Effects of salt and storage temperature on pysico-chemical and sensory properties of salt fermented herring (*Amblygaster sirm*)

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Abstract

Herring (*Amblygaster sirm*) is a abundant fatty fish and has a good potential to develop new fish products. Salt fermentation is a traditional preservation technique, which is practiced to develop different fish products. This study was carried out to identify the effect of salt and storage temperature on pysico-chemical and sensory properties of salt fermented herring. Initially, herrings were salted at three fish: salt ratios (3:1, 4:1 and 5:1) and stored at two different temperatures, 4±1 °C and ambient temperature for a period of 24 and 48 hours under light proof conditions. The salted samples were analysed for sensory attributes (colour, odour, texture, taste and overall preference) after 24 and 48 hours, by 30 untrained panellists and using a hedonic scale. Herrings treated with 4:1 ratio shown significantly ($p<0.05$) high acceptable sensory attributes, than other two treatments. Moreover, salted herrings (4:1) stored for 48 hours, at both temperatures had significantly ($p<0.05$) favourable sensory attributes. Herrings salted at 4:1 ratio were selected for further processing and analysed for physico-chemical properties. The samples were immersed in 75% and saturated salt solution at 4±1 °C and ambient temperature for further fermentation process. Samples were tested for Total Volatile Base Nitrogen (TVB-N) content and sensory attributes, at weekly intervals. The level of TVB-N was found to increase gradually in the salted herrings stored in 75% salt solution and sensory attributes became gradually unacceptable, by the sixth week at both storage temperatures. Even though, the above parameters of salted herrings (4:1) stored in saturated brine solution, had gradually varied they remained within the acceptable limit. Therefore, salt fermentation of herrings at 4:1 ratio for 48 hours, followed by storage in saturated brine preserves herring (*A. sirm*) at least up to three months without affecting their sensory qualities.

Keywords: Herring (*Amblygaster sirm*), Salt fermentation, Sensory qualities, Total Volatile Base Nitrogen (TVB-N)

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Introduction

Fish is one of the excellent sources of protein, which is highly digestible and as good as any other class of animal protein in respect to its content of essential amino acids (Potter and Hotchkiss, 1995). Even though, global fish production continues to rise, still some of the countries are not able to reduce the post harvest losses to a desirable level. The storage temperature didn't have any impact on the sensory attributes. Processing, preservation and development of value added products reduce postharvest losses, increase shelf life of fish and guarantee a sustainable supply.

Herring (*Amblygaster sirm*) is a high fat pelagic fish species, living in coastal water, It's not highly popular among consumers due to its small size. Herring has been an important source of food for human due to its high nutritive value, specially vitamin D and Ω-3 fatty acids. However, it is highly susceptible to spoilage by bacteria, hence there is a need for preservation. As a result numbers of herring products are available throughout the world such as pickled herring, cured herring, and salted herrings.

Salting process can be combined with other preservation methods, such as drying or smoking to extend the shelf life and to improve sensory qualities (Berhimpon *et al.*, 1991). Dry salting, wet salting or combinations of these two methods are used to produce salted fish products, as per the required final product (Bellagh *et al.*, 2007). However, fish with high levels of lipids are prone to oxidation and easily develop rancid and unacceptable odours and flavours during storage (Waterman, 1976). Due to the limitation of drying application, most of the fatty fishes are preserved as fermented, pickled or cured form.

Salt fermentation has been used to preserve fresh fish by hindering, enzymatic and microbiological activities, for three to nine months. Salt is added to retard the growth of undesirable, putrefactive microorganisms as well as, allows desirable halotolerant fermentative species such as lactic acid bacteria to grow. Most of the time, fish flesh may liquefy or turn into a paste with obnoxious odour and cheesy fishy flavour, which limits its use as a protein source (Huss and Valdimarson, 1990). Moreover, due to the poor sensory qualities especially texture, most of these products are not popular among consumers and used only as condiments than a main fish dish. Therefore, the present

study is aimed at developing a salt fermented fish product from herring by preserving its sensory qualities.

