UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

United Nations Industrial Development Organization

SOME OBSERVATIONS ON FISH PROCESSING[1]

by

[illegible] Jones
Tropical Products Institute
London, U.K.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been reproduced without formal editing.

id.69-4 90

UNIDO

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.[illegible] SUMMARY
[illegible] September 1969

ORIGINAL: ENGLISH

Expert Group Meeting on Fish Protein
Concentrate Production

Agadir, Morocco, 14 - 18 December 1969

SUMMARY

SOME OBSERVATIONS ON FISH PROCESSING 1/

by

N.R. Jones
Tropical Products Institute, London, U.K.

The paper discusses a selected range of topics requested by UNIDO. While some of these are related, no overall coverage of fish processing is attempted.

Processing at sea

Fish processing on vessels has been carried on for centuries. The recent acceleration in developments, particularly in the context of freezing at sea results from an increasing shortage of fish on traditional grounds and the entry of new fishing nations into the industry. Factors arguing for processing at sea, rather than ashore include (i) distance of grounds from home base (ii) the unavailability of local bases (iii) seasonal or short-lived fisheries. Such factors have to be weighed against the higher costs of processing at sea.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id. 69-4791

[illegible]

[illegible] fish products, [illegible] and [illegible]

There is a [illegible] among [illegible] as [illegible] in [illegible] S. E. Asia, [illegible] transference [illegible] altered by [illegible] proteins.

[illegible] is [illegible], mixed [illegible] salt and fermented [illegible]. In certain cases more aerobic fermentation is encouraged [illegible] starting materials, plant tissue containing [illegible] enzymes and (more recently) fungal enzymes may be added [illegible] accelerate, or modify, fermentation.

Fermentation [illegible] to proceed until complete liquifaction of the [illegible], in which case fish sauces are produced; or it may be less severe, when pastes are formed. In some forms of fish product, more typical of European [illegible], milder fermentations are encountered and the [illegible] retains structure.

[illegible], to form amino acid, or peptide, mixtures, as [illegible] to meat and yeast extracts can also be produced.

Fish sausage etc.

Fish sausage production has largely been a development of Japanese industry [illegible] the past fifteen years. Its success followed largely upon the development of casings and seals that would withstand pasteurising temperatures, together with the permitted use of anti-bacterial additives. The commercial success of the industry depended also on [illegible] integration of the catching and processing ends of the operation.

[illegible], fish sausage production is based essentially on the earlier 'Kamaboko' process in which muscle myosin is moulded in gel form. For sausages, other materials are added to the salted muscle mince however. In addition to [illegible] fat, chemical flavour enhancers and spices to modify [illegible], polyphosphates and starches are mixed in to improve texture and water binding capacity, and preservative chemicals are also used. Shelf lives of up to three weeks at ambient Japanese temperatures are achieved.

In the production of fish 'hams', cured diced tuna is added to the mix.

[illegible]ing

[illegible] is an integral part of traditional fermentation products [illegible] sauce production. More commonly, however, it is used as a [illegible] preserving process, either alone or in conjunction with drying. [illegible] hot and [illegible] are [illegible], particularly [illegible] of [illegible] salting and its variants. [illegible] for [illegible] and non-fatty species are [illegible].

[illegible] is [illegible] drying. Difficulties are encountered [illegible] and storing [illegible] in the humid tropics, [illegible] is compared with [illegible] fish produced in the dry climate of the [illegible] East.

[illegible] salt quality on that of the final product are discussed. It is concluded that salt quality is of variable consequence commercially, depending on local preferences. Contamination with copper ions is generally objectionable however.

Drying and dehydration

Factors that control rates of drying are introduced in terms of those that govern the escape of water from inside the flesh and at the surface - and related heat input.

'Natural' drying is still practiced in a number of countries. As in some other forms of drying, optimal rates often represent a balance between an avoidance of spoilage by microorganisms and damage to the proteins. In some countries very high losses can be encountered from insect attack on the dried material. This can be reduced if microbial spoilage is limited prior to, and during, drying. Often, insect attack can be severe also during the drying operation: stockfish production, for instance, is limited in Scandinavia to the Spring, before the seasonal increase in the insect population.

Variants in hot air drying are discussed from the simple open fires or stacks used in many developing countries to sophisticated tunnel dryers. The necessity to control humidity, temperature and airflow is discussed in the context of product quality, particularly in relation to reconstitution properties and surface appearance. In this relation also the advantages of press piling (and related "water horsing" of salt fish) are discussed.

The drying of pressed [illegible] by [illegible] air is described. The material of good reconstitution properties, it is necessary to avoid the over [illegible] of [illegible] about [illegible]. [illegible] of the material [illegible] advantageous [illegible] from [illegible].

Reference is [illegible] made [illegible] material, producing a [illegible] of [illegible] properties and texture, [illegible] press plate dryers, [illegible] drying and [illegible] extraction processes.

Vacuum drying, freeze drying and accelerated freeze drying processes are considered in greater detail. Development is traced from the original Danish 'Pressfiss' process. The importance of adequate plate contact, while still facilitating the escape of vapour [illegible] is made for instance, [illegible] use of expanded aluminium [illegible] fish-plate interface in assisting the escape of vapour and [illegible] of local [illegible] effects which damage the fish. [illegible] loss is assisted also by evaporation along the line of the fibres.

It is pointed out that the successful commercial application of Accelerated Freeze Drying has been confined largely to high price fish commodities such as shrimp. Technically, some of the products are excellent.

A concluding section on drying considers quality aspects in marketing dehydrated fish products. The innate variability of consumer populations is noted, particularly in the partiality of some to 'strong' flavours. Effects of carbonyl-amino and lipid oxidation reactions are examined. It is observed that optimal packaging conditions for the avoidance of one type of deterioration may aggravate the other.

Factors governing reconstitution properties and control are examined, particularly the effects of high drying temperatures, and related effects on the nutritional properties of the protein.

Smoking

In countries using simple artificial drying processes in developing [illegible] a degree of smoking, even if [illegible] [illegible] [illegible] according to the [illegible] [illegible] a degree of [illegible] and [illegible] given.

[illegible]

[illegible] and [illegible] [illegible] in the [illegible] temperature, [illegible] are dipped [illegible]

[illegible] lightly salted and [illegible] dried products do not keep well [illegible] the absence of refrigeration.

CONTENTS

1. INTRODUCTION

Under the terms of his invitation to this meeting by UNIDO the author has been asked for a contribution on fish processing at sea together with some coverage of a specified range of traditional and newer processes for preservation ashore. It will be appreciated, therefore, that this paper must of necessity present a somewhat disjointed picture of fish processing as a whole but it is hoped that, while [illegible] is excluded from its remit, the following will be of some value in placing current developments in this field against the wider background.

2. PROCESSING AT SEA (1,2,3,4,5)

2.1 Simpler forms of processing at sea have been employed for many years. For instance, Portuguese fishermen were engaged in the production of salt fish at sea in long-range operations in the Sixteenth Century (Villiers, [illegible])[illegible]: whale processing, canning, and even freezing at sea have quite extensive histories. The great development of processing and preservation at sea, however, can be considered primarily to be a development of the post-World War II years. It derives from an increasing shortage of fish of species traditionally desirable to sophisticated catcher-consumer countries, and available to Iberian trawlers, together with the well-known drive towards increased fish production in countries not traditionally associated with "distant water" operation.

2.1.1 The depletion of stocks has been a major factor in the development of processing at sea;[illegible] but others have entered into the balance of economic considerations. For instance, some fisheries are seasonal, or so short-lived that shore-based operation becomes unprofitable. In such situations in particular, it is necessary to examine the fishing industry against the background of the local food industry as a whole, however. Other crops may have complementary seasons: tomatoes; the canning or freezing of fruits and vegetables, using common facilities, can tilt the economic balance away from processing at sea to a shore-based operation.

2.1.2. Another factor that has contributed to the development of processing at sea is the unavailability of shore bases, as in some parts of the North Pacific and in the Atlantic Oceans for instance, where problems of communication and climate are considerable. The extent of processing required will, of course, depend on the nature of the operation overall, including that at landing, perhaps after transhipment. In general, processing costs ashore are considerably lower as will be discussed below. It is well recognised that almost any fishing operation on the high seas involves a degree of processing such as gutting prior to chilling.

