

The sample lot from each market were randomly selected and placed in separate sterile polyethylene bags and labelled according to the species, place and time of purchase. They were then stored in insulated boxes filled with ice for analysis in the laboratory. Quality parameters determined include the following:

Physical characteristics (determined immediately on arrival)

Sensory evaluation, Chemical composition, and Microbiological analysis.

Where analysis could not be carried out immediately, the fish

samples were kept enclosed in the sterile polyethylene bags in ice in the fish insulated boxes.

2.3. Physical Freshness Examination

Physical examination of the fish was done within a maximum period of one to two hours of purchase, using about 10 pieces of fish per sample lot in sample groupings of each specie. This involved evaluation of the outer general appearance, firmness, belly walls, gills, eyes, and external odour. Also examined was the state of the vertebral bones. Quality scores of these attributes were based on a combination of indices from the Torry freshness and EEC Sensory schemes as well as other supplementary references on fish and fish inspection (Appendix II), by employing the five-point hedonic scale as follows:

E (extra) = 5 points
A = 3 points
B = 2 points
C = 0 point

2.4. Chemical Analysis

2.4.1. Total Volatile Base Nitrogen (TVBN)

Fish samples were analysed for Total Volatile Bases (TVBN) using the method described by Pearson (1970). Ten grams fish flesh was macerated and added to 2g Magnesium oxide with 300ml tap water in the distilling flask of macro-Kjeldahl distillation apparatus.

The distillate was collected in 2% Boric acid solution with screened Methyl red as indicator. The TVB was determined as N per 100g flesh by multiplying the titre value of the distillate by 14.

2.4.2. Free Fatty Acids (FFA)

Free fatty acids (FFA) were determined by the method of Pearson (1970). One gram of the crude fat extract from fish flesh sample was mixed with a neutral solvent (25 ml diethylether added to 25 ml alcohol with 1 ml of 1% phenolphthalein solution neutralised with 0.1N alkaline) and titrated with aqueous 0.1N NaOH.

2.4.3. Drip Loss

Drip loss was obtained by homogenizing 10g of fish flesh in 20ml of distilled water. Percentage drip loss was determined as volume of filtrate over volume of water added.

2.4.4. pH

Hydrogen ion concentration (pH) of the filtrate or drip loss was measured with Kent EIL 7055 pH meter supplied by Electronic Instruments Ltd., Chertsey, Surrey.

2.4.5. Proximate Analysis

Crude protein, fat ash and moisture were determined by standard methods (AOAC, 1990).

2.5. Sensory Evaluation

Sensory evaluation of the fish samples was carried out to determine the acceptability of the cooked product to the consumer.

Fresh fish species were first scaled and cleaned. They were then manually beheaded, eviscerated and cut into small portions without filleting. The cut portions were placed in aluminium saucepan and steamed in minimum amount of water for fifteen minutes. The cooked samples prepared were then coded and served hot to 8-12 trained panelists of the Food Research Institute who were very conversant with sensory evaluation procedures.

The panelists evaluated the freshness quality of the cooked fish by means of a descriptive scorecard based on a modified Torry Sensory Scheme for freshness quality assessment. Cooked sensory attributes evaluated were fish odour, texture and flavour in terms of desirability and intensity based on the Torry - 10 to 0 hedonic-scale (Appendix III). Clean tap water was provided for mouth rinsing in between tasting. Odour and flavour intensities were recorded on a 10-point scale, while texture was recorded on a 5-point hedonic scale by panelists.

2.6. Microbiological Analysis

2.6.1. Total Viable Counts (Pour plate technique)

a. Skin of fresh fish:

A sterile template was placed on the skin of the fish towards the dorsal region. By means of a sterile scalpel and tweezers, an area of 2.5 sq. cm of fish was aseptically removed and placed into 90 ml Ringers solution. Duplicate plates from 10^{-1} to 10^{-6} serial dilutions were then prepared with 1 ml dilutions in plates. These were overlaid with Plate Count Agar (PCA) and mixed by careful

rotation clockwise and anti-clockwise. The plates were then incubated at between 28 and 30 °C for 72 hr.

b. Flesh of fish:

To obtain a sample of flesh, the skin in the dorsal region to be sampled was seared with a hot spatula. This was removed and discarded. Then 10 g of flesh under was removed aseptically and weighed to 0.1 of a gram. The sample was macerated for about 1 min and similarly treated as the skin sample to obtain duplicate plates of 10^{-1} to 10^{-6} serial dilutions. The plates prepared were then incubated at between 28 and 30°C for 72 hr.

2.6.2. Drip from fish

The drip from the fish in the display trays of retailers in the markets was collected and analysed for qualitative as well as quantitative bacterial enumeration. For quantitative enumeration, the total bacterial aerobic counts were estimated.

A 10^{-1} to 10^{-6} serial dilution was made from 1 ml of the fish drip in 90 ml Ringers solution. Duplicate plates were prepared by overlaying 1 ml of each dilution with Plate Count Agar and careful clockwise and anti-clockwise rotation done to effect good mixing. These were incubated at 28 - 30 °C for 72 hr. For qualitative enumeration, a swab was made from the drip and inoculated directly onto suitable bacteriological media. These were incubated at between 28 - 30 °C for 48 hr after which growth from the plates were

identified.

2.6.3. Culture Identification

Smears of growth of organisms on plates were prepared on sterile slides. These were Gram-stained. Stained growth were then viewed under the microscope to identify Gram positive or negative microorganisms as well as the morphology.

2.6.4. Coliforms

One mililiter portion of one-tenth dilution was added to 5 ml MacConkey broth in tubes and incubated at 37°C for 12 - 18 hr. Incubated samples were then identified for acid and gas production.

2.6.5. Pathogenic Organisms

a. Salmonella:

A 25 g sample of fish flesh was aseptically collected and cultured in selenite broth. The broth was incubated at 37oC for 12-18 hr. The sample was then subcultured onto Bismuth Sulphite agar and incubated at 37°C. for 72 hr.

b. Staphylococcus:

A 5 g sample of fish flesh was aseptically collected and placed in cooked meat medium with the addition of 10% salt and incubated at 37°C for 12 - 18 hr. The sample was subcultured onto Mannitol salt agar and incubated at 37°C for 72 hr.

2.7. Post-mortem Hydrogen Ion Concentration (pH) of Fish Muscle

The pH of the fish tissue and skin were taken using a Metrohm 620 pH meter (Swiss-made) to determine poor keeping quality of the fish. A 10% (wt/vol) extract of the fish tissue was prepared using a sterile saline solution. The pH of the filtrate was taken.

3. RESULTS AND DISCUSSION

3.1. FISH MARKETING CENTRES - LOCATIONS, CHARACTERISTICS AND AVAILABLE FACILITIES

Table 1 shows the breakdown of the number of respondents, facilities, average distance from point of acquisition, and the space available at the various fish marketing centres surveyed in this study. In general, a total of 12 respondents were interviewed from each centre. It was observed that women constituted the dominant sex involved in the fresh fish retail trade. Out of a total of 48 respondents, only 2 were men (representing only 4% of the total involved in fish retailing). Apart from Tema where the involvement of men was observed, all other fish markets surveyed were run by women in the age group of sixteen and fifty years of age.

