PDF - DEVELOPMENT OF A MODEL FOR THIN LAYER SOLAR DRYING OF SALTED FISH FILLETS - researchcub.info**ABSTRACT**

A batch type direct passive solar dryer was designed andfabricated to dry salted tilapia fish fillets. The dryer has a capacity acapacity of 1500g/batch. The tilapia fish species were obtained from DomitaFarms Nig. Ltd,.Uyo, Akwa Ibom State and transported immediately to Nsukka in acold storage container. The salted fish fillet was prepared to conform to thinlayer drying specification of 3.0mm-5.0mm thickness before drying. The solardrying experiments were conducted at the Department of Agricultural andBioresources Engineering, University of Nigeria, Nsukka. Nsukka is located onlatitude 6^{0}56 N and longitude 7^{0}25 E. and 397m above sealevel. The work was carried out as a factorial experiment with two factors intwo and three levels respectively arranged in a completely randomized design(CRD) with six treatments and ten replicates. The first factor was fish withtwo levels, descaled fish and fish with intact scale. The second factor wascommon salt (sodium chloride) (NaCl) having 0%, 10% and 20% concentrations. Thesamples when removed from refrigerated storage were allowed to equilibrate withthe ambient conditions before being prepared for solar drying. The fish werecharacterized to obtain its initial moisture content (M,% db),length(m),mass(g), crude protein(CP) (%), crude lipids (CL) (%), equilibrium moisturecontent (EQ) (%db) and ash (%). A total weight of 1200g/batch drawn from refrigeratedstorage were cleaned, eviscerated, heads removed, washed and filletedlongitudinally to expose the backbone in preparation for solar drying. The fishfillets were treated with salt (Nacl) to prevent spoilage by microorganisms andto dehydrate the fish thereby enhancing the drying process. The experimentaldrying data was fitted to 19 models and the quality of fit evaluated. Agood fit is indicated by a high coefficient of determination (R^2),low reduced chi- square (^{2}), standard error (Se) and mean relativedeviation modulus (P). Four out of the 19 models showed reasonable fit. Out ofthese four models, the Wang and Singh model was fairly good andtherefore was further modified and ran on a non linear regressionprogram (NLREG) which gave higher R^2, and lower ^{2} Seand P when compared with the original Wang and Singh model of the form MR = M ' +At +Bt^2. A is the initial drying constant; B isthe final drying constant, MR is the moisture ratio, M is a constant. A fairquality fit to the experimental data when modified yielded the new model. MR =M+ 0.048 $t^{0.8}$ + 0.067 $t^{0.76}$. For the newmodel R^2 varied between 0.9779 and 0.9989, Se varied between0.0014067 and 0.042528, ^{2} varied between 1.8495×10^{-6} and0.00189 and P varied between 0.0139 and 29.78% respectively.Thelength of tilapia fish was found to vary between 9cm and 13cm, weight variedbetween 50g and 100g.The proximate composition of tilapia fish were: initial moisture content (M_o) varied between 254.43 –293.13%(db), crude protein (CP) varied between 13.0 and 16.25%, crude lipids(CL) varied between 15.5 and 27.83% and ash between 14.74 and 16.16%,equilibrium moisture content (EQ) varied between 15-20% (wb). Drying kineticsof salted fish had moisture ratio (MR) varying between 0.022 – 1.0 at 10 %

saltconcentration, 0.0408 – 1.0 at 20% salt concentration. M_o wasbetween10.38 – 573.4 and 18.63 – 564.48 for 10% and 20% respectively. Fishfillets without salt treatment had MR varying between 0.020 – 1.0, M_o variedbetween 12.82 –564.89. Physico-chemical quality had the followingvalues microbial count (MC) varying between 0.6×10^4 -1.1×10^4 CFU/g(colony forming unit per gram),Fungal count (FC) varied between 0.7×103 –4.6×10^4 CFU/g, total volatile basic nitrogen (TVBN) varied between12.0 –20.7 mg N/100g flesh (milligram nitrogen per 100g flesh). For fishfillets without salt treatment, MC varied between 0.7×10^4 -1.3×10^4,FCvaried between 0.9×10^3 – 2.8×10^3,TVBN was between 29-50.TVBN for control was above 30.0. Specific solar radiation available variedbetween 32.53 - 37.70MJ/m^2.

