

**BUSITEMA
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Pursuing Excellence

**FACULTY OF ENGINEERING
DEPARTMENT OF CHEMICAL AND PROCESS
ENGINEERING**

**DESIGN AND CONSTRUCTION OF A ROTARY CAGE FISH
SMOKER**

BY

TUSUBIRA PAUL

BU/UG/2015/131

Email: tusubirapaul001@gmail.com

Tel: 0706165451/0788012250




Main Supervisor: MR. SSERUMAGA PAUL

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DECLARATION

I **TUSUBIRA PAUL** declare to the best of my knowledge that all the educative material contained in this project report is an account of my own efforts and has never been submitted to any university or institution for an academic award.

Signature.....

Date..16/05/19



APPROVAL

This report has been submitted after the approval of the supervisor.

Sign.....

Date.....

DEDICATION

This report is dedicated to my beloved parents Mrs. Namuli Margret and Mrs. Bibono Pauline, my uncles and aunts in appreciation for their selfless care and unflinching support provided to me since childhood, and for the spirit of hard work, courage and determination instilled into me, which attributes I have cherished with firmness and which have indeed made me what I am today, To my brothers and sisters. May the Almighty God reward you abundantly for such good work.

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ABSTRACT

The main aim of the study was to design and construction of a rotary cage fish smoker. The rotary fish smoker was successfully fabricated and tested with drying efficiency of 60.5% depending on natural flow of air. It's environmentally friendly, easy to operate and fish is processed in a hygienic way.

With the rotary cage fish smoker, there is uniform distribution of heat within the drying/smoking chamber leading to production of uniform products. The rotary motion of the cage ensured that fish is uniformly exposed to heat this eliminates the use of trays which are occasionally exchanged as this process is laborious, exposes the operator to smoke and heat.

The machine is cheap and affordable in terms of power requirement its power requirement is 0.212kw and it can be operated by a 0.5 HP motor.

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CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

This chapter describes the background information of the project, the problem statement, significance, purpose, objectives and scope of the study. The problem statement describes the research problem and identifies potential causes and a solution. The significance describes the importance of the project. The specific objectives presented will achieve the main objective.

1.1 BACKGROUND

Fish is an excellent source of protein, lipids, vitamins and mineral nutrients people need for a good diet. Fish flesh contains water (60-84%), protein (15-24%), fat (0.1-22.0%), and mineral usually 1-2% (Oparaku, 2005). Uganda has 350 fish species but Nile perch (*Lates niloticus*) and tilapia (*Oreochromis niloticus*) remain most important making up 38% and 46% of the total respectively. The total amount of fish catch is 374,300 metric tons out of which 223,100 metric tons from Lake Victoria, 60,000 metric tons from lake Kyoga and 56,000 metric tons from lake albert. It can be consumed in several forms: fresh, dried or brined, depending on consumer preference.

The fishing industry, despite its importance, suffers from enormous postharvest losses, which are estimated at 35%–40% of landed weight (FAO, 2010). These losses have a profound adverse impact on fishing communities whose status and income often depend on post-harvest activities. Such losses also have a detrimental impact on the socio-economic life of the fishing communities and reduce the amount of animal protein available to large segment of the population. Since fish and fish products are perishable without any preservative and processing measures, it is imperative and essential to process and preserve fish in order to assure quality of product, health safety of the consumers, and reduce water to the barest minimum as much as possible in order to preserve the fish (Mada, 2013).

Various traditional methods are employed to preserve and process fish for consumption and storage. These include smoking, drying, salting, frying, fermenting and various combinations of these (FAO, 2017). In most countries in Africa specifically Uganda smoking is the most widely practiced method. Methods of drying and smoking fish vary between different countries and within the same country depending on the species of fish used and product desired (Chukwu & Shaba,