2.1.3. A facet of unavailability or potential unavailability that must be recognised is the independence of local conditions ashore that factory operation at sea gives to the catcher. Processing becomes immediately free of (or less susceptible to) local labour problems, for instance. Equally, the catcher realises perhaps more readily that his side of the operation must coordinate with the processor's; and the latter is less susceptible to what he might consider to be unreasonable attitudes of local catchers. The very mobility of his asset, which can move on to other grounds as appropriate will also enter into the calculations of an entrepreneur.

2.1.4. It must be recognised, however, that the operations of highly mobile factory or freezing fleets can also perhaps present problems of control; and that local fishing interests may resent their presence.

2.1.5. From the foregoing sections, it will be seen that a balance of factors is involved in the choice between processing ashore and at sea for any particular fishery, according to whether the operation is to be conducted by local interests, where these exist; or by overseas interests; or, as is not infrequently the case, conjointly.

2.1.6 A range of processing operations can be carried out at sea but in many respects the problems presented by different approaches to fish preservation have little in common. The nature of the species suitable for different approaches may be similar: for instance, clupeids may be suitable for salting, freezing or for canning at sea. Requirements for processing prior to final preservation differ, however, even for single species - and more considerably so when, for instance, the freezing of white fish fillets is considered as against those for the canning of king crab. Consequently, the author must necessarily curtail discussion and concentrate on areas of common interest or those of increasing economic importance, such as primary processing and freezing at sea for secondary processing or direct sale ashore.[2,9]

2.2 <u>Preliminary processing: washing, scaling, heading, gutting</u>[3]

2.2.1 In general, heading and gutting are indicated for larger species destined for secondary processing or consumption by populations readily accepting such material. It must be recognised that some populations demand the intact fish and that gutting does not necessarily improve the keeping quality of all species under chilled or frozen conditions.

2.2.2 Technically acceptable washing and descaling equipment (the latter often of revolving mesh drum type) have been available for many species for some years. Heading machines have also achieved commercially acceptable performance for many species, as have, more recently, gutting machines. Machines, that combine these functions with adequate filleting performance when required, are also available for some species.

2.2.3 As is often the case in fish processing equipment of this general nature, performance can vary with the condition of the fish, relative to that of manual operation; and a balance must sometimes be drawn between any price premium deriving from any additional quality consequent upon manual operation as against the lower crewing costs resulting from the use of machines. Both factors must be equated also economically against space demands for processing as compared with those for storage, which can be the determinant of the length of voyage in the absence of transhipment facilities.

2.3 Buffer storage prior to secondary processing aboard[2,3,10,11,12]

2.3.1. Questions of short-term, or occassionally longer term buffer storage enter early into the calculations of factory vessel designers and their economic mentors. Fish is inherently variable raw material which is brought to the ship's processors at widely varying rates. Initially the problem was considered to be essentially one of evening out the passage of material to the processor while limiting spoilage: but increasingly it has been realised that the production of, for instance, frozen fillets of the highest quality for some markets demands periods of specified chilled conditions to allow the controlled bleeding of flesh and appropriate manipulation of rigor mortis[2,3]. It cannot be stated categorically that any one method of chilling is preferable to others under all conditions. Increasingly, however, it is becoming apparent that refrigerated sea water offers many economic advantages for short-term chilling without incurring significant quality losses consequent upon the migration of salts. For longer term storage (1 day approximately) the traditional fresh water ice has advantages quality-wise, but the former conditions are more typical of integrated processing operations at sea.

2.3.2 Perhaps buffer storage of this nature has the greatest significance to processes involving freezing at sea[2]. It should be noted, however, that it is relevant also to others. For instance, in considerations of drying at sea, the control of rigor contractions is necessary since these alter the physical dimensions of the tissues and hence adversely affect the economics of drying. It would appear that greater attention than is commonly the case should be given to such considerations in canning operations, particularly under tropical conditions where the author is aware of a number of projects in difficulty with break-up problems.

2.4 Filleting[2,13]

2.4.1 Filleting is a basic operation in a number of patterns of fish processing. Machines with a high degree of efficiency in sea going operation are in common use, some of them combining capabilities for gutting, skinning etc.

2.4.2 While the economic savings in crewing in such operations can be considerable, some machines have encountered difficulties in filleting in rigor material; and the handling of pre-rigor filleted fish as wet fillet has presented problems to processors. For, instance, fillets subjected to high temperatures, or roughly handled frequently lose weight as 'drip' due to contraction, and this can result, of course, in considerable economic loss. Furthermore, badly contracted fillets are poorly received by some consumer populations (but not all).

2.4.3 Consequently, the control of rigor in pre-rigor filleted fish at sea can be crucial to the economics of operation. Buffer storage of the type indicated above, for whole fish, is generally unsuitable. Short term chilling in water may be an acceptable treatment for some fillets, although presenting certain microbiological hazards which may be of concern to public health authorities (and certain other technical difficulties in all but the shortest immersions). Chilled air appears to be the medium of choice for handling pre-rigor fillets.

2.5 Freezing

2.5.1 The freezing of fish at sea has been the subject of detailed discussion at a recent F.A.O. Technical Conference[14]; and it has also been discussed more in the broad context of the problems of food refrigeration in developing countries in a recent UNIDO Working Party[15]. Consequently, the author will not attempt an extensive coverage of the field. However, it must be recognised that the rapid developments in this field within the last decade have been among the more significant in the fishing industry overall. Not only have they been the basis of new patterns of distribution and of tertiary processing ashore: They promise to provide greatly extended buffer storage for factory operation afloat (although it is doubtful that the latter will replace to any major extent the production of frozen fish at sea for direct distribution or further processing ashore).

[illegible]

readily to an integrated vertical organization of the vessel's processing operation. Horizontal plate freezers have advantages in 'pack' freezing, for instance, of fillets. In some situations they have definite advantages (together with semi-air blast systems) over 'vertical' systems. A number of European vessels combine capability for fillet- and whole-fish freezing, for instance; and certain Japanese vessels extend this versatility to the freezing of muscle mince destined for secondary processing for fish sausage or 'kamaboko' production ashore (see below).

2.5.2 The basic requirements for storage subsequent to freezing are now well understood in terms of time-temperature tolerances and the desirability of temperatures of the order of -30°C. or below for anything in the nature of longer-term storage. Temperatures of this order are commonly employed in current freezer-trawler design.

2.5.3 Currently, there is considerable interest in the potential for use of liquid nitrogen as a refrigerant for freezing fish both at sea and ashore [illegible]. It has been suggested in the former context that such operations may be particularly applicable, for instance, to the preparation of individually quick-frozen fillets for the export market; and it has been pointed out that, by comparison with alternative freezing systems, the initial capital costs of equipment for freezing are low. Further developments are awaited with interest, particularly information on [illegible] points between running and capital costs in practical application at sea.

2.6 Thawing [illegible, 20, 21]

2.6.1 In recent years, attention has been devoted increasingly to the problems of the economics of thawing in relation to the demands of quality control considerations and of speed and flexibility. Such calculations have been based predominantly on experience of shore-based thawing operations for reprocessing and the transport and sale of 'wet' fillet to the consumer.

2.6.2 Somewhat similar considerations apply, however, to proposed uses of frozen buffer storage, longer in term than the chill storage referred to above, for levelling out catches for canning etc., on factory vessels. It would appear at the present time that refinements of buffer storage of this nature, as compared with chill storage, are likely to be economic only for fisheries products of the highest value, such as canned shellfish

2.6.3 Merritt has compared the economic performances of blast: -water-, dielectric and electrical resistance thawers of comparable throughputs. For many purposes, it would appear that a single blast-type thawer of a type derived from the Torry kiln design (see below) has advantages, particularly under conditions of high ambient air temperature; the continuous dielectric systems may well have critical advantages in space saving in shipboard operation.

2.6.4 Potentially the use of such equipment on <u>pre-rigor</u> frozen fish can give rise to difficulties of thaw <u>rigor</u> with attendant economic loss as 'drip'. The technology of the avoidance of such losses is now well understood however[illegible]; and the use of such buffers in ship-board factory operation should not be troublesome if directed by competent quality control staff.

