

DRYING OF FISH - FACTORS TO CONSIDER

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ABSTRACT

Although one of the best possibilities for raising the animal protein of the diets of Nigerians is to increase the consumption of fish; particularly through the use of several methods of long term preservation techniques, such as drying, no radical approach has yet emerged. Although, a great deal of the artisanal fish catch is dried for the huge consumer and distant markets, the traditional methods of fish preservation need improvements to cope with demand for increased quantity, shelf-stable, and improved quality of fish products. There is therefore, a great need to structurally transform the mode of fish drying.

The paper discusses drying requirements, heat and mass transfer, consumer acceptance, fuel sources, storage and marketing of dried fish products; and suggest ways and means of structurally transforming the artisanal technology of fish drying.

INTRODUCTION

Fish Resources of Nigeria

The major proportion of landed fish in Nigeria is by the artisanal sector (Talabi, 1977). According to a recent study (Uboma et al, 1981), the average yearly total domestic fish production between 1971 and 1980 was 486,747 metric tonnes (mt). This figure represented production from coastal and blackish water (55.5%, rivers (28.4%) and lakes and ponds (13.9%); all of which accounted for 97.8% of the total fish catch. Inshore fishing (industrial) represented only 2.2%. However, not much seems to be known about the proportion of this catch which is actually preserved either by drying or smoking.

The growth rate of the various subsector of fisheries (Mabawonku, 1981) are:-

Artisanal:

- a) coastal and blackish water, 3.2%
- b) inland rivers and lakes, 2.7%

Industrial (Commercial Trawlers)

- a) coastal fishing, 9.18%
- b) coastal shrimping, 6.82%

The total average annual growth rate is therefore 5.5%. The average estimated fish production (mt) from Kainji Lake, Lake Chad and rivers and reservoirs are 11,000 40,000 and 130,000 respectively.

It is also estimated that fish represents about 40% of Nigeria's animal protein resources (Uboma et al, 1981). It is clear, therefore, that fish production and processing could play a significant role in meeting the protein needs of Nigerians.

Nigeria imported on the average about 200,000 mt of fish annually between 1971 and 1978. Infact, fish imports rose from 54,416 mt in 1971 to 218,000 mt in 1978 at a rate of 300%. The estimated fish consumption (mt) is shown in Table 1.

Table 1 - Fish consumption in Nigeria

Year	Projected Estimate x 1000 (mt)
1980	993.2
1981	1037.8
1982	1084.6
1983	1133.4
1984	1184.4
1985	1237.7

Source: Federal Department of Fisheries (Mabawonku, 1983)

The level of fish consumption shown above is based on the assumption of:

- (a) an income elasticity of demand for fish of 1.0;
- (b) 2.5% rate of population growth, and
- (c) 2.0% rate of growth of real income.

To what extent Nigeria can meet this huge protein demand will greatly depend on her ability to reduce the massive post-harvest losses of fish through a deliberate and conscious application of science and technology by way of upgrading the artisanal sector of the fisheries industry.

Fish Handling in Nigeria

The marketing of fish includes two broad systems:-

- (a) the modern chain distribution system principally for imported frozen fish;
- (b) the traditional fish collection and distribution system.

The latter involves the collection, processing and transportation of fish from the canoe fishermen at remote production areas to the major consuming centres. At the retail level, fish are displayed in open shelves in the markets. This display method attracts flies and leads to rapid deterioration of the product. There is therefore, considerable amount of spoilage through autolysis, decomposition, insect infestation and such losses are estimated as between 20 and 60% depending on season and location. To reduce such huge losses, and preserve fish, artisanal fishermen and their families engage in either, smoke drying or sun-drying of fish.