CHAPTER ONE

INTRODUCTION

1. 1 GENERAL BACKGROUND OF RESEARCH

Fish is one of the most diverse groups of animals known to manwith more than 20,500 species in existence (Lagler *et al*.1977) asreferenced by Eyo (2001).These species consist of teleost or the bonyfishes (20,000 species) and the elasmobranchii or cartilaginous fishes (500species). The bony fishes are of two types, the pelagic and demersals.The pelagic are the shoal moving fatty fishes such as sardines, mackerel,bonga, herring, tuna etc which move at the surface of the water bodies. Thedemersals dwell at the bottom of the water bodies with less than five percentfat in their tissues. Examples of demersals are cod, haddock and croakersamongst others.

Fish is highly perishable especially in the tropicaltemperature and needs to be preserved for long term storage. Soon afterharvest; the fish dies and begins to spoil. In a healthy fish, all the complexbiochemical reactions are balanced and the fish flesh is sterile. After deathhowever, irreversible changes begin to occur resulting in fish spoilage. Theresultant effect is the decomposition of the fish (Akinola et al. 2006). A lotof factors are responsible for fish spoilage. Some of these factors are thefish health status, the presence of parasites, bruises, and wounds on the skinand mode by which fish was captured. The caught fish quality depends on thehandling and preservation, the fish received from the hands of fishers aftercapture (Akinneye et al. 2007).The handling and preservation practice aftercapture affects the degree of the spoilage. Wrong fishing method does notonly cause mechanical damage to the fish but also creates stress and theconditions which accelerates fish deterioration after death (Okonta andEkelemu, 2005). The less developed countries capture 50% of theworld's harvest and a large proportion of this is consumed internally(FAO,1999) as referenced by Eyo (2001) .In some Asian countries more than50% of the animal protein intake comes from fish whereas in Africathe proportion is 17.5% (Willman *et al.*1998). Here inNigeria fish contributes about 40% of animal protein intake (Olatunde,1989) asreferenced by Eyo (2001). The implication of this fact is that any shortfall infish availability will affect the animal protein intake of people in tropicalcountries.

1.1.1 IMPORTANCE OF FISH

The uses of fish are so enormous in practice such that it isenumerated as follows.

USE OF FISH AS FOOD

Fish has long been recognised as a healthy food in manycountries of the World. Fish is one of the most abundant animal protein foodsavailable in the tropics. It is also rich in minerals and essential fattyacids, vitamins A and D and rich in iodine. Above all man can digest it easily.In Southern part of the World, fish is an essential part of their nutritionoften providing most, if not all their animal protein. In the North too,fish is considered a healthy food choice and is therefore in demand.Appropriate processing of fish enables maximal use of raw material andproduction of value added products which is obviously the basis of processingprofitability. The processing of fresh water fish like other food raw materialsshould ensure best possible quality; provide proper form of semi-processedfinal products. It should apply the most appropriate processing method andreduce wastes to the barest minimum

Fish for controlling diseases: Diseaseslike malaria, yellow fever and other dreadful diseases that are spread throughmosquitoes can be controlled. Larvivorous fish eat larva of mosquito. Theimportant larvivorous fish are Gambusia, Panchax, Haplochitus, Trichogaster,etc

Aesthetic value of fish: A large number of fishesare cultured in aquarium for their beauty and graceful movements. The importantaquarium fish are Macropodus, Trichogaster, Carassinus (gold fish) andPterophyllum (angel fish)

FISHERY BYE-PRODUCTS:

(a) Fish oil: The by-products obtainedduring the drying process include fish oil, which when taken, can help regulatecholesterol in the body. It can be extracted from the liver of the sharks,sawfishes, skates and rays and has medicinal value. These mainly include codliver oil and shark liver oil .There is a wide variety of delicious dishes thatcan be prepared from dry fish. Fish meal is a commercial productmade from both whole fish and the bones and offal from processed fish. It canbe used as protein concentrate animal feed. It is a brown powder or cakeobtained by pressing the whole fish or fish trimmings to remove the fish oil.Fish emulsion is a special kind of coat that is produced as a by-product.Example is the fertilizer emulsion that is produced from the fluid remains offish processed for fish oil and meal industrially. The emulsion is anticorrosive and has wide industrial usages as paints and coating.