2.7. <u>Canning</u>[1]

2.7.1 The operation of floating canneries is currently the concern primarily of Japanese, Russian and United States vessels operating mainly in the Northern Pacific Ocean, with the high value salmon and crustacean fisheries. In certain situations the canning of cheaper species such as brisling may also be economic.

2.7.2 As is the case with modern freezer-trawlers, such vessels carry a range of specialised equipment and machinery. Most canning operations at sea are carried out on mother ships of large size.

2.7.3 Whereas provision for quality adjustment by the economic use of additives is still in its infancy in the freezer-trawler industry, however, considerable possibilities for the improvement of consumer acceptability are available at the packing stage in canning. Flavour, texture and appearance can all be manipulated.

2.7.4 Present day canning operations are capable of a high degree of automation to cut crewing costs. Space does not permit a detailed consideration of individual steps of the operation at sea. Apart from the high costs of crewing and the space requirements for crew and equipment, a major factor in the operation is the availability of fresh water. This, of course, presents difficulties in some other processes, but problems can be serious in a process demanding large volumes. In the past barges were employed to carry water to some off-shore United States canneries but modern factory ships on the high seas employ large-scale distillation equipment.

2.8. <u>Salting and Drying</u>[2,6,22]

2.8.1 General considerations of salting and drying are discussed in greater detail in the sections below, in relation to shore-based operation. But it is appropriate to discuss shipboard operations briefly at this point of the paper. It is of interest to note that salting was the first of the preservation processes to put to sea and that it continues to play an important role in some fisheries.

2.8.2 In the traditional Portuguese dory fishing on the Grand Banks, the fish is taken with bait by men fishing singly in small boats from mother schooners, over the day. The fish are split, washed and salted down in barrels on the monther vessel in the evening.

2.8.3 While some fishermen from other countries are also concerned in this inherently highly hazardous type of operation, there has been a pronounced trend away from it towards salter-trawlers, insofar as salting continues in competion with the rapid development of the freezer-trawler industry and its off-shoots.

2.8.4 The fishery for clupeid species (rather than 'white' fish) for salting at sea is operated both by processor catchers directly and by mother ships escorted by catchers.

2.8.5 Traditional salt fish cures continue to be well received by many populations, although consumption has declined rapidly in others, under the competition of newer fish products and other cheap foods.

2.8.6 Other dried fish products, of stockfish type, also continue in demand in some countries, but traditionally these have been prepared ashore. In recent years, efforts have been made to develop tunnel dryers, suitably programmed for production of dried fish of this type at sea. Rates of heating and drying are controlled carefully within predetermined limits (see below). Further developments in this field are awaited with interest, particularly with respect to proven economics of operation.

2.9 Concluding observations on processing at sea

2.9.1 While canning and salting continue to be significant processing operations at sea, freezing has overhauled them rapidly during the last decade and promises to surplant even conventional icer-trawler operation in many countries.

2.9.2 A high degree of automation is now available for both the preliminary primary processing and the preservation phases of shipboard operation. Equally, biochemical work, in conjunction with that of refrigeration and drying engineers, has established satisfactory operating regimes for a number of species of economic importance.

2.9.3 This information is available primarily on cold- and temperate-water species. On many warmer water species, particularly some of those of interest to developing countries in the Tropics, appropriate guideline information is lacking.(2)

2.9.4 The operation of factory vessels (particularly factory trawlers) requires the closest cooperation between the catching and processing sides of the operation. If necessary, catching rates should be reduced to allow the demands of quality requirements in processing to be met.

2.9.5 Detailed evaluations of quality/price relations are involved in such considerations.

2.9.6 Planners concerned in the development of programmes for processing and preservation at sea should consider in considerable detail the patterns of acceptability of fish products within proposed consumer populations, together with the availability of adequate technical expertise, in their general assessments of economic feasibility. Reference may be made to recent Of African experience with a developing freezing-at-sea industry in this context.

2.9.7 Populations vary considerably in their acceptance of different types of fishery products. Many, in developing countries, require intact fish rather than that that has been filleted, or gutted. 'Fresh' flavours are not always appreciated. Among the developed countries, requirements in appearance, for instance, also vary; and cognisance should be taken of these variations in attempts to build up export industries, particularly with unfamiliar species.

2.9.8 Perhaps even more than with a land-based fish processing industry, the closest co-operation is desirable between the industrial planning and designing staff, the technologist in the vessel and the fishery biologist. Calculations of the relative profitabilities of shore based and shipboard operation in the longer term are dependent ultimately on reliable estimates of the potential productivity of the fishery; and the solution of day to day quality production problems is greatly facilitated by accurate forecasts of the nutritional and general physiological status of the resource.

3. FERMENTED FISH PRODUCTS, AUTOLYSATES AND HYDROLYSATES

3.1 With the increasing emphasis on protein problems in considerations of world food resources the possibilities of improved utilisation of the fishery resource overall have been examined by a number of groups. Among these studies have been scientific and technological evaluations of traditional South East Asian approaches to fish preservation with a view to their transplantation elsewhere largely unmodified, or to their incorporation in more sophisticated approaches to desirable flavour modification by microbial agencies. A number of groups have been involved in this work in the United States, France, the United Kingdom and elsewhere.

3.2 Reference has been made in the preceding section of the paper to varying consumer preferences. In many developing countries these lie in the direction of [illegible] flavoured products rather than the relatively bland or moderately sweet meaty character of 'fresh' fish [illegible], appreciated for instance in [illegible] America, [illegible] European countries and Japan.[8] In S. E. Asia, fermentative processing leads frequently [illegible] fish pastes and sauces of strong [illegible] character, in [illegible] with other characteristic advantages. These provide [illegible] and valuable nutritional supplementation [illegible] diets based largely on rice,[24, 34] and the low costs of the preservation procedures are a major factor in fish utilisation among [illegible] which may not be able to [illegible] costs of canning, freezing or even [illegible]ing.

3.3 However, other products, which are not fermented to the extent commonly practised in S. E. Asia are also prepared elsewhere. For instance, bacterially fermented herring and trout are produced commercially in Scandinavia. These retain their [illegible] structure and are not sold as pastes or sauces.

3.4 Fermented fish pastes [illegible]

3.4.1. Commonly fish (often [illegible]) are cleaned and mixed with salt in the proportion 1 [illegible] fish. [illegible] [24] before fermentation in clay vats and sealed cans in the Philippines and the author has seen wooden barrels and vats employed elsewhere in S. E. Asia.

3.4.2. Often fermentation appears to proceed mainly as the result of the activities of the tissue enzymes rather than microflora. In practice this depends on the degree of evisceration employed.

3.4.3 Precise patterns of fermentation vary considerably from country to country according to the nature of the raw materials and local custom. The basic procedure above refers to the 'bagoong' of the Philippines, where, as in Thailand small shrimp are also used as raw material.

3.4.4 The 'prahoc' of Cambodia is prepared from eviscerated, beheaded, scaled fish after trampling. The material is fermented with salt under pressure, in contact with banana leaves and then partially dried and

fermented in the [illegible]. After further [illegible] more salt is added and the mass is maintained for [illegible] to a month in sealed jars.

3.4.5 While such a pattern of [illegible] fermentation is common in the production of many fish pastes it is not invariable. Some Indonesian shrimp [illegible] pastes, for instance 'trassi', are fermented in their [illegible].

3.4.6 [illegible] with [illegible] and spices. In many instances [illegible] the fish is mixed with vegetable materials either before or during fermentation, as in the preparation of [illegible] containing [illegible], and 'phaak' [illegible] fermented with [illegible] in Cambodia.

3.4.7 [illegible] are also employed in some types of fermentation. For instance, [illegible], which contains small fish, fermented [illegible] in the presence of [illegible] are mixed [illegible]. [illegible] in the Philippines [illegible] fish fermentation [illegible] potential for use in [illegible].

3.5 Fermented fish sauces [illegible]

3.5.1 Fish sauces are commonly prepared in areas that produce pastes and are also found in parts of China. While their salt content limits their intake [illegible], they are widely used as condiments for rice dishes throughout S. E. Asia.

3.5.2 In the fish sauces [illegible] of the pastes is attended; the products are [illegible] free amino acid content. While most of the production is consumed domestically, there is, for instance, some exportation of fish sauces to the West from Hong Kong.