Materials and Methods

Newly caught fresh herrings (*A. sirm*), purchased at Negombo fish market were selected for pre-processing, based on external appearance, eyes, gills, viscera, blood, fillets and overall acceptability, as per the Quality Index Method (Huss, 1995). The selected fish were be-headed, gutted, scaled, washed and drained well. The average weight of fish was measured using random sampling method. The selected fishes were analysed for proximate composition. The average weight of a gutted cleaned fish, used for production was 40±10 g. Subserviently two sets of samples were prepared using dry salting method by mixing fish: salt ratios at 3:1, 4:1 and 5:1, and one set of sample was stored at 4±1 °C and the other set of sample was stored at ambient temperatures under light proof condition for a period of 24 and 48 hours. The best condition for initial preparation of the salted fish was evaluated by 30 untrained panellists using a hedonic scale for sensory attributes of colour, odour, texture, taste and overall acceptability. The selected salting method was used to further processing and analysed for physico-chemical properties of Total Volatile Base Nitrogen (TVB-N), pH, moisture content, salt content and crude protein using the AOAC methods (AOAC, 1996).

Herrings salted according to the selected salting method were immersed in 75% brine and saturated brine solutions, which were previously boiled, cooled and poured into sterilized glass bottles (each bottle contained 160±10 g of salted fish and 160 mL of brine solution) and after sealing, bottles were stored at 4±1 °C and/or ambient temperature for fermentation. Sensory properties of the product were analysed once a week for a period of three months.

In this experiment, dry salting method was used for initial preparation, to obtain an extended shelf-life and firmer texture than wet salting method. Cleaned table salt with small crystals was used to enhance the salting process and to avoid salt burn and discoloration on flesh. The majority of spoilage microorganisms in raw fish had increased rapidly until salt concentration had reached up to 3%, thus alternative layers were used for rapid salt penetration into the flesh. Large amount of salt was used on the

top layer than bottom layer to minimise contamination and light proofing to avoid photo oxidation and rancid formation.

Results and Discussion

Good quality fish were selected by Quality Index Method (QIM) for further processing. The composition of raw herring is crude protein (17.45%), salt content (0.28%) and TVB-N (7.07 mg/100 g) (Table 1).

Table 1. Proximate and chemical analysis of raw herrings

Characteristics	Analyzed values*
Moisture (%wb)	72.65 ±0.02
pH	5.72 ±0.03
Crude protein (%wb)	17.45 ±0.40
TVB-N (mg/100 g)	7.07 ±5.14
Salt content (%wb)	0.28 ±0.06

*All values are the ± mean standard deviation of four independent measurements

The results of first phase of study showed that among the three fish : salt ratios tested, the ratio of 4:1, which was kept for 48 hours, was found to be the best condition than the samples stored for 24 hours. In addition, moisture, pH, salt content and crude protein content of the selected treatment did not show any significant ($p>0.05$) difference with respect to the storage temperature (Table 2). However, the TVB-N value of salted fish stored under ambient temperature (39.89 mg/100 g) was higher than that stored at 4±1 °C (25.34.mg/100 g).

Table 2. Proximate and chemical composition of the samples, selected for initial treatment (fish: salt ratio 4:1)*

Characteristics	Refrigerated temperature 4±1 °C	Ambient temperature (28-30 °C)
Moisture (%wb)	59.73 ±0.03[a]	59.85±0.19[a]
pH	5.74 ±0.01[a]	5.76 ±0.01[a]
Crude protein (%wb)	25.94 ±0.59[a]	24.56 ±0.68[a]
TVB-N (mg/100 g fish)	25.34 ±5.14[a]	39.89 ±5.14[b]
Salt content (%wb)	13.53 ±0.02[a]	13.49 ±0.01[a]

'a' and 'b' means with different letters in a raw are significantly different ($p< 0.05$)

Salted fish (4:1), immersed in saturated brine solution was found to be stable for at least three months under both storage temperature, They have shown no significant difference ($p>0.05$) in sensory attributes of colour, odour, taste, texture and overall acceptability (Fig.1).