(b) Fish manure: The fish waste after theextraction of oil, is used as fertilizers,

(c) Fish glue: It is a sticky product,obtained from the skin of the cod and is used as gum.

(d) Isinglass: It is a gelatinoussubstance, obtained from the air bladder of perches, Indian Salmons and catfish used in the preparation of special cement and in the clarification of wineand beer

(e) Shagreen: The skin of sharks andrays, which has pointed and sharp placoid scales are used in polishing the woodand other materials. It is also used for covering the jewellery boxes andswords,

(f) Leather: A highly durable type ofleather is prepared from the skin of sharks and rays,

(g) Artificial pearls: The silvery boney scalesof cypnmids (a type of fish) are used in the manufacture of artificial pearlsespecially in France.

h)**Fish meal :** Many fishes are dressed and cooked.Then they are dried. Fishes are made into fine powder. This is called fishmeal. It is used by weak and convalescent people.

i) **Fertilizers:** The 'fish waste' materials havemore calcium, protein, phosphorous and other substances. These materials areground into powder. It is used as fertilizer to Grape gardens, Coffee and Teaplants.

Fish harvesting, handling and distribution provide livelihoodfor millions of people as well as providing foreign exchange earning to manycountries. (Al-Jufaili and Opera, 2006).

j) **Employment:** Development of fishingindustry generates more employment opportu-nities.

k) Source of Income: The fishing industry hasbrought a lot of income to the farmers in particular and the country ingeneral. Now we can talk about "Blue Revolution" (fish production) on the samelines as 'Green Revolution' (for producing enough food for all).

1.1.2 IMPORTANCE OF FISH DRYING Drying basically dehydrates or removes the moisture f action inhibits the growth of bacteria, mold, and yeast. It also slows down the enzyme action wi them .This factor ensures that fish does not spoil easily and hence makes drying an effective technique. Since drying removes water from the fish, the weight of the fish is also reduced. Th lighter and also shrinks in size.

1.1.3 IMPORTANCE OF THIN LAYER DRYING AND PRETREATMENT OF FISHWITH SALT.

Thin layer drying is a process of drying of individual particlesor grains of material which are fully exposed to the drying air. In thin layerdrying, the product thickness is sufficiently small such that the air flowcharacteristics, humidity and temperature is considered uniform at a givensection parallel to the product. The process is often divided into two periodsof drying: (1) the constant drying rate period and (2) the falling drying rateperiod. Radiation, conduction or convection provides the energy needed fordrying.

It has been observed that fish is a highly perishable foodmaterial especially when solar drying is considered. Since equilibrium moisturecontent is likely to be achieved in solar drying after several hours ascompared to drying with firewood, natural gas or electricity, pre-treatment isoften recommended. The pre-treatment with salt helps to preserve the quality offish until equilibrium moisture content is achieved. Thepre-treatment is able to accomplish this task by decreasing wateractivity in the fish, inhibits the growth of micro organisms by drawing outwater from their tissues through osmosis.

1.1.4 IMPORTANCE OF MODELING

Modelingis a process of providing a representation of the construction and working ofsome system of interest. A model is often simpler than the system itrepresents. The main purpose of a model is to enable the analyst to predict theeffect of changes to the system. A model should be a close approximation to thereal system and incorporate most of the salient features. It should besimple and easy to experiment. Simulation practitioners recommend increasingthe complexity of a model iteratively. Simulation is a tool to evaluate theperformance of existing or proposed model under different configurations ofinterest over long periods of real time. A simulation of a system is theoperation of a model of the system. Model can be reconfigured and experimentedwith, usually this is impossible, too expensive or impractical to do in thereal system it represents.