3.5.3 Probably the most widely known and examined of the fish sauces is the 'nuoc-mam' of [illegible], Laos and Vietnam. Other sauces such as the 'nuoc-mam' [illegible] of Thailand [illegible] similar [illegible] the 'patis' of the Philippines [illegible] from [illegible], paste preparation from shrimp, [illegible] concentrated liquors from salt fish production (e.g. the tuk-trey of Cambodia) are not strictly comparable with fermented fish sauces.

3.5.4 The scale of fish sauce production in individual operations varies considerably. At its simplest, small fish are mashed by hand or foot, salted and packed in pots which are then sealed and buried in the earth for months or years. After maturation, the liquors are decanted or strained.

3.5.5 In larger scale operation large vats are used. The proportion of salt is higher than that in paste production (5 parts salt : 6 parts fish). In the operation as described by van Veen[22] the fish are piled above the top of the vat with a final layer of salt above. All or a proportion of the bloody liquors that accumulate over the first three days or so is removed, and clarified by heating or standing in air. The fish pack down and are covered with the remaining liquor to a depth of 10 cm. and pressed under 'bamboo wicker work'. In the process as observed by the author, heavily weighted [illegible] was used to increase conditions of anaerobiosis.

3.5.6 Fermentation then proceeds for months or years according to the species and size of fish and the salt content. In the production of 'nuoc-mam' of the highest quality, the liquor is tapped directly. Commonly, however, the residue is extracted with boiling sea water. The extract is mixed with the liquor and with carbohydrate containing materials (e.g. caramel, molasses etc.) to promote browning and to improve keeping quality by lowering pH in secondary fermentation.

3.5.7 While some progress has been made in the [illegible], microbiology and biochemistry of fish fermentation and the rationalisation of basic production processes and their adaptation to the development of new fisheries products, there is [illegible] of control of [illegible] fish sauces, [illegible] species. Nevertheless [illegible] exploitation [illegible] work in the Philippines and elsewhere. An assessment of the current status of development in W. Africa [illegible] offered at this Working Group would be welcome. Work in the Tropical Products Institute in collaboration

with others in W. Africa and S. E. Asia is examining the bases of acceptance and quality and factors affecting the economic manupulation of quality.

3.6 Other hydrolysates [34]

3.6.1 The use of acid and the controlled use of autolysis in the production of fish ensilages and amino acid concentrates have been established for some considerable time; and obviously they have further potential, possibly in combination with fermentation procedures, as competitors in the yeast/meat extract field.

3.6.2 Reference should also be made to the 'tidbit', marinade market in Europe and elsewhere. In the latter, maturation is mainly autolytic. In relation to the former, much work has been carried out on the effects of permitted additives on the microfloras that develop. It may be pointed out also that bacterial fermentation to a degree may also be desirable in the preparation of conventional anchovy packs.

4. FISH SAUSAGE ETC. [35,36,37,38,39,40,41]

4.1 While a considerable volume of work has been carried out in a number of countries on the development and test marketing of meat substitutes and sausages from fish, commercial exploitation on the large scale has been possible mainly in Japan. Development of the industry is comparatively recent. Amano has pointed out that effectively it was established only in 1953 and that its rapid development results from takeovers by the large catching companies, thus ensuring a fully integrated operation.

4.2 'Kamaboko'

4.2.1 Kamaboko production provided the basis of the present sausage industry in Japan. While it has been described as a type of 'meat loaf', its appearance to a Westerner resembles more closely a moulded white or translucent jelly set on a small board. Essentially, it is a gel of myosin extracted from fish muscle. Its manufacture was put on a sound technical basis by the work of Japanese fish muscle biochemists, particularly W. Shimizu and essentially the principles of manufacture are those described below for sausage except that certain additives, particularly pork fat, are omitted.

4.3 Fish sausages and hams

4.3.1 While certain species such as tuna and croaker are preferred for sausages and kamaboko preparation respectively, on grounds of colour and myosin stability, most fish species and also whale meat can be used. The raw fish is filleted, (if suitable sea frozen mince is not to be used). Fillets are then minced and ground under refrigerated conditions, some 3 per cent sodium chloride being added, together as appropriate with other additives (polyphosphate, starch, chemical preservations such as sorbic acid, monosodium glutamate, ribomononucleotide colouring, spices etc.). Pork fat is added late in the grinding process. In the production of fish hams, precured dried tuna meat is also added at this stage.

4.3.2 The ground mixture is then transferred to a semi or fully automatic casing stuffer and sealer. The introduction of vinylidene cloride and satisfactory rubber hydrochloride casings was a crucial stage in the development of the industry. After sealing with aluminium wire, the sausages are conveyed automatically to a heat pasteurizer. Amano describes a heating regime of 85°/20 min. for 3 cm diameter sausage followed by water heating at 90°C/50 min. The sausage then pass to a cooling tank.

4.3.3 Undoubtedly, the high fish intake generally in Japan has played a large part in the successful development of the sausage industry, together with the development of casings that can endure pasteurizing treatment and the "broad minded" attitude of public health authorities in Japan concerning chemical additives.

4.3.4 These notwithstanding, a number of microbiological problems have been encountered in the industry and it could be argued that refrigeration of the sausage for marketing is inherently more desirable than the use of preservative chemicals that may become unacceptable as legislation changes. However, in practice, starch stability problems in the fillet are encountered under these conditions.

4.3.5 Obviously countries contemplating entry into this field must follow closely current developments in film stabilities and sealing efficiency in the context of such considerations. Under Japanese conditions, the use of additives extends shelf life to upwards of three weeks, allowing the penetration of the products to remote rural markets. [illegible] comparison untreated sausage keep only 3 days at room temperature, but two weeks under refrigeration.

4.3.6 Even within Japan, the use of some additives has been questioned on grounds of practical value. Amano and Ukiyama [42] for instance, examined the effect of legally permitted concentrations of nitrofuran compounds on the germination of *B. panthothenticus* spores and found no inhibition of germination. This organism produces softening spoilage. Spoilage due to other *Bacillus* spp. has also been observed in fish sausage.

5. SALTING (22,43,44,45,46,47,48,49,50)

5.1 Salting as a means of preservation takes different forms. In an earlier section, on fermentation, it has been noted that the addition of salt is an integral part of the operation. Somewhat similar treatment involving the tight packing of herring barrels followed by their burial in the ground (but at 0° rather than tropical temperatures) was also carried out in medieval times in Russia. Dry salting, on the other hand, may be considered as a development of simple drying. In another approach to salting, practised in South East Asia, mackerel-type fishes are preserved by boiling in brine. Cold brining and the salting of minces for drying are also practised.

5.2 With the exception of the hot brining process, and that incorporating external drying, the basic requirements for salt preservation are much the same whether granular salt or brines are used in the treatment. The aim is to introduce salt to the concentration required to suppress the development of the spoilage microflora; and, at the same time to allow maturation of flavour while preventing undesirable oxidative effects. With fatty species such as herring this entails, for instance, the tightest packing of barrels when these are used. With larger non-fatty species, treatment in brine is still commonly found.

5.3 Salting of fatty species [illegible]

5.3.1 [illegible]

[illegible]

at the acceptable condition, where [illegible] of salt and lowered water content combine to produce [illegible] acceptable unspoiled product.

5.3.2 Salting [illegible] carried out in containers such as [illegible], tins and barrels. While larger containers have obvious advantages in the handling of high [illegible] catches such as [illegible], for instance, [illegible] fisheries, their use does present difficulties [illegible] of high pressures on soft-fleshed species. Nevertheless, [illegible] of chilling, for instance, [illegible], outweight the disadvantages in their use; and [illegible] operations facilitate the use of pumped brine systems to improve the efficiency [illegible].

5.3.3 However, particularly in shipboard operation, the use of barrels has been [illegible] fishery, and it undoubtedly [illegible] according to local conditions.

5.3.4 [illegible]sky [illegible] distinguishes two basic methods of barrel salting: firstly dense packing without opening the sealed barrel after preservation [illegible]; and [illegible] dense packing, particularly under the pressures of ship-board operation, followed [illegible] repacking, "topping up" using the [illegible] day's catch.