The following gives a brief description of the marketing centres and the conditions under which the activities are carried out. A pictorial representation of the typical scenes and facilities at the centres is also given in Figs. 1 - 9.

a. Labadi Market:

Labadi is a suburb of Accra located 5 km east of the city. Although it is situated along the coastal belt, fishing activities along that stretch of coast is not as encouraging as it used to be a few years ago. The Labadi fish market is located just outside the

western gate of the main market which is some 2 km away from the beach. The market basically lacks such facilities as shed, display stands and there was no tap water on the premises (Table 1).

Table 1. Observations and Characteristics of Marketing centers

Market Centre	Space		Distance from source	No. of resp.	Facilities available
	Type	Area (m^2)			
Tema	Shed	1600	200 km	7	Tap water, WC
	Open	>1600		5	Cold store
Kaneshie	Shed	1500	5 - 10 km	12	Stalls, WC, Tap water
Salaga	Shed	400	1 - 5 km	6	Stalls
	Open	150		6	Stalls
Labadi	Open	100	2 - 35 km	12	-

With the fresh fish market virtually located on public gutters, the poor general environmental condition was clearly brought into focus (Fig. 1). The absence of toilets and garbage disposal facilities were observed and hence the poor sanitary conditions at the market.

As a result of the very little fishing activity in the area, retailers had to travel to beaches or harbours to purchase fresh fish for sale to consumers. On the average, fish retailers at the Labadi market cover distances up to about 35 km to purchase fresh fish.

b. Tema market:

Tema is situated about 29 km east of Accra, and is boarded on the south by a long coast line. The city boasts of a modern fishing harbour as well as a landing beach. Two fish marketing centres were identified which were sited just outside the beach and the harbour. There was an open market which stretched along the beach, and a fish market hall attached to the landing dock.

Although the marketing hall had a shed, the absence of stalls or counters was noticeable. Tap water was however available throughout sales. The absence of proper display stands resulted in fish being displayed on the bare floor (Fig. 2 and 3). Private firms and a few individuals operated cold storage facilities on rental basis at the premises of the market. Fish sold at the centres were procured either at the Tema beach or from the landing dock.

PICTORIAL PRESENTATION OF DISPLAY OF FRESH FISH FOR SALE

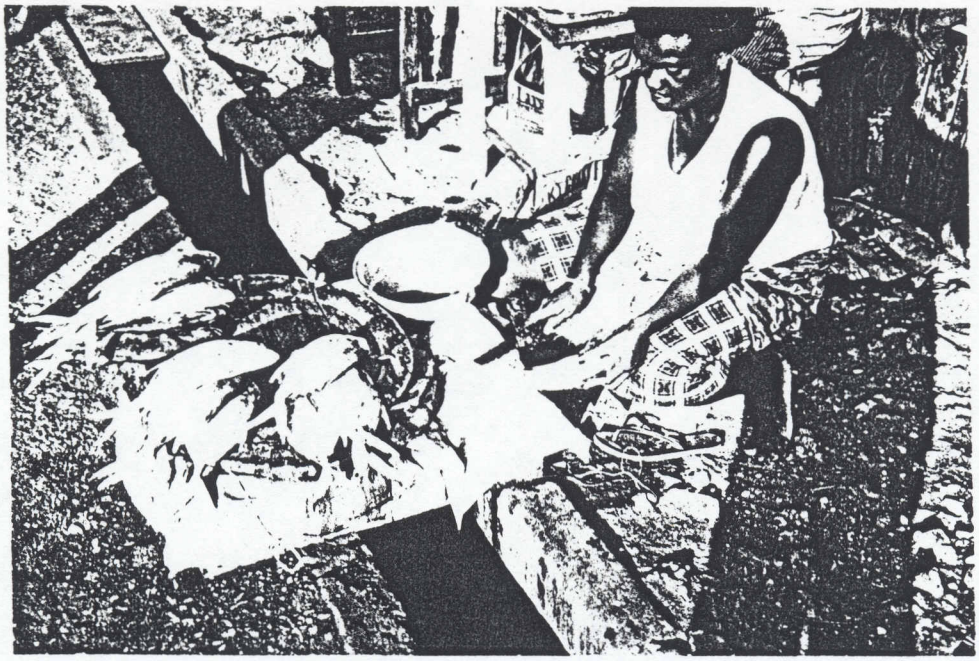

Fig. 1. Fresh fish displayed in the sun on wooden trays placed on a cardboard box directly over an open gutter.

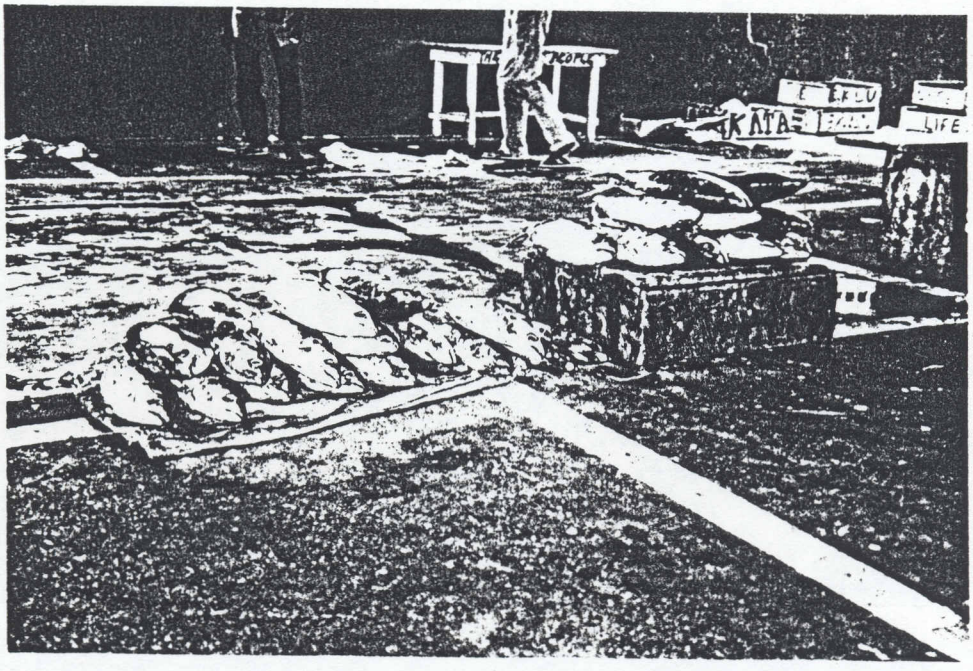

Fig 2. Fresh fish displayed on an upturned wooden box (right) and on jute sac with some fish resting directly on the bare floor.

c. Kaneshie Market:

The fish market which was located within a market complex had such facilities as stalls and a shed. Sanitary facilities include a water closet located in the complex and a waste disposal container outside the main building. Situated towards the northern fringe of Accra, Kaneshie appeared to be a central point for all the suburbs of the Capital. Various species of fish were therefore on display at the market.

Strategically located in the market complex, the general environment of the fish market appeared to be overcrowded with more sellers than it could probably accommodate. Sellers were seen well positioned on the stalls with fish well displayed. Retailers indicated that they travelled virtually all along the coastal belt of Accra district to procure their stock of fish.

d. Salaga Market:

The Salaga fish market which is part of a multimarket complex located within the city of Accra, is equipped with stalls. Facilities like tap water and toilets were however absent (Table 1). There was another open fish market sited at the entrance to the main market. Here, fish was displayed on trays positioned on or near a drainage as shown in Fig 1. The surrounding area in the centre as well as that of the open market were littered with fresh and old fish scales (Fig 6).