Advantages of Simulation Modeling: Whensimulation modeling is properly applied to a system under study, the followingadvantages are obtained.

i) A better understanding of the system by developing amathematical model of a system of interest and observing the systems operationin detail over long periods of time.

ii) Test the hypotheses about the system for feasibility.

iii) Compress time to observe certain phenomena over longperiods or expand time to observe a complex phenomenon in detail.

iv) Study the effect of certain informational, organizational,environmental and policy changes on the operation of a system by altering thesystems model.

v) Experiment with new or unknown situations about which onlyweak information is available.

vi) Identify the “driving” variable –one that performancemeasures or most sensitive to and the inter –relationship among them.

vii) Identify bottlenecks in the flow of entities (materials,people, etc) or information.

viii) Use multiple performance matrices for analyzing systemconfigurations

ix) Employ systems approach to problem solving.

x) Develop well designed and robust systems and reduce systemdevelopment time.

1.2 STATEMENT OF PROBLEM

In the past, various researches have been conducted on fishdrying using various methods. These include the use of conventional fossil fuelenergy sources, solar and a combination of them for drying fish. In most casesit makes the final cost of the fish prohibitory and unaffordable whereas inother cases spoilage may result. Due to this high cost coupled with unavailable/ epileptic power supply of the energy during drying some farmers resorted tosun drying .This method too has their attendant shortcoming. Some of theproblems of sun drying include attack by rodents and insects; success alsodepends on the weather condition which is beyond the control of the fishfarmer. Solar dryer therefore becomes a suitable alternative for farmers whocould not afford to dry their products using conventional energy sources withits attendant benefits. Having known that tilapia fish can be dried inthin layer in a solar dryer effectively and having found that nothin layer drying model exist for tilapia fish fillets, this research wasconceived to bridge the gap in knowledge.

1.3 JUSTIFICATION

The purpose ofmodelling is to allow engineers to choose the most appropriate method of dryingfor a given product as well as to choose suitable operating conditions.Moreover, full scale experimentation for different products and system configurationsis sometimes costly and not possible; hence the prediction of drying kineticsof specific crops under various conditions is very useful in the design andoptimization of dryers. The results of the research will provide a procedurefor selecting optimum solar drying conditions that would guarantee theretention of desirable qualities of tilapia fish after drying. The work willenable accurate prediction of drying rates and drying times thereby help aprocessor map out a schedule for drying a known or anticipated quantity oftilapia fish. The results from the research will provide invaluable industrialinformation, which have hitherto been unavailable, for energy efficient andhigh –quality drying of tilapia fish. The results from the research willprovide information on the equilibrium moisture content of tilapia fish atprevailing temperature and relative humidity which are useful in designingefficient solar dryers. From the standpoint of processing, preservation andstorage of tilapia fish with high efficiency and economy, the research isjustifiable

1.4 RESEARCH OBJECTIVES

The major objective of this work is to identify a thin layerdrying model that best suits the solar drying of salted fish fillets in adirect passive solar dryer. Specificobjectivesinclude:

1. Todesign, fabricate and test run a direct passive solar dryer.
2. To select, and evaluate a thin layer solar dryer model for salted tilapia fish fillets
3. Tocharacterize the tilapia fish used in the study to obtain the initial moisturecontent, length, mass, crude protein and lipids, ash, and equilibrium moisturecontent.
4. Toinvestigate the drying kinetics of the salted fishfillets in the direct passive solar dryer usingthe identified thin layer drying model
5. Toestablish the physico- chemical qualities of the dried salted fish fillets
6. Toevaluate the specific solar radiation available, optimum angle of inclinationof the dryer possible at any location using the program codeswritten in MATLAB.

1.5 SCOPE OF THE RESEARCH

The Tilapia fish (Oreochromis Niloticus) is an important fishspecies reared in most aquacultural systems in various parts of theworld. It is highly valued due to its low fat content, slim size and highquality protein. In Nigeria it is also abundantly harvested in the wild as wellas being reared. Losses are often encountered due to poor or absence of storagesystems. In view of the inherent advantages as listed, it was chosen for thisresearch. The work will be limited to the drying kinetics encountered in directpassive solar drying of eviscerated salted tilapia fish fillets.

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