5.3.5 Methods of treating herring and other species vary widely according to the nature of the catch in terms of size and physiological condition - and the pressures of the operation, which are considerably greater on a vessel in a high [illegible] than in a salting house ashore. Dutch fishermen [illegible] salt concentration of [illegible] per cent, using [illegible] salt, whereas the Icelandic shore-based operation employs [illegible] per cent salt on beheaded fish. In the Scottish operation ashore, the herrings are packed relatively lightly initially and then repacked. When young fish are being salted,

relatively low concentrations of salt are employed, with excellent results. The Russian high seas fleet operates with whole herring, using loose packing and a mixed brining/dry salting system whereas the Norwegians resalt ashore fish that have been handled at sea similarly to the Dutch method. As with other forms of processing it would appear that an intelligent versatility rather than the dogmatic adoption of standard methodologies is indicated in the preservation of new species.

5.4 Salting of white fish

5.4.1 While gadoid species, particularly cod, are major items of commerce in the salted form, still commanding considerable world markets, this basic approach to the preservation of white fish is undoubtedly of considerable application in, and interest to, other fisheries.

5.4.2 Commonly, fish in rather poor condition is salted to prevent total loss. However, a body of evidence indicates that for the production of good salt fish it is essential to use raw material of good quality.

5.4.3 As with fatty species, approaches to salting vary. In 'kench' salting, the fish are split and are stacked in layers between layers of salt, the latter being in contact with flesh rather than skin. The liquor or 'pickle' is allowed to drain away and the fish is then dried after the removal of the adhering salt layer. In 'pickle' salting, a similar process is used, but the fish is placed in barrels or tanks and so remains in a strong brine as water is removed from the flesh by osmosis. In a variant of this process, brine, rather than dry salt is used.

5.4.4 Often, salting is followed by drying; and the degree of salting will depend in part on conditions of drying later. Dry salting under tropical conditions reduces the moisture content of fish to varying degrees. For instance, water contents of the order of 36 - 65 per cent have been measured in Singapore markets whereas those in Aden range from 33 - 69 per cent, the fish being dried in the dry atmosphere of the Gulf or the Red Sea (45).

5.4.5 At the higher end of the moisture range, in Singapore, the fish keeps only a few weeks whereas fish sold through Aden is commonly marketed in Ceylon and E. Africa three months after processing. It will be noted that the main preservative action is the removal of water by osmosis. The

direct supression of the microflora by salt is secondary. Heavily salted material is difficult to dry in the humid tropics and tends to absorb moisture.

5.4.6 Van Klaveren and Legendre[43] comment in this general context on the effects of high temperature in determining the concentration of salt necessary to control bacterial attack under Canadian conditions. Obviously a balance of factors is involved in optimising operations.

5.4.7 Van Klaveren and Legendre comment also that Mediterranean importers of Canadian salt fish insist on first rate products and are prepared to pay for them. Quality in salt fish is affected by a number of factors, such as that of the raw material, as indicated above. Another major quality factor is the purity of the salt. Cole and Greenwood-Barton[48] point out that fish salted in pure sodium chloride tends to produce a "flabby pale yellow" product without the characteristic flavour of salt fish; and comments that small quantities of calcium and magnesium salts are always present in commercial salt, and that these whiten and stiffen fish imparting a bitterness appreciated by many consumers of salt fish. The author has noted, however, that the use of some crude solar salts of commercial origin can produce fish of very bad colour. He has also seen commercial samples of purified brine that contained unacceptable levels of copper. The presence of copper[49] and iron salts in traces catalyses carbonyl-amino reactions producing discolourations and off-flavours. In this respect it may well be that Cole's views represent an over-simplification of the situation; on balance it would appear that for many consumers preferring fish that approach the original state or reconstitution, the purer the salt the better.

5.4.8 Much fish is dried further after salting. The drying process is discussed in the following section.

6. DRYING AND DEHYDRATION[43,51,52,53]

6.1 It is assumed that physical and general engineering considerations in fish drying will be considered in depth in the discussions of plant operation for fish meal and FPC production that are a major concern of this meeting. In the space available, the author seeks to introduce mainly a discussion of simpler drying procedures, particularly those relevant to salting and smoking; and to refer briefly to certain aspects of vacuum dehydration, and meal production.

6.2 For convenience, the term dehydration, as distinct from drying, may be restricted technically to any process of drying by controlled artificial means.[52]

6.3 **In developing** mathematical models of the drying process Jason[52] and others have considered the factors controlling the outward movement of water from the fish, together with those controlling the inward transfer of **heat**. In practice (although this may represent a theoretical over-simplification) the early stages of drying are characterised by a constant rate phase. This is followed by a period of falling rate, during which internal diffusion is the limiting factor. The lack of basic physical data on fish muscle appears to be a limiting factor in theoretical analyses of some drying situations. Briefly, the rate of outward movement of water can be considered as relating to its removal from the medium surrounding the surface, to its **mixing** with the medium or atmosphere at the surface **and migration** within the material. In the more conventional methods of drying, **heat** transference into the fish is, in turn, dependent on a number of factors such as conduction within the system, partial enthalpy of solution, and emission from source together with transmission to the surface. Having noted this it must be recognised that the relative importance of different factors vary widely in practice, according to species for instance, and the nature of the drying operation. For instance, the drying characteristics of frozen and unfrozen muscle are quite different/in so far as the latter remains a gel through much of the drying operation, behaving largely as an isotropic medium whereas the former behaves anistotropically. The reader is referred to Jason's excellent review[52] for a detailed discussion of diffusion coefficients together with considerations of density and thermal conductivity as determinants of drying rate.

6.4 Natural drying[46,54]

6.4.1 Air drying under the prevailing atmospheric conditions is a commonplace in many countries. Commonly, the fish are gutted and split; and they are then perhaps beheaded and hung on a drying rack. In

Scandinavia the fish are hung in pairs over poles and drying frequently takes from 2 - 6 weeks. In the tropics fish are often set to dry in the open sun, sometimes on mats, or racks, often on the sand [45].

6.4.2 It may be noted that while high temperatures are desirable in some respects, they are disadvantageous in others, leading to an unacceptable degree of spoilage and fly damage for some markets. Thus, for instance, the stockfish production of Norway takes place largely in the Spring when the fly problem is minimal.

6.4.3 In the past, the final drying of salt fish was the major use of natural drying. However, salt cod is now mainly dried artificially. In the old process, the moisture content was reduced progressively from the 55 - 60 per cent after salting to some 40 - 45 per cent.

6.4.4 There is still a very considerable market for such stockfish and salt fish in the Mediterranean and many tropical countries. In the latter, infestation by insects can be a very considerable problem, particularly with locally produced dried fish.

6.4.5 Adequate drying and handling techniques can eliminate a number of quality defects commonly encountered in dry salted fish prepared or stored under tropical conditions.[45] For instance, 'pinking' due to halophylic microorganisms can be eliminated by reducing the moisture content rapidly and the employment of deep 'pickle' technique at the salting stage.

6.4.6 At the same time, it should be noted that the acceptability of dried and dry salted fish follows quite different patterns in different countries.[8] As indicated in the section on fermented products, the populations of many developing countries prefer strongly flavoured fish. That which a European or N. American population would consider to be of excellent quality may well be rejected for material affected by the flavours of rancidity, 'pink' or bacterial decomposition. Indeed, partial fermentation is an integral stage in some W. African drying operations.

6.4.7 In practice in such situations, natural drying is often complemented by the use of open fires, together with, perhaps, simple kilns made of oil drums. Such approaches to drying are quite common in the

humid tropics. It may be noted, however, that recently there have been suggestions that such processing may possibly contribute to the high incidence primary carcinoma of the liver in some countries, as a result of contamination of the fish by polycyclic hydrocarbons and the suggested formation of nitrosamines.[8]

6.5 Tunnel Drying

6.5.1 The essentials for satisfactory tunnel drying are the control of temperature, humidity and air velocity. Control of temperature is necessary in that the rate of drying, as effected by this parameter, must be equated to the ill effects of over-high temperatures, particularly in the early stages, in terms of 'break-up' and irreversible damage to proteins, affecting reconstitution. Humidity affects both the drying rate and final appearance. Linton and Wood[55] found that drying rates increased with air velocity up to 200 - 300 feet per second. Above this, power costs increased without further significant improvement in drying rate.

6.5.2 As indicated in an earlier section of the paper, development work has been carried out on programmed tunnels for the production of material of 'stockfish' type at sea. However, at the present time such dryers are employed mainly ashore, often for the final stages of salt fish production.