Fish sold at this market came mainly from the Accra beach. The retailers however indicated that they sometimes obtained their stock

of fish from beaches like Tema, Chorkor, and Weija and its surrounding areas.

3.2. HANDLING OF FISH AT THE MARKETS

Fish is transported in either wooden fish boxes measuring 60 x 45 x 15 cm, cardboard boxes of about the same dimension as the wooden boxes or plastic/metal basins and also in sacs (Figs. 5, 6, and 8). Most retailers procured about 15 - 20 kg fish per day for sale, although a few of the traders had weights in excess of this figure. It was observed in the survey that retailers generally placed little or no crushed ice on the fish, and if they did at all, the ice was not placed on each single layer of fish but rather on top of the last or upper layer of fish. This situation was particularly observed for consignments coming from long distances to the retail points.

3.2.1. General Marketing and Display Techniques

Fresh fish were sold as single, two or more whole pieces depending on the sizes. Large sized fish of certain species were scaled, gutted and cut as heads, mid-portions and tail sections at varying prices. Fish were generally displayed on flat wooden trays as shown in Figs. 1 and 4, or on an upturned wooden box (Fig. 2) or metal basins (Fig. 6). Except where there were specially constructed stalls to raise the trays at a height of about 90 cm above the floor level as observed at the Kaneshie and the Salaga markets, the trays were generally placed on fish boxes or on stools just about 20 cm

from the floor. Some retailers were seen sitting on the raised talls provided for the display of fish, with the fish virtually at their feet.

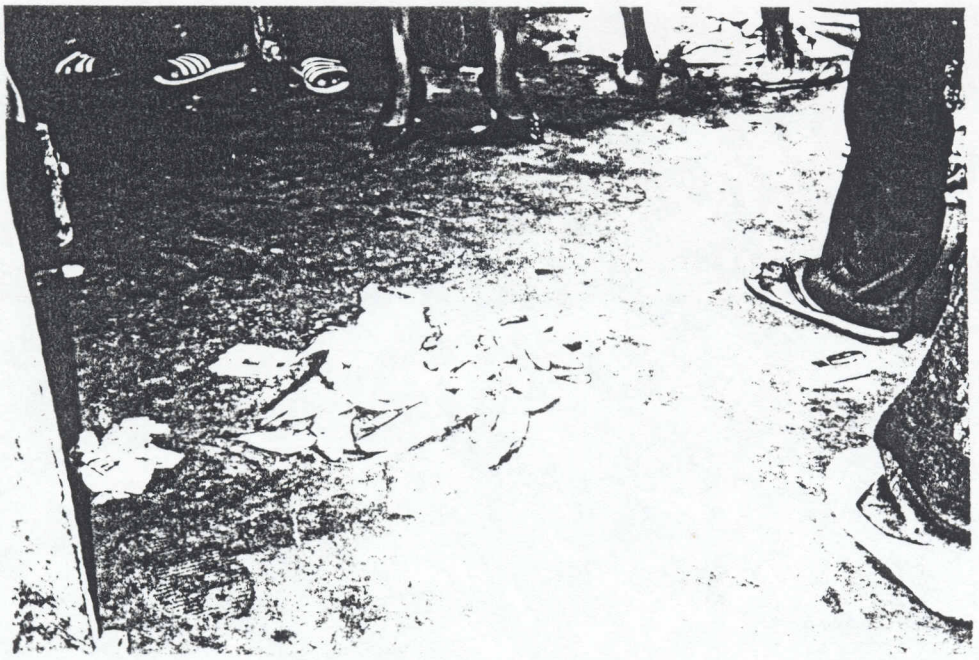

Fig. 3. Fresh Fish being displayed for sale directly on the bare dirty floor in the market.

Fig 4. Fresh fish displayed on stone slabs in a well-organised fish market. Note distance of the floor from the display surface.

DISPLAY OF FRESH FISH FOR SALE (Contd).

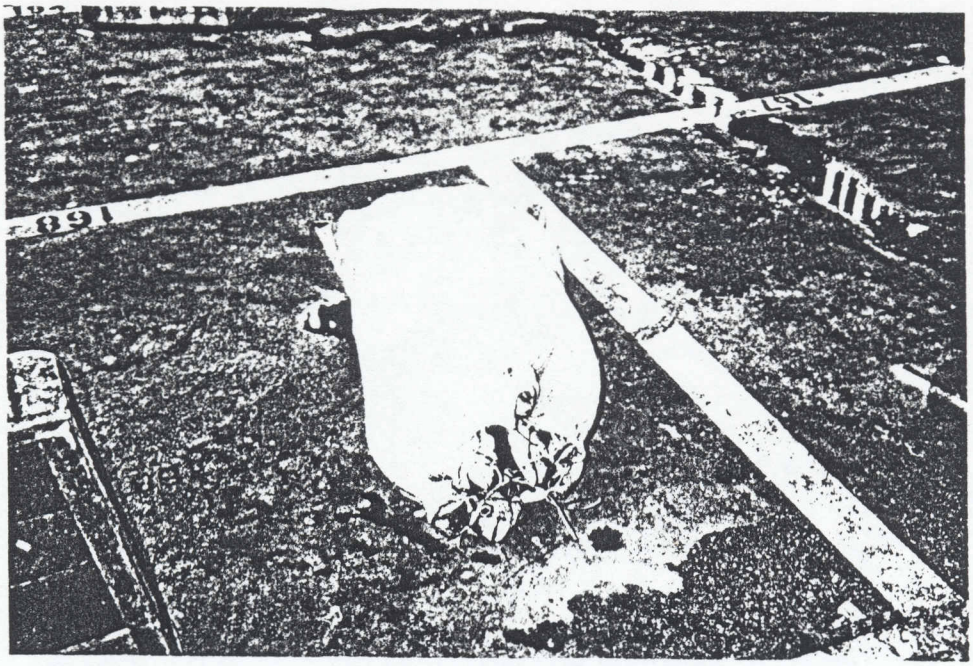

Fig 5. Fish overloaded and tied up in a jute for sale. Note drip from fish which may be a source of contamination for other fish directly displayed on the bare floor.

Fig 6. Fish displayed in metal bowls. Mixture of different species and grades of fish in this manner enhances contamination and spoilage. Note dirty floor and surrounding.

At the Labadi market, retailers displayed fish on wooden trays or on upturned fish boxes placed on top of an open public gutter. Fish were seen displayed on the bare cemented floor at Tema (Fig. 3) with both retailers and buyers threading their ways through. While it was apparent that no ice were kept on the display trays, most retailers believed that constantly sprinkling water on the fish maintained a fresh and attractive look. This practice was observed more frequently at markets where fish was displayed in the open sun.

Some retailers also employed the use of dyes with which to colour the fish to ensure better attraction of consumers to their products. Red fish, apparently gone stale, was found to have been coloured red to increase its attractiveness, in a bid to deceive the unsuspecting buyer. Unsold fish at the end of the day were stored where cold storage facility existed or in the absence of that, crushed ice was placed on the fish. Where such facilities do not exist, retailers reduced their prices to get their stock sold to other processors who in turn smoke, salt, ferment or fry the fish as the case may be.

STACKING OF FISH BOXES DURING SALE OF FRESH FISH.

Fig 7. Fish overloaded in wooden boxes heavily stacked together and squashing the fish to release digestive juices from gut onto whole fish.

Fig 8. Although not heavily stacked, display shows upper fish boxes resting directly on the fish.