References

- A.E Ghaly et al., 2010. Fish spoilage mechanism and preservation techniques. *American journal of applied sciences* , pp. 859-877.
- A.E Ghaly et al., 2010. Fish spoilage mechanisms and preservation techniques. *American journal of applied sciences* , pp. 859-877.
- Abdullahi A, A. D. S. E. R. A. .. J., 2001. *Nutrient Quality of Four Oven Dried Freshwater Catfish in Northern Nigeria*, s.l.: Trop. Biosci.,
- Adamu I. G, K. H. U. H. I. D. a. M. A. D., 2013. Design and Construction of Fish Smoking Kiln. *Journal of Engineering and Technology Research*, Volume Volume 5 (1), pp. Pp 15-20. .
- Adebowale, B. L. D. C. J. a. S. O., 2008. Comparative quality assessment of fish (*Clarias gariepinus*) smoked with cocoa pod husk and three other different smoking material. *J. Food Technol.*, Issue DOI: 10.3923/jfttech.2008.5., pp. 5-8. .
- al., A. e., 2013. Design and construction of a fish kiln. *journal of engineering and technology research*, p. 15.
- AMEC, 2003.. Management of wastes from Atlantic seafood processing operations. *AMEC Earth and Environmental Limited*.
- Andrew, I. H. P. a., 2010. Fish Oil Production and Use Now and Future., *International Fish Meal and Fish Oil Organization (IFFO)*.
- Anon., n.d. s.l.: s.n.
- Aoki, T. a. R. U., 1998.. Involvement of cathepsins B and L in the post-mortem autolysis of mackerel muscle.. *Food Res. Int.*, pp. 30: 585-591..
- Axtell, B., 2002. *Drying food for profit: A guide for small business*. , London:: Intermediate Technology Development Group Publishing Ltd..
- Bagamboula, C. M. U. a. J. D., 2004.. Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragol, linalool and pcymene towards *Shigella sonnei* and *S. flexneri*.. *Food Microbiol.*, Volume 21, pp. 33-42.
- Berkel, B. B. B. a. C. H., 2004. *Preservation of Fish and Meat*., Wageningen, The Netherlands: Agromisa Foundation.
- Chukwu, O. & Shaba, I. M., 2009. Effects of drying methods on proximate compositions of catfish.. *World journal of agriculture science*, p. 114.
- Clucas, I., 1975.. "*Fish Spoilage and General Introduction to Preservation*", s.l.: Food and Agricultural organization of the United Nations/Swedish International Dev. Authority Seminal on the Planning and Implementation of Utilization Programmes in Africa. F1.
- Clucas, I., 1982. "*Fish Handling, Preservation and Processing in the Tropics: Part 2*". *Report of Tropical Product Institute*, London, UK. 3-9.: s.n.

- Dalgaard, P. H. M. N. S. a. J. E., 2006.. Biogenic amine formation and microbial spoilage in chilled garfish (*Belone belone*) effect of modified atmosphere packaging and previous frozen storage.. *J. Applied Microbiol.*, Volume 101: 80-95..
- Ehiem, J. C. S. V. I. a. S. E. O., 2009.. Design and development of an industrial fruit dryer.. *Research Journal of Applied Sciences, Engineering and Technology*, . Volume 1(2), pp. 44-53..
- Ekechukwu, O., 1987. "Experimental Studies of Integral-Type Natural Circulation Solar-Energy Tropical Crop Dryers". *Ph.D. Thesis.*, UK. 211-215: s.n.
- Engvang, K. a. H. N., 2001. Proteolysis in fresh and cold-smoked salmon during cold storage; Effects of storage time and smoking process. *J. Food Biochem.*, pp. 25:379-395.
- Eyo, 2001. *Fish Processing Technology in the Tropics*, s.l.: University of Ilorin Press.
- FAO., .., h., 2005. *Post-harvest changes in fish. In: FAO Fisheries and Aquaculture Department*, , Rome, Italy.: Food and Agriculture Organization.
- FAO, 2010. *The Prevention of losses in cured Fish*, s.l.: s.n.
- FAO, 2017. An innovative way of fish drying and smoking: FAO Thiaroye Processing Technique (FTT-Thiaroye). *Food and Agricultural Organisations for united nations*.
- Frankel, E., 1985. . Chemistry of free radical and singlet oxidation of lipids.. *Progress. Lipid Res.*, Volume 23: 197-221..
- Fraser, O. a. S. S., 2016. Compositional changes and spoilage in fish ... *Nutr. Food Sci.*, pp. 5: 275-279.
- Ghaly A.E., D. D. S. B. a. M. B., 2010 . Fish Spoilage Mechanisms and Preservation Techniques: Review. *American Journal of Applied Sciences* , 7(ISSN 1546-9239), pp. 859-877,.
- Gram, L. a. H. H., 2000. Fresh and Processed Fish and Shellfish.. In: L. (Eds.). Chapman and Hall, ed. *The Microbiological Safety and Quality of Foods*, Lund, B.M., A.C. BairdParker and G.W. Gould . s.l.:s.n., pp. pp: 472-506.
- Hansen, T. T. G. S. R. a. H. H., 1996. Importance of autolysis and microbiological activity on quality of cold-smoked salmon. *Food Res. Int.*, Volume 29: 181-186..
- Huis in't Veld, J., 1996. Microbial and biochemical spoilage of foods: An overview.. *Int. J. Food Microbiol.*, Volume 33: 1-18.
- Hultin, H., 1994. Oxidation of Lipids in Seafoods.. In: F. a. J. B. (. Shahidi, ed. *Seafoods Chemistry, Processing Technology and Quality, 1st Edn, Blackie Academic and Professional*. London UK.: ISBN: 10: 0751402184,, pp. pp: 49-74.
- Huss, H. H., 2004. Assurance of sea Food Quality.. *FAO Fisheries Technical Paper* , pp. 334: 9-1 J..