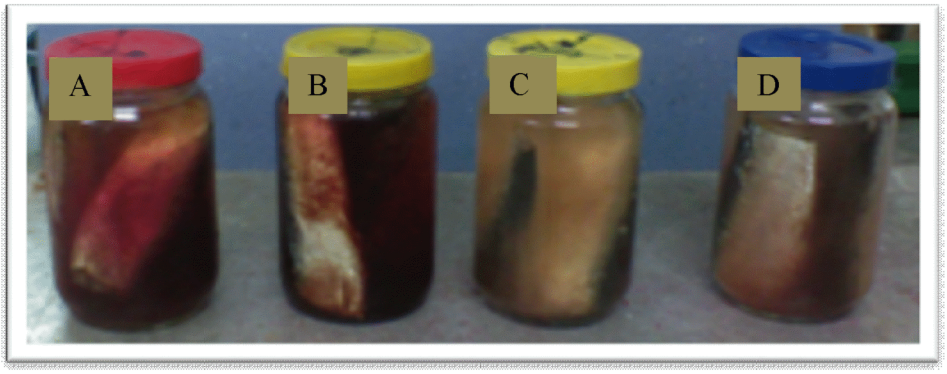

Fig. 1. Herrings salted at 4:1 and immersed in saturated salt brine at ambient (A) and 4 °C (B), and 75% salt solution at ambient (C) and 4°C (D).

The physical and chemical changes that occur during the fermentation determine the overall sensory qualities of the salt fermented fish products (Sikorski *et al*., 1995). These changes are induced by enzymes, which break down both proteins and fats. At the initial stages of the storage, sensory attributes were almost similar regardless of the storage temperature and salt concentration, however after 6th week, sensory attributes deviated rapidly with the salt concentration (Fig.2).

Colour of the herrings had developed until 6th week of storage. After that, colour of the herrings immersed in 75% salt solution was found to be decreased, while colour of the herrings immersed in saturated salt solution was found to be increased. Colour development of a fish could be facilitated through fermentation process and when fish undergoes spoilage, reduction of colour intensity may occur due to the degradation of haemoglobin (Voskresensky, 1965). Hence, the colour reduction of samples may be an indicator of the initiation of spoilage.

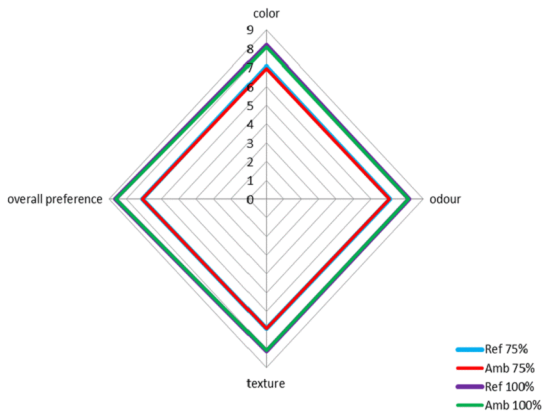

Fig. 2. Sensory attributes of the salted herrings fermented for three months in different salt concentration (Ref- Refrigerated, Amb- Ambient temperature)

Herrings, fermented in saturated salt solution for three months, had turned into pink, which was highly accepted by the panellist. Odour of the herrrings were also increased upto 6th week of storage and decreased therafter. Characteristic strong aroma mixed with some sweet, fruity and acidic notes along with some saltiness (Majumadar and Basu, 2009) were observed in herrings fermented for three months in saturated salt solution, while obnoxious odour was observed in herrings immeresed in 75% salt solution after 6th week of storage. The typical aroma, odour and flavour of fermented fish are the result of enzymatic and microbiological activity in the fish muscle (Majumadar and Basu, 2009). According to the results, texture of the herrings fermented for three months in saturated salt solution remained firm and the flesh did not easily separated from its bone and similar results were obtained in spice-salted fillets (Gudny and Gudmundur, 1997). However, softness of the herrings immersed in 75% salt solution was found to be increased after the 6th week of storage and finally it became a semi solid paste like *lanhouin* and *momone* which reduces the acceptability of panellists (Huss and Valdimarson, 1990). Ripened taste of the herrings, immersed in saturated salt solutions, tend to increase during the nine weeks of storage and the intensity of raw fish taste had decreased with respect to the storage time due to the fermentation process (Voskresensky, 1965). After 6th week of storage the taste of herrings immersed in 75% salt solution was reaching at an unacceptable level, which is an indication of spoiling, thus after the 9th week of storage, samples were not evaluated for taste due to safety

issues. However, it was reported that some gutted salted herring did not acquire the characteristics ripened taste due to the absence of pyloric caeca (Luijpen, 1959) but here characteristic ripened taste was obtained without pyloric caeca in gutted herrings and previous studies also shown similar results in gutted spice-salted herring during storage (Stefansson *et al.*, 1995).