Smoked fish form the bulk of the retailed fish products. It is estimated that 95% of the total artisanal landings are smoked or sun-dried. The smoking is carried out at different stages of the distribution chain. In majority of cases, the fish is smoked in

the fishing settlements by the fishermen's wives or family. Smoking is also done by wholesalers and even at retail levels. In areas close to fishing settlements, the fish is light-smoked or semi-dried. In the hinterland, hard smoked fish predominate which have longer shelf-life but command higher prices than the semi-dried or lightly smoked ones.

In the northern drier parts of the country, solar drying has been very important because:

- (1) the relative humidity is low; and
- (2) wood as a source of heat smoke is relatively scarce and expensive.

A great deal of the fish landed in the Lake Chad shores, are sun-dried but with associated problems. Traditional sun-drying of fish as practiced, is relatively slow, and because fish is highly perishable, losses through spoilage are high and products are not uniformly dried. Another major problem encountered with open-air sun-drying is fly infestation. In the absence of intense sunlight maggots develop and cause disintegration of the fish. Eggs laid on exposed fish could hatch and cause damage to the products during subsequent storage (Capiro, 1982). Handling the materials during unexpected rains presents another problem. To alleviate such problems there is need for controlled procedures and appropriate equipment to ensure the maximum yield of sun-dried fish with a satisfactory storage life.

Post-Harvest Fish Losses

Food wastage from the farm level to the "dinner table" has been recognised as a significant constraint in achieving the much desired self-sufficiency in food and fibre production in Nigeria (Akinrele, 1977). Efforts to quantify the magnitude of such losses have encountered difficulties; both in definition and in magnitude. Losses of fish foods post-harvest have been estimated as 50%, at least in the Lake Chad area of Borno State. Much of the existing catch is either under utilized, malused or misused; leading to considerable wastage after capture. Microbial spoilage represents the most serious loss of wet fish. Further serious problems can also arise from contamination by pathogenic microorganisms.

Although technologies for control of spoilage of fish are well established, Nigeria has been unable to apply such technologies. Substantial spoilage losses also occur in processed (smoked, and sun-dried) products. Problems arise particularly in the dried fish industry as practised by artisanal fishermen. The problems include microbiological and lipid oxidation, leading to off-flavours and poor storage stabilities. Dried fish represent a significant source of low-cost protein among Nigerian consumers. There is also the problem of large scale insect infestation as a result of inadequate drying, poor handling and inadequate packaging, storage and retail. Losses as high as 50% are reported for dried-fish products.

Optimal Handling of Fish

Fish is a notoriously perishable commodity (Jones and Disney, 1977). In the tropics, at ambient temperatures, spoilage is rapid, occurring within 24 hrs. Tropical fish often spoil more rapidly than cold water fish. Freezing of fish or the iced distribution of fish for the internal markets has become widely practiced and holds much prospects in Nigeria. Canning has also been successfully applied to fish processing in many countries, and canned fish products abound in Nigerian markets. However, canning, freezing and icing, which are simple and relatively cheap methods of preserving fish in Europe and North America, are generally too expensive to adopt in Nigeria for

various reasons. On the other hand, socio-cultural as well as conservative attitudes regarding consumers acceptance of frozen or canned fish should be considered.

The drying of fish, using the sun's thermal energy or wood fuel as means of preservation, have been carried out for centuries throughout the world in general and in Nigeria in particular. Fish drying has therefore, become very popular in Nigeria (Mabawonku, et al, 1982) because it is within the socio-economic levels of the fishermen and also a meaningful technological input. Above all, there is an insatiable market for dried fish products in Nigeria (Mabawonku et. al, 1982). Nevertheless, consumers are interested in the characteristics of fish processed. In relation to that is the fact that there are various species of fish sold in the Nigerian market and each has different characteristics. A particular consumer will purchase fish in relation to the distinct characteristic which that consumer attaches to what he buys.