6.5.3 In general lightly salted fish present considerably greater difficulties for dehydration than heavily salted material.

6.5.4 A number of designs have been described, usually employing trucks or racks to mount the fish laid on trays Linton and Wood's design recirculates part of the drying air, which can be heated indirectly by steam where this is available. Under conditions of high external relative humidity, drying will not be possible unless some form of dehumidifying system is operated. Lithium chloride has been employed in Canada, but it is expensive. More usually precooling below the dew-point before drawing air into the heater, or activated alumina or silica gel are used. An early European system employed sulphuric acid as desiccant[56].

6.5.5 Conversely there may be a requirement to humidify incoming air in some situations since the appearance of the product suffers if the humidity of the drying air is too low.

6.5.6 Desired conditions of temperature and humidity vary continuously through the drying process, according to the species of fish and the preferred product. Obviously, as in other forms of fish processing and preservation, quality considerations must be balanced economically against the possible variations in the drying regime.

6.5.7 Most development work has been carried out on temperate- or cold water-species. Drying temperatures are often of the order of 25°C, although variable according to the state of drying, as indicated above. Many tropical species can withstand considerably higher temperatures of operation.

6.5.8 Reference should be made to ancillary practices in the drying of salt fish. In the production of salt cod, for instance, an undesirably rough surface results from drying freshly salted material. Consequently, on the completion of salting the salted fish is washed and placed in piles. The pressure flattens and smooths the product, expressing brine and increasing the surface area presented to the drying air. Drying times are reduced. This process is known in Canadian practice as "water horsing". A somewhat similar procedure can be introduced into the drying operation later. Rates of water evaporation fall when the surface of the fish has dried. Removal of the remaining water can take a considerable period, particularly from large fish. Consequently fish is removed from the dryer periodically and placed in piles (but unwashed). Water then equilibrates throughout the fish from the inner layers to the surface. This process is known as "press piling" and considerably reduces time in the drier.

6.5.9 From the foregoing paragraphs it will be apparent that a wide range of operating conditions can be found in practice and that continuously variable automatic control will have (at least theoretically) considerable advantages over manual manipulation of the dryer and fish. In practice, however, the commercial salt-fish dryers have commonly adopted a compromise fixed temperature fixed humidity regime, without air conditioning control as costs can be unacceptably high. However, fully automatic systems have been developed for commercial use: for instance, Legendre[57] has described the artificial drying of salt fish by thermocouple control and [illegible], at the [illegible] Research Station, Aberdeen, has collaborated with a major British shipbuilding company in the development of a [illegible] drier. [illegible], under conditions of fine control, such as the Canadian thermocouple system, it is possible to dry fish to good condition at higher external dew points than would normally be acceptable in commercial manual operation.

6.6 Drying of minces with warm air

6.6.1 A considerable volume of research and development was carried out during the War years on the drying of fish minces for human consumption. In some respects the problems raised were similar to those of fish meal production, as carried out commercially; and they bear on some approaches to very high quality meal production such as are likely to be discussed in this meeting. However, as in other approaches to dehydration discussed in this paper, questions of reconstitution are more important than in meal production generally.

6.6.2 Although elasmobranch species develop ammoniacal flavours during storage in both wet and dried conditions, almost any type of material can be used, provided that it is fresh, and has not been subjected, for instance, to lipid oxidation reactions before processing. In the basic process as discussed by Cutting et al[illegible] the fish is washed, headed, gutted and filleted, only the fillet being used.

6.6.3 The fillet is then either cooked directly in live steam at a pressure of 2lb per sq. in. for about 30 min. or it is minced and the mince cooked similarly. Something of the order of 30 - 40 per cent of water escapes, together with some nutrient, as in the case of the "glue water" or "solubles" in meal production.

6.6.4 Cooked fish is cooled and minced ([illegible] ¼ inch holes) for loading on to drying trays at a density of 2 lb per square foot to present a roughly granular bed. Pressing at this stage is avoided since this results in a product of poor reconstitution characteristics. For this reason, also, the drying of flakes is contraindicated.

6.6.5 Drying is carried out at between 85° and 65°C with relative humidity controlled initially (wet bulb temperature above 50°C) to avoid bacterial spoilage. Quite low air velocities, of the order of 10 - 15 ft. per sec. can be employed.

6.6.6 The dried material is packed in cans under nitrogen. Shelf life varies from several years at [illegible] to a few months at 37°C.

6.6.7 It will be appreciated that such approaches are not dissimilar to the less mechanised operations in meal production[54]. Primarily the differences lie in the degree of initial processing, the care taken to avoid spoilage and the avoidance of high temperatures in the drying condition such as would be conducive to poor reconstitution characteristics.

6.6.8 In comparison, commercial meal operations often use offal as raw material. With white fish, flame drying can be employed directly without precooking, and if inlet temperatures are high, difficulties with glue water are avoided. More commonly the cooked minced material is pressed to remove some water and oil, which is recovered and the mass is then heated to a temperature of about [illegible] at the outlet).

6.6.9 The loss of solubles in the warm-air drying processes represents a considerable loss of nutrients. In many variants of meal manufacture this is avoided, either by recirculation into the drying meal, or by direct recovery as condensed solubles.

6.6.10 It is taken that detailed discussion of meal production (e.g. dry rendering) is outside the terms of reference of this paper.

6.7 Roller drying and hot press plate drying

6.7.1 Although a development in roller drying was patented as long ago as 1922[56] application appears to be limited. Cutting *et al*[57] have reported experience with the roller drying of minces. The products reconstituted well but difficulties were encountered in obtaining uniform samples. However, the agreeable texture in the mouth, somewhat resembling that of freshly cooked fish is at variance with much of the experience obtained with other products; and it may well be the case that the possibilities should be examined further.

6.7.2 In Japan, pre-processed squid rings are dried and fried under pressure between hot plates in a variant of fat drying (below).

6.8 Fat oil drying

6.8.1 Sparre[54] has reported, in the context of meal production developments in dehydration under vacuum in hot oil, pointing out that heat transference in such systems is excellent. He points out that pressing, to obtain a pure oil and reasonably fat free cake presents difficulties, and that success depends on developments in solvent extraction.

A patent[59] in which foodstuffs more generally are dried by heating pieces in oil or fat under reduced pressure at 80°C does not appear to have been taken up commercially. Removal of the fat by drainage, centrifugation or solvent extraction was proposed. Drying times of the order of 2 hr. were reported.

6.9 Solvent extraction, wet extraction[60]

It is taken that these will be the subject of detailed discussion in other papers. The basic approach to drying in the wet extraction process has some part in common with oil dehydration but essentially the processes differ in that solvent in the wet extraction process is added directly to the wet product and water/solvent mixture evaporates azeotropically.

6.10 Freeze drying; accelerated freeze drying etc.

6.10.1 Essentially the development of freeze drying as a commercial process for the preservation of foods followed upon the earlier introduction of the Danish 'Pressfish' process[61]. Fish were placed between heater plates in a vacuum chamber. Since the pressure of water vapour in the system always exceeded that of ice at the highest temperature at which fish will remain frozen (~ - 1°C) the fish did not freeze dry. However, appreciating the basic possibilities of the process, further development work was carried out in the Aberdeen Experimental Factory of the British Ministry of Agriculture, Fisheries and Food[53], supported by applied research at the Torry Research Station;[see 62,63, 64,65] and eventually products of excellent quality were obtained.

6.10.2 In the original operation, pressure was brought on the product during drying, by the hydraulic manipulation of the heater plates, with the object of increasing bulk density. In practice, this adversely affected reconstitution properties and was abandoned. To ensure uniform initial heat transference, attention was devoted rather to the presentation of uniformly thick fillets to the dryer and appropriate cutting equipment was developed. However, it was quickly appreciated that the drying of steaks, rather than fillets had advantages in that water vapour migrated more rapidly along the line of muscle fibres than across them.

6.10.3 Frozen fish steaks are readily sawn to uniform thickness. Drying times of the order of 11 hr. were obtained at 1.7 cm thicknesses.

6.10.4 Times were reduced considerably when it was appreciated that the rate of vapour loss from the plate/fish interface was the limiting factor. These were reduced by some 40 per cent by placing of expanded aluminium sheet between the plate and the fish[66]: Heat flow is adequate and that of vapour is greatly increased through the mesh gaps. At the same time, difficulties that had been encountered with local thawing effects, which damaged the fish, disappeared. A number of further developments have been made in plate design, to improve heat flow, but some of these are of limited commercial application since they present cleaning problems.