The test results of pysico-chemical analysis up to six week of storage shown no significant ($p>0.05$) difference on moisture content, pH, TVB-N content, crude protein and salt content, in salted herrings stored in both saturated and 75% salt solutions. After 6th week, the physical-chemical parameters were found to gradually changed to unacceptable level in the salted herrings stored in 75% salt solution, while salted herrings stored in saturated brine solution, remained at acceptable levels.

The mean value of moisture contents of fermented herrings, immersed in saturated salt solution for three months at 4±1 °C and ambient temperature (28-30 °C) were 51.84 and 52.07% respectively, while herrings fermented for three months in 75% salt solution at 4±1 °C and ambient temperatures (28-30 °C) were 52.06 and 52.43% respectively (Table 3). The highest moisture content was recorded in herrings immersed in 75% salt solution at ambient temperature (28-30 °C), however significant difference ($p > 0.05$) was not observed among the different conditions. The reduction in moisture content of all the samples throughout the storage period could be the result of osmosis. Diffusion of salt into the fish and elimination of water from the fish had occurred throughout the fermentation process and such transfer of moisture from the fish resulted decrease of water activity and microbial load in the fish.

The pH values of fish fermented at different conditions for three months were below seven and the reason of low pH values of the products can be attributed to the fact that samples were undergoing fermentation (Tanasupawat and Komagata, 1995). This implies that the fish underwent sufficient fermentation with endogenous and exogenous enzyme systems. However, the pH of the samples immersed in 75% salt solution had also seems to be increased after 6th week of storage, which may be due to the initiation of spoilage by bacteria. The standard pH requirement for *Pedahsiam,* Thailand fermented fish product is 6.0-6.4 and when it reaches to 6.5, it's considered as an indication of poor

quality (Nerquaye *et al.*, 1978). However, pH value of *lanhouin* and *momone*, fermented fish in Ghana were reported as around 7 or above 7 due to the usage of partially deteriorated fish (Abbey *et al.*, 1994; Nerquaye *et al.*, 1978).

Salt content of herrings fermented for three months in saturated salt solution was 14.44%, while herrings immersed in 75% salt solution had 12.00%, regardless of the storage temperature as revealed by significance ($p<0.05$) difference. This may be due to the lower osmosis rate from low concentrated salt solution than saturated salt solution. The role of salt is highly significant to ensure the quality and stability of the finished product in this category. Moreover, most of the pathogenic bacteria survive and spoil fermented fish products like *lanhouin,* which has low salt concentration as 4-7% and to achieve water activity (a_w) of 0.90, which inhibits most bacteria, a salt content of approximately 15.5% is required (Davidson, 1997). In general, food borne pathogenic bacteria are inhibited by a water activity of 0.92 or less which is equivalent to NaCl concentration of 13% (Eyo, 1991). High salt concentrations were reported in most fermented fish products 10-15% in *momone* 19.4% in salt fermented anchovy (Hernandaz *et al.*, 1999), 17.5% in dry salted mackerel and >21.0% in pink perch (Srikar *et al.*, 1993) stored at ambient temperature which is significant from the view point that high dietary salt pose a severe health risk. Crude protein content of herrings fermented for three months in saturated salt solution at 4±1 °C and ambient temperatures (28-30 °C) were 17.47 and 17.45% respectively and herrings fermented for three months in 75% salt solution stored at 4±1 °C and ambient temperatures (28-30 °C) were found as 14.26 and 14.02% respectively (Table 3).

Large reduction of protein content was recorded at all different fermenting condition at the first week and it may be due to oozing out of water soluble protein to the high concentrated salt solution. After the first week of storage, crude protein content of herrings, immersed in saturated salt solution were constant throughout the three months period, regardless of the storage temperature. However, after the 6^{th} week of storage, crude protein content of herrings immersed in 75% salt solution had reduced drastically. Low protein content in fermented fish products might have resulted due to degradation of tissue protein and solubilisation in the medium (Abbey *et al.*, 1994).

Total Volatile Basic Nitrogen content of herrings fermented for three months in saturated salt solution at 4±1 °C and ambient temperatures (28-30 °C) were 42.44 and 49.52 mg/ 100 g respectively and herrings fermented for three months in 75% salt solution at 4±1 °C and ambient temperatures (28-30 °C) were 77.81 and 84.88 mg/ 100 g respectively (Table 3).