Unfortunately however, fish drying as a technology has not improved in Nigeria due to several factors; some of which are related to the level of technological developments within the artisanal subsector of the conomy. Two major phenomenon have taken place in Nigerian fisheries in the last two decades. The first began with the modernization of the fishing boats, the increase in the number of inshore fishing vessels, and the growth of refrigerated or frozen fishes in the market, all within the industrial sector of the fishing industry. However, no radical change has taken place as far as preservation of fish by drying is concerned. Fish processing by drying is not standardized and there is a wide variation in quality.

Processed fish products in the markets include salted-dried; unsalted-dried/half salted; unsalted-smoke-dried/salted smoke-dried; sun-dried (salted/unsalted) and fermented dried. Given the array of dried fish products on the market, one would hope that given the dynamic and growing economy of Nigeria, consumers attitudes could greatly influence the type and quality of dried fish available on the market. This could then lead both to a change in techniques of product processing and product delivery as well as to changes in consumers preferences.

Studies of consumers preferences and attitudes to dried fish should aid in the improvement of the technology of fish drying such as:-

- (1) buyers preferences,
- (2) reasons for those preferences,
- (3) the quality of the dried fish and their shelf life, and
- (4) constraints in selling and suggestions for product quality improvements.

Such information is required to guide the development of improved processing and drying technology. There is also a need for a marketing survey to identify important characteristics for marketing dried fish; regarding salt content, species of fish, and storage life including packaging.

Technology of Fish Dehydration

Fish drying has become more of a science than an art, considering the present-day technological development in drying as a science. Drying in food is referred to as the removal of moisture so that environment is unfavourable for the development of moulds and bacteria (Hall, 1957). It is therefore, to minimize the chances of spoilage by microbial action. The problems facing fish drying

in Nigeria include the low level of technological development in the science and art of moisture removal to conserve fish resources and produce qualitative dried products.

Drying of Fish

Drying and smoking are widely used in fish preservation. In the process of drying and smoking, much of the moisture content of the fish is extracted through heat, thus inhibiting the action of the microorganisms and prolonging shelf life. Furthermore, the fish while being smoked becomes impregnated with wood smoke, and is thus given a distinctive flavour and becomes less liable to spoilage, since many components of the wood smoke act as antiseptics.

Depending on the type of contact of moisture with the product, we may distinguish surface moisture which clings to the body of the fish by adhesion, capillary moisture which fills up the pores of the colloidal particles, and moisture which is chemically linked with the cells of the fish. In the process of drying and smoking, practically all the surface and capillary moisture is extracted from the fish. According to the principle by which heat is applied, drying installations may be divided into atmospheric dryers, vacuum dryers and special dryers in which the product is exposed to high frequency currents and infra-red rays. Similarly, smoking installations may be divided into cold-smoking plant (with temperature not exceeding 40°C) and hot-smoking plant (with temperature between 80 and 140°C).

In the course of drying and smoking, the amount of absolutely dry matter remains constant (provided there are no mechanical and other losses) and may be expressed by the formula:

$$Gd = \frac{G_1}{100} (100 - W^1) = \frac{G_2}{100} (100 - W^2)$$

Where G_1 = amount of moist material admitted to the dry and smoking installation, kg/hr.

G_2 = amount of dehydrated material, kg/hr.

Gd = amount of absolutely dry matter in the dehydrated material kg/hr.

W^1, W^2 are respectively, the moisture contents of the material before and after drying, %.

The amount of moisture extracted during drying and smoking is
 $W = G_1 - G_2$

The amount of moisture extracted in relation to 1kg of moist material can be expressed as:

$$W = G_1 \frac{W - W^2}{100 - W^2}; \text{ similarly the amount of moisture extracted}$$

in relation to 1kg of dehydrated material can be expressed as:

$$W = G_2 \frac{W^1 - W^2}{100 - W^1}$$

Allowing for losses in the drying and smoking installations, the yield of the finished product may be determined from the formula:

$$G_2 = EG_1 \frac{100 - W^1}{100 - W^2}, \text{ where } E \text{ is the coefficient of}$$

conservation of the product. E equals 0.98 for drying and 0.97 - 0.99 for smoking.