6.10.5 The successful application of such Accelerated Freeze Drying techniques in commercial application has been confined largely among fishery products to the production of such high priced commodities as shrimp, which is often excellent in quality at reconstitution. Operations producing lower cost products, such as dehydrated cod steaks, have been less successful.

6.11 Some consideration of quality in the market of dried and dehydrated fish

6.11.1 While it will be appreciated that material displaying some of the 'defects', to which I have referred in this section, are less important to (or even welcomed by) some consumer populations, the housewife usually requires a dried product of good appearance, without 'off' odour, and which reconstitutes well on preparation and cooking.

6.11.2 Apart from the discolourations arising from microbial attack (such as 'pink' and 'dun' salt fish) which can be controlled, together with sliming, by adequate attention to plant sanitation, and the correct drying and packaging to ensure that moisture contents remain low, the most common discolourations in dried fish products are those resulting from carbonyl-amino reaction. Frequently, the 'carbonyl' in such reactions is contributed by the free or phosphorylated hexoses and pentoses of the muscle. In fatty species the products of lipid oxidation can contribute.

6.11.3 While sugar-amino reactions in their later stages can be suppressed by the addition of sulphite, this meeting may well consider much additives undesirable nutritionally. At the present time it would appear that a pre-processing leaching with water is the better appraoch to control. When lipid oxidation is implicated, little can be done with cheaper products, that cannot withstand the costs of expensive packaging, other than, for instance, recourse to solvent extraction or antioxidants, where this is permissible on toxicological and economic grounds. Where such reactions present difficulty with more sophisticated products, such as in the cooxidation of carotenoid pigment in freeze dried shrimp, improvement can be introduced by improved packaging, or as with that type of product, breaking the vacuum in the process with nitrogen.

6.11.4 It should be recognised that packaging requirements at the more sophisticated end of the range may represent to some extent a compromise between requirements for the avoidance of different types of deteriorative reaction. For instance, a very high degree of dehydration has advantages in the avoidance of sugar amino reaction whereas a little water in the product has significant anti-oxidant properties.

6.11.5 At the less sophisticated end of the range of dehydrated products other factors are considerably more relevant to acceptability and losses. Although in some developing countries, such as parts of East Africa the problem is not serious, in others, such as in the Lake Chad area for instance, losses due to insect attack are enormous. It is known that adequate control of bacterial spoilage during the early stages of drying, and prior to drying, can reduce subsequent attack considerably, but undoubtedly a major contribution to the avoidance of losses of this nature in simpler dried fish produce could be made by further developmental work on packaging.

6.11.6 Quality at reconstitution is important in many dried products. In part it is affected by carbonyl-amino reactions; and hence, for instance, control of copper concentration of salt used in processing is indicated. More important in many instances, however, is the control of protein 'denaturation' and aggregation reactions during processing and storage, particularly by adequate attention to temperature at critical moisture concentrations.

6.11.7 While it is commonly accepted that excessively high temperatures can damage protein during processing in terms of nutritional quality in addition to 'organoleptic' quality, there is currently less agreement on the relevance of such reactions to the production and storage of dried fish at lower temperatures. In the author's view the known patterns of variation in concentration of basic reactants are such that wide variations in practical performance of a limited range of products are to be avoided. However, such considerations are of considerable significance to the rational exploitation of the fishery resource in the context of the Protein Gap. While they may not be immediate relevance to marketability for the human population in the current situation it is ironic that fish meal is sold increasingly on nutritional quality.

7 SMOKING(67,68,69,70,71,72,73,74)

7.1 Discussion of fish drying must of necessity include some reference to smoking, since, even in the mildest of smoke during drying plays a key part in the process particularly at the surface. More commonly in the process the physical removal of water and an associated salting or brining both contribute together with the deposition of smoke constituents to preservation overall.

7.2 General considerations of drying and salting have been introduced above. In the smoking process, pre-salted material is dried in the presence of a complex system of gases and particles being deposited

on the fish differentailly The degree of salting varies according to the keeping qualities desired. While 'hard' cures are less marketable in western countries than formerly, they are still of interest to countries with limited resources of transport and refrigeration.

7.3 A considerable volume of physical and chemical work on wood smoke has been carried out, and this has combined with some excellent developmental work in the production of improved kilns. However, in many countries the pattern of the operation has changed little over the centuries. In many situations the open fire, or the simplest of stacks is still found.

7.4 It is commonly understood in Western countries that the production of 'quality' smoked fish, as demanded by their markets, requires fresh fish, handled carefully; However, in many African countries, for instance, the smoking of spoiling fish to avoid complete loss, is a common place; and the product is readily marketable. Thus a wide range of dry-smoked products is found in practice in terms of flavour. Methods of preparation vary widely also, but in general, fish are split prior to salting and smoking. Salting is carried out either in brine or with dry salt as described above.

7.5 Smoking processes *per se* can be divided into two main groups. In the 'cold' smoked products such as 'kippers' temperatures do not exceed 30°C whereas the hot smoked products such as kieler spratten employ smoke temperatures as high as 100°C or above. The flesh of the latter is cooked whereas that of the cold smoked products remains essentially uncooked below the surface. Moisture loss varies according to the product; kippers commonly lose 15 - 20 per cent during smoking; but in the production of some hot-smoked products, a preliminary drying at lower temperature is carried out before smoking, to lower moisture by 20 per cent. This prevents over softening during the subsequent cooking in the kiln.

7.6 The fish are hung in a kiln for smoking, either directly or on a movable trolley. The type of wood used varies according to the species being processed. In general, however, the flavour of the product depends more on the quantity of smoke applied rather than the wood. A number of automatic or semi-automatic smoke producers have been developed.

7.7 In general, kilns are of two types: 'chimney' and 'mechanical'. The first of these varies widely in design, and operation is an art insofar as factors such as airflow, temperature and humidity are difficult to control. The positions of the fish in the kiln are changed repeatedly in an attempt to ensure a measure of uniformity in the product.

7.8 Many industrial producers of smoked fish employ mechanical kilns controlling key variables such as rate of smoke production, temperature, airflow and humidity. Most operate batchwise, although attempts have been made to develop continuous systems.

7.9 Reference should be made also to smoke concentrates and dips. In the use of these the fish is first dipped in the concentrate and then dried conventionally.

7.10 The marketing of particularly, lightly cured smoked products can present difficulties in that the preservative actions of the smoke constituents and salt are of limited value in a situation where recontamination with a spoilage microflora can take place rapidly. Obviously ice cannot be used as a preservative and that of alternative refrigeration is indicated. Smoked fish can, if necessary, be cold stored, but for countries without an adequate refrigeration chain the continued use of traditional hot smoking techniques, possible modified as appropriate, is preferred.