Table 3. Proximate and chemical composition of salt fermented fish, stored at different temperatures

Chemical characteristics	Immersed in 75% salt solution		Immersed in saturated salt solution	
	4±1 °C	Ambient Temperature (28-30 °C)	4±1 °C	Ambient Temperature (28-30 °C)
pH	6.11 ±0.01[c]	6.15 ±0.02[b]	5.45 ±0.02[a]	5.46 ±0.01[a]
Moisture (%wb)	52.06 ±0.88[a]	52.43 ±3.16[a]	51.84 ±0.07[a]	52.07 ±1.08[a]
Salt content (%wb)	12.01 ±0.01[b]	12.00 ±0.01[b]	14.44 ±0.01[a]	14.44 ±0.01[a]
TVB-N (mg/100 g)	77.81 ±5.14[d]	84.88 ±5.14[c]	42.44 ±5.14[b]	49.52 ±5.14[a]
Crude protein (%wb)	14.26 ±0.01[b]	14.02 ±0.02[b]	17.47 ±0.02[a]	17.45 ±0.01[a]

'a', 'b', 'c' and 'd'- mean values with different letters in a raw are significantly different ($p < 0.05$)

Level of TVB-N in fish is commonly used as a spoilage indicator. TVB-N levels below 20 mg/100g indicate that the fish is fresh, whereas the fish would be rejected for human consumption when the TVB-N level exceeds approximately 50 mg/100 g (Silva, 1998). Accumulation of low molecular weight nitrogenous components might have resulted due to degradation of tissue protein and enzymatic actions at high storage temperature and low salt concentration (Abbey *et al.*, 1994; Yankah, 1988) hence, after 6th week of storage TVB-N level of herrings immersed in 75% salt solution increased significantly (Fig.3). Salting of fish at 4:1 fish to salt ratio for 48 hours and storage in saturated brine solution protects the desired sensory qualities of product up to three months at room temperature.

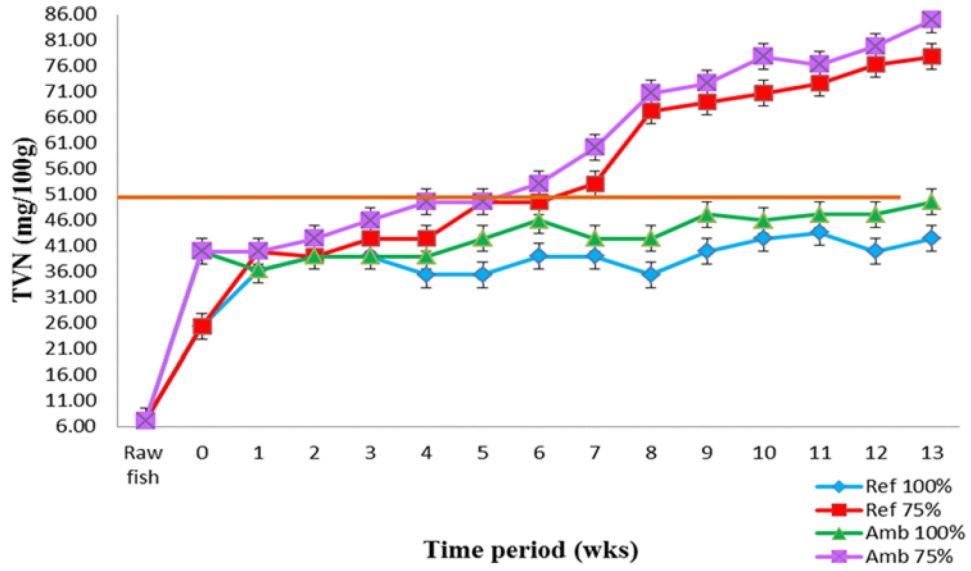

Fig. 3. Proximate and chemical composition of salt fermented fish (fish:salt, 4:1) stored for 3 months (Ref- Refrigerated, Amb- Ambient temperature) MR level- Maximum recommendation level for human consumption

Conclusion

Combine process of dry salting and brining can preserve the sensory quality of salt fermented herrings up to three months period in ambient temperature.

References

Abbey, L.D., Hodari-Okae, M. and Osei-Yaw, A. (1994). Studies on traditional processing and quality of fermented fish (*momone*). Ghana/Netherlands Artisanal Fish Processing and Applied Research Project Report. Food Research Institute, Accra, Ghana. p. 48.