Drying, either without or after salting and with or without smoking is a widely accepted traditional practice of preserving fish. Salting, smoking and drying are processes that can be employed with the minimum of equipment and operated by semi or unskilled workers. However, as "pressures" mount to seek new ways and means of improving the animal protein intake by Nigerians, it has become imperative to "advance" the processes of fish drying from minimum equipment to maximum equipment and from semi-skilled to skilled workers. The quality of life of the fisherman and his family also adds urgency to the need to improve the returns on his hazardous labour, through the infusion of the relevant technology.

Evidence of both social and structural transformation of the Nigerian society can now be found not only in the advances in the techniques of production; but more especially in the areas of urbanization, commercialization of the economy and the demand for high quality products by Nigerian consumers. In the area of fish processing, the traditional methods of fish preservation, (smoking/drying, salting or sun-drying) need improvements or should be modernized to cope with the increasing consumer and national demand for fish products.

The improvements required include increased quantity, shelf-stable and improved quality of preserved fish products. Technological innovation (the scientific study of a practical art) in the drying of fish holds much prospect; but who initiates, prosecutes or executes such innovation? Should the innovation originate from Government, the industrial sector of fishery industry or the artisanal fishermen? My thesis is that it will be unrealistic to expect technological innovation alone to contribute a decisive input; coming from the artisanal subsector. Any effective action to upgrade the technology of fish drying must be taken by governments, their agencies, private enterprise or industry; action which should lead to a structural transformation of the "practical art" of fish preservation.

"The Nigerian Fishery Industry has developed into a mere fish importer or shore based frozen fish-handling institution with little or no plans for upgrading its role into a manufacturing industry as a means of qualitatively and quantitatively improving its outputs" (Talabi, 1977). The artisanal subsector, which accounts for about 98% of the total fish catch is totally incapable of upgrading the quality of processed dried fish and fish products. Herein lies the dilemma facing the fishery industry. Prospects of the Nigerian Fisheries in the Eighties" lies in our ability to structurally transform the industry into a viable and enduring enterprise. However, this calls for a systematic series of studies specific on Nigerian fishes and which must be backed by the goodwill of government and other agencies charged with the destiny of this country. Meanwhile, some fundamental work need to be done on important "Nigerian" fishes.

AREAS OF WORK REQUIRING ATTENTION

a) Equilibrium Moisture Content

The isotherms of a number of Nigerian important species of fish, salt or fresh water varieties within the relative humidity range of 20 to 80% should be studied scientifically regarding the attainment of desired equilibrium moisture content (MCe). This is essential and fundamentally necessary.

b) Rate of Drying

As indicated earlier, the whole idea of fish drying is centered on the removal of sufficient moisture (free moisture) to ensure the preservation of the food material. The rate at which the free

moisture is removed from the product does not remain constant. Jason (1962) and Burgess et.al (1967) described the drying process as composed of the constant rate period where moisture is removed at uniform rate until it reaches a critical moisture (MCC) after which the rate of moisture removal decreases as the drying process enters a falling rate period. In the case of fish muscles, which initially have a water content of about 4 g/g of dry weight, the moisture evaporates at a constant rate until it falls to about 1 g/g of dry weight (Jason, 1962).

Henderson and Perry (1955) have described the free surface evaporation of moisture during the constant rate period in the equation:

$$1) \quad (dW/dt) = 4.39 \times 10^{-5} f_v A (P_s - P_a)$$

$$2) \quad = 0.4536 K_f A (t_s - t_a)/hfg$$

Where: (dW/dt) = drying rate, kg of water/hr;

f_v = water vapour transfer coefficient $\text{kg}/(\text{m} \cdot \text{m}^2 \text{kg}/\text{m}^2)$;

A = water surface area, m^2 ;

P_s = water vapour pressure at t_s , atm;

K_f = thermal conductance of air film, $\text{Kcal}/(\text{m} \cdot \text{m}^2 \text{ } ^\circ\text{C})$;

t_a = air temperature, $^\circ\text{C}$;

t_s = water temperature, wet bulb, $^\circ\text{C}$; and

hfg = latent heat of vaporization, Kcal/kg .