TRANSPORTATION OF ICE TO FISH MARKET.

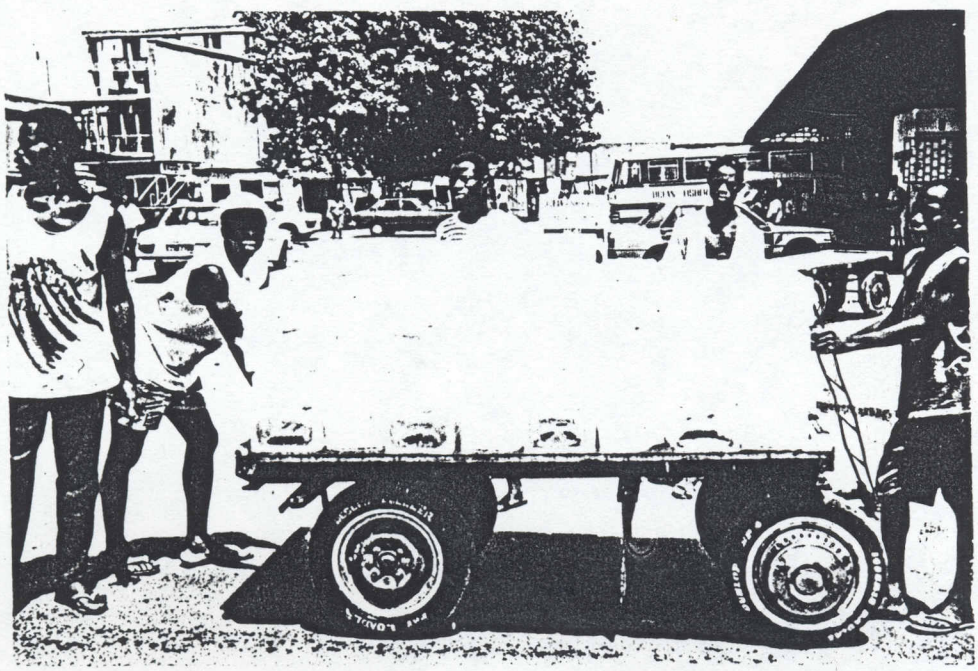

Fig 9. Ice transported unprotected leading to contamination with dust particles. Economic loss also occurs due to melting of the exposed ice.

3.3. PHYSICAL, CHEMICAL AND MICROBIOLOGICAL QUALITY OF MARKET FRESH FISH SAMPLES

The results of physical examination of market samples of fish are shown in Tables 2 to 5. The physical determinations were based on a combination of the various freshness schemes, as shown in Appendix II and III. From the observations, it was quite obvious that generally all the samples might have been captured for quite a while as suggested by the presence of mucus on the gills. Typical indications that lead to loss of freshness of fish have been shown to include sunken eyes, decreasing loss of the familiar sea weedy odour, loss of scales and darkened colour of the skin (Amu and Disney, 1973).

Assessing the physical condition of each specie with respect to the marketing centres, sea bream (*Pagrus pagrus*) bought under sheds at the Kaneshie and Salaga markets were found to be of fair physical quality, ie. Grade B (Table 2). Those purchased displayed in the open sun at the Labadi and Salaga markets were graded C, indicating unfit quality. The physical condition of the Grade B fish could be attributed to the fact that they were not exposed directly to the sun and to high temperatures in the open spaces but rather displayed under the shed and shaded from the dusty environment as well. High temperatures tend to promote rapid deterioration of fish due to elevated temperatures of the fish flesh. Putro et al. (1989) and Amu and Disney (1973) demonstrated that reducing fish temperature by the use of ice maintains the quality of fish by slowing down the rate of deterioration.

Table 2. Quality assessment of Sea Bream (*Pagrus pagrus*) from various marketing centres.

Market	Skin	Gill	Eyes	Odour	Grade
Kanehie (shed)	pink, silver and firm	pink purple mucus	slightly opaque, and sunken	slightly sea weedy	B (fair)
Salaga (shed)	slightly pink and firm	pink purple mucus	opaque and sunken	slightly sea weedy	B (fair)
Salaga (open)	dull pink, loose scales belly not firm	brownish with thick mucus	opaque sunken and dull	less sea weedy	C (unfit)
Labadi (open)	dull pink, loose scales soft belly	brownish, thick mucus sweet odour	opaque sunken bloody tinge	less sea weedy	C (unfit)
Tema (open)	pink, silver firm belly and flesh	purple mucus	slightly opaque slightly sunken	sea weedy	B (fair)

Note: Assessment was based on the average score of ten whole fish samples per batch.

However, fish bought in the open sun at Tema were found to be of good quality. This may be attributed to the fact that the fish might have been obtained by the retailers from the landing site nearby and were still in a very good condition.

Table 3, which shows the physical quality assessment of Jack mackerel (*Caranx hippos*), gives results similar to that of sea bream (Table 2). Fish sold under the shed at Salaga market, and that purchased in the open space at Labadi market were both found to be unfit. Whilst the high temperature exposure may be the main factor resulting in the poor quality of the fish samples from Labadi, the condition of those obtained from Salaga might have resulted from a combination of factors such as temperature increase and the fact that the fish might have been transported from quite a long distance to the market without any cooling facility.

Jack mackerel from Tema and Kaneshie markets were of good quality. Keeping the fish under sheds definitely provided adequate protection from the direct heat of the tropical sun. The sheds used were found to provide cooler environment for the fish.

Physical quality of the Round sardines (*Sardinella aurita*) shown in Table 4, indicated poor conditions of handling and marketing. In the exception of samples from the Tema fish market, all the market samples were graded C (unfit). This was irrespective of whether they were displayed in the sun or under sheds. Again inadequate handling procedures coupled with the prolonged delays in getting them sold could be good reasons for the poor quality. The fish was in abundance on the markets, and disposing of them was not fast enough.

Table 3. Quality assessment of Jack mackerel (*Caranx hippos*) from various marketing centres.

Market	Skin	Gill	Eyes	Odour	Grade
Kaneshie (shed)	slightly glossy & firm	brown	slightly concave	slightly sea weedy	B (fair)
Salaga (shed)	bluish sheen & soft	dark brown mucus	opaque concave	slightly sea weedy	C (unfit)
Labadi (open)	dull sheen soft belly	dark brown thick mucus	opaque concave	not sea weedy	C (unfit)
Tema (shed)	slightly glossy yellow tinge, firm belly	brown	convex	slightly sea weedy	B (fair)

Note: Assessment was based on the average score of ten whole fish samples per batch.

Table 4. Quality Assessment of Round sardines (*Sardinella aurita*) from various fish markets

Market	Skin	Gill	Eyes	Odour	Grade
Kaneshie (shed)	scales peeling off, soft belly, dull	dark brown mucus	concave opaque	loss of sea weedy	C (unfit)
Salaga (shed)	scales peeling off	dark brown mucus	opaque concave	slightly sea weedy	C (unfit)
Labadi (open)	dull loose scales, soft belly	brownish thick mucus	opaque concave bloody tinge	less sea weedy	C (unfit)
Tema (shed)	glossy, firm belly and flesh	brown	plain	slightly sea weedy	B (fair)

Note: Assessment was based on the average score of ten whole fish samples per batch.

Tema market was obsreved to be an exceptionally clean and suitable environment for the sale of fresh fish. Cold storage facilities were available and ice was used more frequently.