REFERENCES

1. Jul, M. in 'Fish as Food' Edit. by G. Borgstrom. Academic Press: New York and London. Vol. 4, p. 437, 1965.
2. Jones, N. R. F.A.O. Technical Conference on the Freezing and Irridation of Fish. Madrid 1967. Paper TFI 67/R/3.
3. Ranken, M. B. F. Ibid. Paper TFI 67/R/12.
4. Merritt, J. H. 'Refrigeration on Fishing Vessels'. Fishing News (Books) Ltd. London, 1969.
5. Chupakhin, V. and Tormenko, V. 'Fish Processing Equipment'. MIR Publishers: Moscow, undated.
6. Villiers, A. 'The Quest of the Schooner Argus', Scribner: New York, 1951.
7. Heen, E. F.A.O. Technical Conference on the Freezing and Irradiation of Fish, Madrid, 1967, Paper TFI/67/R/5.
8. Jones, N. R. UNIDO Expert Group Meeting on the Problems of Preservation and Refrigeration of Food in Developing Countries, Vienna, 1969. Paper ID/WG 28/7.
9. Jones, N. R. O.E.C.D. Meeting on Fish Technology, Scheveningen, 1965.
10. Merritt, J. H. in 'Fish Quality at Sea'. Grampian Press; London, p. 24, 1966.
11. Roach, S. W., Harrison, J. S. M., Tarr, H. L. A., MacCallum, W. A., Chan, M. S. and Lanz, A. W. Fish Res. Bd. Canada Bull. 126, 1961
12. Peters, J. A., Slavin, J. W., [illegible] and [illegible]aker, [illegible] O.E.C.D. Meeting on Fish Technology, Scheveningen, [illegible].
13. Jones, N. R. in 'Fish Quality at Sea'. Grampian Press: London, p. 81, 1966.
14. F.A.O. Technical Conference on the Freezing and Irradiation of Fish, Madrid 1967. Reported by [illegible] (Edit.) in 'Freezing and Irradiation of Fish'. Fishing News (Books) Ltd.: London, [illegible].
15. UNIDO Expert Group Meeting on the Problems of Preservation and Refrigeration of Food in Developing Countries, Vienna, [illegible].
16. 'Fish Quality at Sea' Grampian Press: London, [illegible].
17. Breyer, F., Wagner, [illegible] and [illegible], [illegible] F.A.O. Technical Conference on the Freezing and Irradiation of Fish Madrid, 1967. Paper TFI/67/[illegible]/28.
18. Rasmusen, [illegible] in 'Freezing and Irradiation of Fish'. Fishing News (BOOKS) Ltd.: London, p. [illegible], [illegible].
19. Merritt, J. H. F.A.O. Technical Conference on the Freezing and Irradiation of Fish, Madrid, 1967. Paper TFI/67/R/4.
20. Crepey, J. R. and [illegible], Ibid. TFI/67/[illegible]/[illegible].
21. MacCallum, W. A. and Sepic, K. Ibid. TFI/67/R/[illegible].
22. Voskresensky, N. A. in 'Fish as Food' Edit. by G. Borgstrom. Academic Press: London and New York, Vol. 3. p. 107, 1965.
23. Van Veen, A. G. Adv. Food Res. 4, 209, 1962.

24. Van Veen, A. G. in 'Fish as Food', Edit. by G. Borgstrom. Academic Press: London and New York, Vol. 3, p. 227, 1965.

25. Hamm, W. S. and Clague, J. A. U.S. Fish. Wildlife Service. Res. Rept. 24, 1950.

26. [illegible]yenco, [illegible], Rodriguez, P. and [illegible], [illegible] Philippine J. Fisheries, 2, 85, 1953.

27. Martin, C. and Silit, J. [illegible] Proc. F.A.O. Indo-Pacific Fisheries Council Quezon City. Rept. Philippines [illegible], 11, [illegible]

28. Martin, C. and Silit J. [illegible] Philippine [illegible] Fisheries, [illegible], [illegible]

29. Westenberg, [illegible] Inst. [illegible], [illegible], 1941.

30. Rose, E. Bull, econ. Indo [illegible], [illegible], 1918.

31. Lafont, [illegible] Ibid. [illegible]

32. Truong Van [illegible] Ind. Conser[illegible], [illegible], 1951.

33. Ngo [illegible] Thank. Proc. [illegible] Bangkok 1957, 5, 139.

34. Sparre, [illegible] in 'Fish [illegible]', [illegible] Borgstrom. Academic Press: London and New York [illegible]

35. Okada, [illegible] F.A.O. Technical Conference on the Freezing and Irradiation of Fish, Madrid, 1967, Paper [illegible]

36. Ikeuchi, [illegible] and Shimizu, [illegible] Bull. Jap. Soc. Sci. Fish, [illegible], [illegible], 157, 258, 196[illegible]

37. Migita, M. and Okada, M. [illegible] Fish [illegible], [illegible], 21, 1963

38. Amano, K in 'Fish as Food' Edit. by G. Borgstrom. Academic Press: New York and London, Vol. 3, [illegible]

39. Yokoseki, M. Bull. Jap. Soc. Sci. Fish. 23, 53[illegible], 1957.

40. Yokoseki, M. Ibid. [illegible], [illegible], [illegible]

41. Shimizu, Y. [illegible] Ibid. 20, 209, 1954.

42. Amano, K. and [illegible], [illegible] Paper presented to Ann. Meeting of Jap. Soc. Sci. Fish, 19[illegible]: Quoted by Amano, K. (ref. 38 above).

43. Van Klaveren, F. W. and Legendre, [illegible] in 'Fish as Food' Edit. by G. Borgstrom. Academic Press: New York and London, Vol. 3, p. 133, 1965.

44. Jarvis, N. [illegible] U.S. Fish. and Wildlife Service Rept. 1[illegible], 1950.

45. Cole, [illegible] and Greenwood-[illegible], L. [illegible] Tropical Science, 7, 165, 1965.

46. Cutting, C. L. 'Fish Saving'. 'A History of Fish Processing from Ancient to Modern Times'. Leonard Hill, London, [illegible].

47. Murata, K. and [illegible], [illegible] Bull, Jap. Soc. Sci. Fish 19, 579, 1953.

48. Rulev, I. E. Rybnoe Khoz. 34, [illegible], [illegible], 1958.

49. Arnesen, G. Aegir, 47 [illegible], [illegible], 1954.

50. Fougere, H. Fish Res. Bd. Canada Rept. Atl. Coast St. 52, 15, 1952.

51. Legendre, [illegible] J. Fish Res. Bd. Canada, 15, 543, 1958.

52. Jason, A. C. in 'Fish as Food', Edit. by G. Borgstrom. Academic Press: New York and London, Vol. 3. p. 1, 1965.

53. Hanson, S. W. F. 'The Accelerated Freeze Drying (AFD) Method of Food Preservation'. H.M. Stationery Office: London, 1961.

54. Maruchi, [illegible] and Hino, Y. Bull. Jap. Soc. Sci. Fish. 23, 320, 1957

55. Linton, E. P. and Wood, [illegible] J. Fish Res. Bd. Canada, 6, 380, 1945.

56. Tressler, [illegible] K. in 'Marine Products of Commerce' Edit. by D. K. Tressler, Chemical Catalog Co.: New York, [illegible]

57. Cutting, C. L., Reay, [illegible] and Shewan, J. M. 'Dehydration of Fish'. Dept. Sci. Ind. Res. Spec. Report. 62. H. M. Stationery Office: London, 1956.

58. Townsend, [illegible] S. 'Improvements relating to fish foods'. British Patent No. 1[illegible]7, [illegible], 1922. London.

59. Platt, [illegible] and Heard, C. R. [illegible] 'Improvements in and relating to the treatment for preservation and storage of vegetable and other edible material. Brit. Pat. No. 528,611. London.

60. Lovern, J. A. Advances in Chemistry, 57, 37, 1966.

61. Hay, J. M. J. Sci. Fd. Agric. 6, 43[illegible], 1955.

62. Connell, J. J. in 'Fundamental Aspects of the Dehydration of Foodstuffs'. Soc. Chem. Ind.: London, p. 167, 1959.

63. Jason, A. C. Ibid. p. 1[illegible].

64. Jones, N. R. 'Non Enzymic Browning Reactions in Foods'. C.R. Comm. Tech. Sucrerie London p. 17[illegible].

65. Jones, N. R. Nature, London 174, 605, 1954

66. Dalgleish J. H. and Thompson, H. P. Prov. Brit. Pat. 27044/58.

67. Cutting, C. L. in 'Fish as Food', Edit. by G. Borgstrom. Academic Press: New York and London, Vol. 3, p. 55.

68. Cutting, C. L. 'The Torry Research Station Controlled Fish Smoking Kiln'. Dept. Sci. Ind. Res. Food Invest Leaflet No. 1[illegible], London

69. Anderson, C. L. and Peterson, [illegible] in 'Marine Products of Commerce. Edit. by D. K. Tressler and J. M. Lemon. Reinhold: New York, 2nd Edit. p. 394. 1948.

70. Bramsnaes, F. and Peterson, [illegible] in 'The Technology of Herring Utilisation'. Edit. by M. Jul and M. Kondrup. Greig: Bergen, p. 266, 1953.

71. Linton, E. P. and Wood, A. L. Fish Res. Bd. Can. Prog. Repts. Atl. Coast Stas. 34, 10. 1944.

72. Nicol, D. L. Improvements in and relating to the production of smoke. British Patent No. 781, 591, London 1957.

73. Shewan, J. M. Chem. and Ind. (London), 501, 1949.

74. Tilgner, D. J. Food [illegible], 32, [illegible].

25. I. 72