The mass migration equation (equation 1) describes the rate of drying as being dependent on the vapour pressure difference between the product surface and the bulk of air and on the mass transfer coefficient. The constant rate of drying may also be evaluated in terms of the heat transferred to the product to evaporate the surface moisture (equation 2).

Usually, at the end of the constant drying rate, the hygroscopic material has reached the critical moisture content that can sustain a uniform rate of flow of free water to the surface which is equal to the maximum rate of water vapour removal from the surface (Capio, 1982). The moisture diffusion within the fish decreases below that needed to replenish the moisture at the surface, and as such, the rate of moisture removal from the product slows. The falling rate period is largely controlled by the movement of moisture within the material to the surface by liquid diffusion and removal of moisture from the surface (Hall, 1957).

The drying rate at this stage may be described by the Fick's law of diffusion:

$$3) \quad (dMC/dt) = DL(S \quad 2MC/S \quad x^2)$$

Where: DL = liquid phase diffusion coefficient applicable for movement through the solid phase, m^2/hr ;

MC = moisture content, dry basis;

t = time and

X = distance along travel of moisture, m

The foregoing has important practical applications for us. The equations are of practical value in that for the drying of fish to be efficiently carried out, we need to determine the drying constant for the different species of fish of commercial value.

One cannot therefore, over emphasise the importance of scientific appraisal in the much needed upgraded large scale commercial drying required today and in the decades ahead, to be able to exploit our fish resources.

c) Design of Suitable Equipment

Dehydration is defined as "drying under controlled conditions of temperature and humidity to a specific end point in a given time" (Parker et al, 1954). There are several means of drying fish products; the most important of which is air convection dryers since they are relatively simple to operate and are expensive. The work done at the Nigerian Institute of Oceanography and Marine Research (NIOMR), Lagos, which lead to the design and development of a smoking kiln is in the right direction. This effort should however, be seen as only setting the stage for a greater task ahead if Nigeria is to be able to improve the quality of dried fish available to consumers.

Consequently, this calls for a radical approach which can lead to a structural transformation of the erstwhile backward primitive technologies practised by artisanal fishermen to the application of modern techniques of fish dehydration. Such a radical approach should lead to:-

- (i) The development of smoking kilns which stress simplicity, low cost with some measure of control of the main variables in smoking - smoke quality, volume, air velocity, temperature and humidity;
- (ii) The introduction of dryers which are simple to construct, operate and maintain; made of local material, acceptable to the users, cost effective and capable of drying a variety of commodities;
- (iii) the evolution of shorter-time smoking procedures vis-a-vis savings in wood and fuel;
- (iv) Development of adequate salting as per species of fish;
- (v) Evaluation of consumer attitudinal preferences for processed fish products and their keeping quality;
- (vi) Evaluation of the chemical, nutritional, toxicological, flavour and colour qualities of smoke dried, dried, and sun-dried fish products; and
- (vii) Evaluation of the best procedures/methods of packaging, marketing and storage of heat preserved fish and fish products.

The realisation of the set objectives calls for a multi-disciplinary and team approach to drying as a technology. The steps that should be taken in the development of a drying system include:

- (i) cooperation between the Engineer and the Food Scientist/Technologist to determine the quantity and nature of the fish product to be dried and specific consumer requirements;
- (ii) determine drying requirements, heat and mass transfer phenomena and fuel sources. Following the development of drying equipment, the Home Economist could begin consumer-acceptance testing, while the Food Scientist looks at product quality, storage and packaging.

Such a team approach with interactive feedback is then used in prototype modification until the prototype is suitable for the drying of high-quality products acceptable to the consumer.

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