Table 5 shows the results of the physical assessment of market samples of barracuda (*Sphyraena* spp.). The trend was found to be similar to that observed with the round sardines. Fish from the Kaneshie market, though displayed under sheds, were of poor quality (Grade C); while samples obtained from Tema, displayed in the open sun, were good. Reasons already deduced for the other species may be equally assigned to the physical conditions of the barracuda. Poor handling resulted in breakage and damage of the skin of fish from Kaneshie. This may have resulted from over-loading of the boxes and consequent crushing and bruising of the lower bulk. Such a situation could result in belly burst leading to release of intestinal contents onto the main body of fish in the boxes.

Table 6 shows the comparative assessment of the quality of fresh fish from the various markets. As expected, fish from Tema were all found to be of good quality (Grade B). This substantiates the fact that proximity of the landing sites and, to a greater extent, provision of sheds and the use of ice could play a significant role in maintaining fish freshness at the marketing centre. In addition, proper handling practices ensure good fish quality. All fish from Labadi were graded unfit, ie Grade C. Kaneshie also recorded 50% unfit while Salaga market had 80% of the lot declared unfit. Apart from Labadi which had no sheds, Salaga and Kaneshie markets had sheds; but fish to these centres were generally obtained from distant landing sites.

Table 5. Quality Assessment of Barracuda (*Sphyraena* spp.) from various marketing centres.

Market	Skin	Gill	Eyes	Odour	Grade
Kaneshie (shed)	broken dull & soft	dark red mucus	plain opaque	not sea weedy	C (unfit)
Salaga (shed)	broken, slimy soft belly	dark red mucus	opaque concave	loss of sea weedy	C (unfit)
Tema (open)	slightly glossy firm belly and flesh	dull red	slightly convex	slightly sea weedy	B (fair)

Note: Assessment was based on the average score of ten whole fish samples per batch.

Table 6. Proportional Assessment of Fresh Fish from the various markets.

Market centre	No. of fish lot examined	Grading			
		Grade B	%	Grade C	%
Kaneshie	4	2	50	2	50
Salaga	5	1	20	4	80
Labadi	3	-	0	3	100
Tema	4	4	100	-	0

Note: Lot examined were totals of samples irrespective of species.

At Salaga and Kaneshie markets, fish not sold at the close of the day were deep frozen. The following day, the frozen fish was thawed and ice chips placed on it, or sea sand rubbed over it to deceive the unsuspecting consumer. Repeated thawing and freezing is carried out until the fish is finally disposed of. This practice, needless to say, leads to very poor quality fish with poor sensory properties.

Results of the chemical analysis of fish samples collected from the various fish markets are given in Tables 7 - 10. It was observed that variations in the composition of a particular specie of fish were minimal, irrespective of the source; indicating a good sampling procedure. The proximate composition of the fish species may have been affected by factors of an intrinsic nature related to the physiological, morphological or environmental conditions with regards to the living conditions (Borgstrom, 1961).

Generally, the off-odours associated with fish spoilage are volatile compounds. As determined quantitatively by the TVB values in this study, these volatile compounds were found to be within the suggested limits of acceptability of 30mg N/100g sample for temperate species (Farber, 1965). The highest value of 26.6 mg N/100 g sample for seabream (Table 7) was obtained for the batch from the Labadi market. In addition, the slight variations in TVB values observed within the same species for seabream (Table 7), jack mackerel (Table 8), round sardines (Table 9) and barracuda (Table 10), could suggest that TVB values may not be adequate as quality indices for fresh fish. However, this suggestion may not be true since no objectionable odour was detected thus showing

Table 7. Chemical properties of market fresh Sea Bream (*Pagrus pagrus*).

Chemical characteristic	Marketing centre				
	Tema (open)	Kaneshie (shed)	Salaga (shed)	Salaga (open)	Labadi (open)
pH	6.7±1.8a	6.4±1.3a	6.6±1.5a	6.7±0.9a	6.7±1.4a
Drip loss/cc	12.0±2.3b	7.3±1.8c	8.2±1.6c	11.3±2.3b	12.0±2.1b
Ash (%)	1.4±0.6d	1.5±0.9d	1.3±1.1d	1.4±1.2d	1.2±1.3d
Moisture (%)	79.7±1.9f	77.5±2.8f	79.9±2.3f	79.3±2.2f	79.4±2.5f
Fat (%)	3.6±1.8g	3.7±1.3g	2.1±1.3h	3.6±1.5g	2.4±1.2h
FFA (%)	8.3±1.1k	7.5±0.8k	4.5±0.7l	5.4±1.2l	8.2±1.7k
TVBN(mgN/100g)	20.4±3.6m	10.6±2.8n	8.4±2.3n	15.9±2.7o	26.6±2.9m
Protein (%)	20.2±1.2x	21.5±0.7z	20.8±1.2z	19.3±1.5z	18.1±1.8z

abcd..... Values in a row with the same letter are not significantly different.

that an advanced stage of spoilage might not have been reached afterall. Jacober and Rand (1982) observed that TVB showed appreciable increase at a well advanced stage of spoilage. After 29 days' storage of bumper, Amu and Disney (1973) recorded a level of 29 mg N/100 g. Bonsu and Sutcliffe (1974) showed that TVB values for mackerel at the point of condemnation was far below the upper limits for acceptability for temperate fish. However, the presence of measurable quantities of TVB may well be related to bacterial activity (Saluan-Abduhassan, 1989).

Variations in pH of all the species were not very significant in each case (Table 7 - 10). This tends to support observations by Bonsu and Sutcliffe (1974) on the iced storage of mackerel, that even after 19 days in storage at a fairly constant pH of 6.8, spoilage nonetheless occurred. This may mean that slight changes in pH cannot be a good index for freshness assessment. As observed earlier by Paladino (1943), pH values could not be used to indicate early spoilage. However, Connell (1980) showed that spoilage bacteria of fish are more active in higher flesh pHs. A pH of above 6.5 indicates poor keeping quality. When the pH rises to 6.8 or higher and the contents of volatile nitrogen bases, ammonia and mono-, di- and tri-methylamines are found to rise, then spoilage has defitely set in (Van Veen, 1965).

Fish spoils rapidly due in part to the fact that fish tissue becomes less acid post-mortem as compared to warm blooded animals. Also fish contains trimethylamine oxide (TMAO) which stimulates anaerobic growth of spoilage bacteria (Raa, 1981).

Table 8. Chemical properties of market fresh Jack mackerel (*Caranx hippos*).

Chemical characteristic	Marketing centre			
	Tema (open)	Kaneshie (shed)	Salaga (shed)	Labadi (open)
pH	7.1±1.2a	6.1±0.7a	6.9±0.9a	6.7±1.4a
Drip loss/cc	10.5±0.6b	6.0±1.2c	10.0±1.9b	12.0±2.1b
Ash (%)	1.6±2.2e	1.2±0.8e	1.3±0.5e	1.2±1.3d
Moisture (%)	77.7±2.9f	78.0±2.2f	77.6±2.4f	79.4±2.5f
Fat (%)	1.0±0.1g	0.6±0.1g	2.2±0.3h	2.4±1.2h
FFA (%)	2.5±0.4k	4.5±0.5k	15.4±0.8m	18.7±1.7m
TVBN(mgN/100g)	17.7±1.3n	19.2±1.7p	18.2±2.1n	26.6±2.9r
Protein (%)	20.2±1.2z	19.2±1.5z	20.5±1.3z	18.1±1.8z

abcd..... Values in a row with the same letter are not significantly different.