Ichsani, D. D. W. A., 2002. Design and experimental testing of a solar dryer combined with kerosene stoves to dry fish.. *American Society of Agricultural and Biological Engineers*, pp. 1-3.

Jiang, M., 2009. *Development of smoked and gelatin based products from catfish*. Alabama: Auburn University .

John C. Sainsbury et al., 1999. *Fisheries technologies for developing countries*, Washington: National academy press.

KHURMI, R. ., J. G., 2005. *Machine Design*. First multicolour ed. RAM NAGAR, NEW DELHI-110 055: EURASIA PUBLISHING HOUSE (PVT.) LTD..

Lin, T. a. J. P., 1996. Protein solubility in Pacific whiting affected by proteolysis during storage.. *J. Food Sci.*, pp. 61: 536-539..

Mada, A. e. a., 2013. Design and construction of a fish smoking kiln. *journal of engineering and technology research*, 5(1), p. 15.

Mahmoud, B. K. Y. K. M. I. S. a. T. S., 2006. A new technology of fish preservation by combined treatment with electrolysed NaCl solutions and essential oil compounds.. *Food Chem*, Volume 99, pp. 656-662.

Micheal, A., 2014. 'Development and Performance Evaluation of a Motorized Fish Smoking Kiln. *African Journal of Food Science and Technology*, Volume volume 5 (5), pp. Pp 199-124..

Ogunleye, I., 2006.. "Preservation of Fish through Solar Drying". *Journal of Science and Technology Research* . 5(3)(ISSN 1596- 9649.).

Okonta, A. A. & E. J. K., 2005. *A preliminary study of micro-organisms associated with fish spoilage*. Asaba, Southern Nigeria., s.n., p. pp. 557-560.

Olayemi F. F, R. A. O. a. A. M. R., 2012. 'Microbiological Quality of Catfish (*Clarias Gariepinus*) Smoked with Nigerian Stored Products Research Institute (NSPRI) Developed Smoking Kiln. *International Research Journal of Microbiology* , Volume volume 3(13), p. Pp 426 – 430..

Olayemi Foline Folorunsho et al., 2013. Effective fish smoking kilns for developing kiln. *International journal of scientific and engineering research* , 4(1), p. 1.

Oparaku, N. F., 2005. *Design, Construction, of Solar Fish Dryer and Comparative Studies of Sun and Solar Drying of Three fresh Water fish Species*, s.l.: Biological Sciences :Zoology.

Peter, F. a. A. H., 1992. *Small Scale Food Processing*, Southampton Row, London WC1B4HH, UK. 60-64. : Intermediate Technology Publication.

Undeland, I. G. H. K. W. I. G. a. A. R., 2005. Preventing lipid oxidation during recovery of functional proteins from herring (*Clupea harengus*) fillets by an acid solubilization process. *J. Agric. Food Chem*, Volume 53: 5624-5634..

UNIFEM, 1998. *Fish processing. United Nations Development Fund for Women.*, New York, USA.: s.n.

Yongsawatdigul, J. J. P. P. V. a. S. V., 2000. Proteolytic degradation of tropical tilapia surimi.. *J. Food Sci.*, pp. 65: 129-133..