Association of Official Analytical Chemists (AOAC). (1996). Official methods of analysis. 16th ed. Washington DC.

Bellagha S., Sahli, A., Farhat, A., Kechaou, N. and Glenza, A. (2007). Studies on salting and drying of sardine (*Sardinellaaurita*): Experimental kinetics and modeling. *Food Engineering* **78**: pp. 947-952.

Berhimpon, S., Souness, R.A., Driscoll, R.H., Buckle, K.A. and Edwards, R.A. (1991). Salting Behavior of Yellowtail (*Trachurusmccullochi Nichols*). *Food Processing and Preservation* **15**: pp.101-114.

Davidson, P.M. (1997). Chemical preservatives and natural antimicrobial compounds, In *Food Microbiology Fundamentals and Frontiers* Eds. Doyl, M.P, Beuchat, L.R. and Montville, T.J. ASM press, Washington DC. pp. 101-128.

Eyo, A.A. (1991). Studies on the preparation of fermented fish products from *Alestes nurse*, In: *FAO Expert Consultation on Fish Technology* Africa. p. 154.

Gudny-Gudumundsdottir and Gudmundur- Stefansson. (1997). Sensory and chemical changes in spice-salted herring as affected by handling. *Food Science* **62(4):**pp. 894-897.

Hernandaz-Herrero, M.M., Roig-Saugues, A.X., Lopez-Sabater, E.I., Rodriguez-jerez, J.J. and Mora-Ventura, M.T. (1999). Total volatile basic nitrogen and other physicochemical and microbiological characteristics as related to ripening of salted anchovies. *Food Science* **64(2):**pp. 344-347.

Huss, H.H. (1995). Quality and quality changes in fresh fish. In *FAO Fisheries Technical Paper* 348. Rome, pp.14-17, 76-77, 83-86.

Huss, H.H. and Valdimarson, (1990). Microbiology of salted fish. *Fish Tech.News (FAO)* **1**:pp.189-190.

Luijepen, A.F.M.G. (1959). The influence of gibbing on the maatjes cured herring. Thesis University of Utrecht, Holland.

Majumdar, R.K. and Basu, S. (2009). Characterization of the traditional fish product *Lona ilish* of Northeast India. *Indian Journal of Traditional Knowledge* **9(3):**pp. 453-458.

Nerquaye-Tetteh, G.K.K, Eyeson, J. and Tete-Marmon, (1978). Studies on Bomone a Ghanaian fermented fish product. *Ghana J. Agricultural Science* **11**:pp. 21-26.

Potter, N.N. and Hotechkiss, J.H. (1995). Seafood. In: Food Science. 5th edn, pp. 345-358,U.S.A,

Sikorski, Z.E., Gildberg, A. and Ruiter, A. (1995). Fish products. In Fish and Fishery Products: Composition, Nutritive Properties and Stability. Ed. Ruiter, A. CAB international, UK. p. 93.

Silva, C.C.G., Da-Ponte, D.J.B. and Enes-Dapkevicius, M.L.N. (1998). Storage temperature effect on histamine formation in big Eye Tuna and Skipjack. *Food Science* **63(4)**: pp. 644-647.

Srikar, L.N., Khuntia, B.K., Reddy, G.V.S. and Srinivas, B.R. (1993). Influence of storage temperature on quality of salted mackerel (*Rastrelliger kanagurata*) and pink perch (*Nemipterus japonicus*). *Science of Food and Agriculture* **63**: pp. 319-322.

Stefansson, G., Nielse, H.H. and Gudumundsdottir, G. (1995). Ripening of spice salted herring. ThemaNord, Nordic Council of Ministers, Copenhagen. p. 613.

Tanasupawat, S. and Komagata, K., (1995). Lactic acid bacteria in fermented foods in Thailand. *World Journal of Microbial Biotechnology* **11**: pp. 253-256.

Voskresensky, N.A. (1965). Salting of herring. In *Fish as Food,* vol. 3. Ed. Borgstrom, G. Acadamic Press, New York, London..

Waterman, J.J. (1976). The Production of Dried Fish. *FAO Fish Technical Paper* **160**: pp. 1-52.

Yankah V.V. (1988). Studies on *momone*: a Ghanaian fermented fish product. B. Sciences thesis. Department of Nutrition and Food Science, University of Ghana-Legon.