Proteolytic changes which thus occur may be the result of softening of the fish muscle. Tissue hydrolysis in the fish may have occurred through autolytic enzymes in the cells and the guts, probably released onto other fish in heavily loaded boxes. So that on reaching the markets, the quality attributes further decrease.

Proteolytic enzymes in combination with microbial invasion may have led to very rapid breakdown and spoilage of the fish. Hence, for the market samples obtained, it was observed that jack mackerel and barracuda had low texture scores due to decreased firmness.

Free fatty acid (FFA) values determined have wide variations from each other for jack mackerel (Table 8). The highest of 18.7% was obtained for fish bought from Labadi which had also been graded C (unfit). The fish sample from Salaga, also graded C (Table 3) recorded the second highest FFA value of 15.0%. These findings may be significant in correlating FFA values and physical properties of the fish. It was observed that higher FFA values were recorded for Grade C fish while lower values of 2.5 and 4.5 % were recorded for Grade B fish. Lassen et al. (1951) related the rise in FFA to fish spoilage as it increased from 1.1% to 8.1% after 120 h of storage. Although the variations in FFA for the other species may be regarded as minimal, its presence being related to degradation of fats leads to a decrease in consumer appeal for the fish (Ranke et al., 1957).

Drip losses, though of varying amounts within the species, were appreciably high. Drips occur when the water-holding capacity of protein is decreased as a result of protein denaturation (Seagran, 1958). Hence, all the fish species may have undergone some form of protein denaturation due in part to prolonged storage before sales.

Table 9. Chemical properties of market fresh Round sardines (*Sardinella aurita*).

Chemical characteristic	Marketing centre			
	Tema (shed)	Kaneshie (shed)	Salaga (shed)	Labadi (open)
pH	7.1±1.2a	6.5±1.4a	7.9±1.3a	7.9±1.7a
Drip loss/cc	10.3+0.9b	9.0+0.8b	13.0±1.2c	16.0±2.3d
Ash (%)	1.4±0.6d	1.3±0.3e	1.5+0.2e	1.5+0.7e
Moisture (%)	77.3±1.9f	78.2±2.4f	75.0±2.1f	74.4±1.7f
Fat (%)	2.9+0.8g	3.1±0.5g	3.5±0.3g	3.7±0.2g
FFA (%)	7.0±1.7h	4.3±0.6l	7.5±1.2h	7.7±1.1h
TVBN(mgN/100g)	18.2±1.9m	18.9±1.7m	19.4±1.4m	21.6±1.6m
Protein (%)	20.1±1.5n	19.6±1.7n	20.5±1.2n	20.3±2.1n

abcd..... Values in a row with the same letter are not significantly different.

Table 10. Chemical properties of market fresh Barracuda (*Sphyraena* spp.).

Chemical characteristic	Marketing centre		
	Tema (open)	Kaneshie (shed)	Salaga (open)
pH	6.4±1.3a	6.5±0.3a	7.2±1.1a
Drip loss/cc	6.0±1.7b	4.3±0.8c	12.6±1.3d
Ash (%)	1.3±0.7e	1.3±0.9e	1.4±0.5e
Moisture (%)	79.2±1.5f	80.1±2.3f	77.1±2.1f
Fat (%)	2.9±1.1g	2.7±1.3g	2.3±1.4g
FFA (%)	11.7±1.2h	11.5±1.5h	9.7±1.7h
TVBN(mgN/100g)	18.7±1.4l	17.8±2.1l	16.9±0.9l
Protein (%)	18.7±1.8m	17.9±1.3m	21.8±1.2m

abcd..... Values in a row with the same letter are not significantly different.

The results of microbiological analysis of the fish samples collected from the various fish markets are given in Table 11 - 14. Quantitative and qualitative enumeration of organisms in the drip water from the display pans of the various species is also given in Table 15. In general, the fish drips were found to contain higher microbial loads than the displayed fish itself. The fish drip water from herrings recorded the highest aerobic count of 482×10^7 . Spoilage microorganisms isolated were Micrococci, *E. coli, Bacillus.* spp., *Corynebacterium* and *Aeromonas*.

Microbial counts recorded for the different species of fish ranged from as low as 27×10^1 to as high as 332×10^4 for sea bream displayed in the open. Although some of the values obtained in this study seem to be quite low, proper handling and good marketing practices could have further reduced the microbial proliferation and consequent spoilage. The presence of coliforms and faecal coli in some of the samples is quite disturbing, and it is a direct reflection of the unhygienic conditions under which fish retailing is carried out at some of the marketing centres.

Table 11 shows the presence of enteric bacteria such as *E. coli* in the samples collected from the Labadi market. This observation was not unexpected since the fish was displayed on top of open gutters which are known to be full of wastes from all sources. The practice was considered highly unhygienic for sale of fish. The exposure could also facilitate transfer of spoilage organisms through flies and dust.

In all the samples analysed, pathogenic organisms such as

Salmonella and Staphylococci were not observed. Also, similar organisms were observed in all the species from the centres.

Table 11. Microbiological Quality of fresh fish from Labadi fish market.

Microbiological determination	Fish sample			
	Sea bream (open)	Herrings (open)	Herrings (open)	Jack mack. (open)
Total viable count per gram (aerobic)				
skin count	$270x10^3$	$454x10^2$	$321x10^2$	$147x10^4$
pH	6.4	6.7	6.4	6.2
flesh count	$397x10^2$	$161x10^1$	$27x10^1$	$431x10^2$
pH	6.0	5.8	5.8	6.1
Culture	Micrococci *Bacillus* spp *E. coli*	Micrococci *Corynebacterium*	Micrococci *Corynebacterium*	Micrococci
Coliforms (0.01 g)	Present	Absent	Absent	Absent
Faecal coli	Present	Absent	Absent	Absent
Pathogens:				
Salmonella (0.25 g)	Nil	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil	Nil

Table 12. Microbiological Quality of fresh fish from Tema fish market.

Microbiological determination	Fish sample			
	Herring	J. mackerel	Barracuda	Sea bream
Total viable count per gram (aerobic)				
skin count	$258x10^3$	$214x10^4$	$270x10^3$	$56x10^3$ ($53x10^3$)
pH	6.5	5.9	6.4	6.7 (6.4)
flesh count	$135x10^1$	$177x10^2$	$364x10^1$	$319x10^3$ (4980)
pH	6.1	6.0	6.3	6.5 (6.3)
Culture	Micrococci *Bacillus* spp	Micrococci	*Coryne-bacterium* Micrococci	Micrococci *Bacillus* spp
Coliforms (0.01 g)	Absent	Absent	Absent	Absent
Faecal coli	"	"	"	"
Pathogens:				
Salmonella (0.25 g)	Nil	Nil	Nil	Nil
Staphylococci	"	"	"	"

Table 13. Microbiological Quality of fresh fish from Kaneshie fish market.

Microbiological determination	Fish sample			
	Herring	J. mackerel	Barracuda	Sea bream
Total viable count per gram (aerobic)				
skin count	350×10^2	193×10^3	260×10^3	437×10^1, 300×10^4
pH	5.6	6.3	6.3	6.7 , 6.6
flesh count	101×10^2	211×10^1	307×10^1	343×10^1, 72×10^3
pH	5.7	6.2	6.3	6.6, 6.7
Culture	Micrococci *Aeromonas*	Micrococci	*Coryne-bacterium* Micrococci	Micrococci *Bacillus* spp
Coliforms (0.01 g)	Absent	Absent	Absent	Absent
Faecal coli	"	"	"	"
Pathogens:				
Salmonella (0.25 g)	Nil	Nil	Nil	Nil
Staphylococci	"	"	"	"

Table 14. Microbiological Quality of fresh fish from Salaga fish market.

Microbiological determination	Fish sample		
	Sea bream (open)	Sea bream (shed)	Sea bream (open)
Total viable count per gram (aerobic)			
skin count	$332x10^4$	$191x10^3$	$354x10^3$
pH	6.7	6.6	6.6
flesh count	$420x10^3$	$407x10^2$	$152x10^3$
pH	6.7	6.6	6.7
Culture	Micrococci *Bacillus* spp	Micrococci *Bacillus* spp	Micrococci *Bacillus* spp.
Coliforms (0.01 g)	Absent	Absent	Absent
Faecal coli	Absent	Absent	Absent
Pathogens:			
Salmonella (0.25 g)	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil

Table 14. Continued....

Microbiological determination	Fish sample		
	Herrings (shed)	J. mackerel (open)	Barracuda (open)
Total viable count per gram (aerobic)			
skin count	$98x10^3$	$81x10^3$	$179x10^3$
pH	6.2	6.0	6.3
flesh count	$45x10^1$	$98x10^1$	$35x10^2$
pH	5.7	6.0	6.5
Culture	Micrococci	*Corynebacterium*	Micrococci *Aeromonas* *Corynebacterium*
Coliforms (0.01 g)	Absent	Absent	Absent
Faecal coli	Absent	Absent	Absent
Pathogens:			
Salmonella (0.25 g)	Nil	Nil	Nil
Staphylococci	Nil	Nil	Nil

Table 15. Qualitative and quantitative enumeration of microorganisms in fish drip of display containers.

Sample drip	Type of fish	Total viable count/gram (aerobic)	Culture
1	Sea bream	$328x10^6$	Micrococci *E. coli* *Bacillus* spp
2	Herrings	$482x10^7$	*Corynebacterium* *Bacillus* spp *Aeromonas* Micrococci
3	Jack mackerel	$253x10^6$	Micrococci *Corynebacterium*
4	Barracuda	$261x10^5$	Micrococci *Aeromonas* *Corynebacterium*

3.4. SENSORY PROPERTIES OF MARKET FRESH FISH

Mean sensory scores for fish samples from the various markets are given in Table 16 for the odour, texture and flavour of the cooked products. For comparison, ten samples collected from landing sites along the beaches of Tema and Accra were also analysed for their sensory characteristics and the results presented in Table 17. All the species of fish purchased from the landing sites showed no apparent signs of spoilage and were all acclaimed by sensory panelists to possess fresh sea weedy odour. All the samples from the various sites scored highly for odour and flavour with very little variation among scores (Table 17).

In contrast, samples purchased from the fish marketing centres showed a wide variation in sensory attributes of the cooked products. Some species, especially the small-size and less fatty ones, had relatively strong fresh sea weedy odours while the larger species and more fatty ones like the Barracuda had lower mean sensory scores, indicating loss of freshness.

In general, however, all the samples analysed had mean odour scores that were far above the acceptability limit of 5. The most obvious criterion of spoilage for the potential consumer is the presence of strong offensive odours in the fresh fish. This was apparently absent in all the samples, hence the high level of acceptability. The least odour score was obtained for samples that had to be transported over long distances to the retail centres.

As with odour, the textural characteristics of fresh fish also play an important role in consumer acceptability.

Table 16. Mean Sensory Scores of fresh Fish samples from fish Marketing centres.

Source and Type of fish	Sensory Attributes of cooked fish		
	Odour	Texture	Flavour
Salaga Market			
Herrings (shed)	8.50±0.97	3.50±1.08	9.30±1.06
Barracuda (open)	7.60±2.59	2.80±0.92	7.00±2.79
Jack mack. (open)	8.60±0.84	4.30±0.67	9.50±0.53
Kaneshie Market			
Herrings (shed)	9.10±0.87	4.10±0.87	9.90±0.71
Barracuda (shed)	8.43±1.09	3.36±0.93	8.43±1.65
Jack mack. (open)	8.78±1.05	4.28±0.73	9.14±1.23
Tema Harbour			
Herrings (shed)	9.28±0.83	4.64±0.63	9.64±0.63
Barracuda (open)	8.07±1.33	3.36±1.39	7.93±2.46
Jack mack. (open)	8.86±0.86	4.50±0.52	9.30±0.83
Labadi Market			
Herrings (open)	9.00±0.53	4.00±0.93	8.00±1.93
Herrings (open)	8.50±1.12	4.25±0.71	8.75±0.70
Jack mack.(open)	8.75±0.89	4.25±0.71	8.50±1.93

Tissue softening from muscle breakdown is the direct result of proteolytic activity. Fresh fish samples from landing sitea were found to have better cooked texture scores than fish samples that were obtained from the markets. Samples from landing sites were judged to have firm texture without discolouration. The texture scores ranged between 2.7 and 4.4 (Table 17). For cooked texture, a score of 3 was considered the lowest limit for acceptability. Values below 3 were therefore unacceptable.

For the market samples, Barracuda was found to consistently score lowest in texture among the other species. This shows the relative ease of tissue breakdown in the barracuda. The barracuda was also found to have relatively lower flavour scores for the cooked products. All the other samples from the landing sites had sweet flavours characteristic of the species. There were no off-flavours detected.

Table 17. Mean Sensory Scores of fresh Fish samples from selected landing sites.

Landing site and sample No.	Sensory Attributes of cooked fish		
	Odour	Texture	Flavour
I			
1	8.55±0.73	2.88±1.05	7.55±1.33
2	8.44±1.66	3.88±0.92	8.33±1.93
3	8.11±0.92	3.55±0.88	8.11±1.16
4	8.60±1.65	3.44±1.13	8.22±1.78
II			
5	9.00±0.95	4.41±0.79	9.41±0.79
6	8.66±1.07	3.88±1.19	9.08±1.24
7	8.33±0.77	3.16±1.19	8.66±1.07
8	8.83±0.93	2.83±1.11	8.33±1.49
III			
9	6.91±2.10	2.75±0.96	7.41±1.97
IV			
10	8.80±0.63	4.00±0.81	9.10±0.87

4.0. CONCLUSIONS AND RECOMMENDATIONS

At most of the fish marketing centres surveyed, handling and general marketing practices were found to be highly inadequate in preserving the fresh quality of the fish. Improper handling and marketing practices identified were as follows:

a. overloading of fish in sacks and wooden crates,
b. display of fish in the hot humid environment,
c. display of fish close to the ground and at times over open gutters,
d. repeated freezing and thawing of fish,
e. distant conveyance of fish from landing sites to marketing centres without adequate cold storage protection
f. display of fresh fish in dirty containers with drips from previous sales.

These practices had a direct deteriorative effect on the quality of fish sold in these markets to the comsumer. Apart from obvious physical changes such as bruising, loss of scales, colour changes of the skin, gills and eyes, the fish was found to undergo changes in odour, texture and flavour that led to poor sensory characteristics of the cooked product.

Fish displayed in the open sun at certain markets had appreciable degrees of deterioration (both physical and microbiological) setting in. Also, certain species of fish,

especially jack mackerel and barracuda, although displayed under sheds, showed signs of deterioration faster than the other species. Generally, fish sold in the Ghanaian markets are poorly handled and, as such, most of the fish reaching the consumer deteriorate to an appreciable extent physically, chemically, organoleptically and microbiologically. Major microorganisms isolated from the market samples of fish were Micrococci, *Corynebacterium*, *Bacillus* spp. In some cases, *E. coli* and *Aeromonas* were also isolated.

The different marketing centres surveyed followed different handling and marketing practices which was the reason for the quality differences observed in the fish sold at the various marketing centres. With the exception of Tema which had 100% of fish sold declared good, a greater proportion of the fish from the other markets were found to be of poor quality. Labadi, Salaga and Kaneshie had 100%, 80% and 50% respectively of the fish declared unfit. The Tema center was found to observe the best handling and marketing practices, with the remaining centres involving in fish retail trade under some (and in some cases, all) of the improper conditions listed above .

Although the physical, chemical, and microbiological analyses of fish samples from some of the marketing centres declared them unfit, mean sensory scores of the cooked products were above the minimum values for acceptability for most of the sensory attributes examined. The worst samples however had lower scores than those declared good by the physical, chemical and microbiological quality assessment. This showed that spoilage was not too advanced to

warrant total rejection by the consumer.

There was a fair correlation between free fatty acid (FFA) content of some species of fish and the physical quality. For jack mackerel, samples graded C (unfit) had the highest FFA values of 18.7% and 15% while those graded B (fair) had lower FFA values of 2.5% to 4.5%. Other chemical attributes also showed some changes with physical deterioration.

From the findings of the study, it is recommended as follows:

1. Extensive education of both fish retailers and consumers is needed on the importance of quality indices in the sale of fish as well as the dangers imposed as a result of poor handling.

2. Basic facilities like running tap water, toilets, fly-proof sheds and good sanitation should be provided at all times in the marketing centres.

3. Retailers should be encouraged to employ ice in all their fresh fish handling operations. Display of fish may either be on beds of ice flakes, crushed ice or any other convenient cold facility.

4. The use of aluminium and plastics containers should be encouraged among retailers, as these have many advantages over the wooden fish boxes used.

5. Repeated and intermittent freezing and thawing of same batch of fish promotes deterioration and retailers should be discouraged from that practice.

6. Further research work is needed to elucidate the storage characteristics of the fish species used in this study. Research work could also be undertaken to ascertain the correlation between physical quality of fish and free fatty acid (FFA) development which would serve as a good index for quality assessment. These aspects would form the basis for the establishment of freshness schemes for the species examined.

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APPENDICES

APPENDIX 1. Description of the characteristics belonging to different freshness grades

(Modification of the EEC scheme, based on proposals by Torry Research Station)

Elements	Characteristics			
	E	A	B	C
Skin	bright, shining, iridescent or opalescent, no bleaching, full bloom, clean	Waxy, slight loss of bloom, very slight bleaching, slight dullness	dull, some bleaching, loss of bloom	dull, gritty, marked bleaching and shrinkage, no bloom
Outer slime	transparent or water white	milky	yellowish-grey, some clotting, brownish	yellow-brown, very clotted and thick
Gills	bright red, mucus translucent	pink, mucus slightly opaque (dark red for saithe)	grey and bleached, mucus opaque and thick (brown for saithe)	brown or bleached, mucus yellowish grey and clotted
Eyes	convex, black pupil, translucent cornea	plane, slightly opaque pupil, slightly opalescent cornea	slightly concave, grey pupil, opaque cornea	completely sunken, grey pupil, opaque discoloured cornea
Peritoneum (gutted fish)	glossy, brilliant, difficult to tear from flesh	slightly dull, difficult to tear from flesh	gritty, fairly easy to tear from flesh	gritty, easily torn from flesh
Gill odour	fresh, strong seaweedy, shellfishy (fresh oil, metallic, freshcut grass, peppery for plaice)	no odour, neutral odour trace musty, mousy, milky, capryllic, garlic or peppery (oily, seaweedy, aromatic citric for plaice)	definite musty, mousy, milky, capryllic, garlic or peppery, malty, beery, lactic or slightly sour (oily, definite musty, slightly rancid, painty for plaice)	acetic, butyric, fruity, turnipy, amines, sulphide, faecal (muddy, grassy, rancid for plaice)

tes: The descriptive terms are meant to be guides and not all the characteristics described will necessarily occur in every fish. For two important species, ie plaice and saith, important deviations from the general characteristics are mentioned. With fat fish like herring and mackerel deviations may occur as well.

APPENDIX II

QUESTIONNAIRE ON FRESH FISH MARKETING

A. GENERAL INFORMATION

1. Name of respondent:.....
2. Age:.....
3. Location:.....

B. MARKETING OF FRESH FISH

1. Where do you normally obtain your fish?.....
2. What time of the day do you normally acquire your fish?..
   .....
3. How far is your source of supply from your sale centre?..
   .....
4. What types of fish do you usually sell?.....
5. By what means do you convey the fish to the market?.....
   .....
6. In what container do you usually acquire your fish to the market?.....
7. What quantity do you usually acquire for sale?.....
8. If you are unable to sell all your stock, how do you keep it overnight?
   a. Throw away?.....
   b. Convey home for use?.....

c. Freeze in a commercial cold store?.....

d. Freeze at home?.....

e. Smoke it?.....

f. Salt it?.....

g. Dry without salting?.....

h. Keep it in any cold environment?.....

10. How do you display your fish for sale?

a. On wooden trays?.....

b. Plastic trays?.....

c. Metal trays?.....

d. In wooden boxes?.....

11. What do you do to keep the fish attractive to the buyers?

.....

12. What do customers look for when buying fresh fish?.....

.....

13. How close are you to any means of getting water?.....

14. How could you tell when fish goes bad?.....

15. What do you use water for in your trade?.....

16 Is there any public place of convenience, rubbish dump close by?.....

17. How do you dispose of your rubbish?.....

18. Do you sell your fish in the open or under a shed?.....

19. What packaging material do you sell your fish in?

a. Polyethylene bags?.....

b. Leaves?.....

c. Newspapers?.....

APPENDIX III

SENSORY EVALUATION OF FRESH FISH

Name..... Date.....

Please taste these samples and give your best assessment of the odour, texture and flavour of the product.

A. ODOUR OF COOKED FISH (10 points):	**SCORE**
Very fresh odour, typical of the species...	10
Fresh odour	9
Weak fresh odour...	8
Neutral or none	7
Slight bad odour...	6
Slightly rotten odour..	5
Spoilt milk odour..	4
Spoilt butter odour	3
Noticeable rotten odour	2
Very rotten repulsive odour	1

TEXTURE OF COOKED FISH (5 points)	**SCORE**
Firm, succulent...	5
Firm	4
Succulent, mealy..	3
Soft, mealy...	2
Very soft, like butter, mushy.	1

Appendix III (contd.)

FLAVOUR OF COOKED FISH (10 points)	**SCORE**
Fresh sweet flavour...	10
Slight loss of flavour	9
Slight sweetness and loss of the flavour characteristic of the species...	8
Neutral flavour, definite loss of flavour but no off-flavour	7
Absolutely no flavour.	6
Trace of off-flavours, some sourness but no bitterness ...	5
Some off-flavours and some bitterness.	4
Strong bitter flavours, some rubber-like flavour..	3
Strong bitter flavours but not nauseating.	2
Very nauseating...	1

COMMENTS: