BUSITEMA UNIVERSITY
Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL AND PROCESS ENGINEERING

FINAL YEAR PROJECT

DESIGN AND CONSTRUCTION OF AN EVAPORATIVE COOLER FOR THE PRESERVATION OF FRESH CABBAGES

BY

GONANSA GIRISOMU

BU/UG/2015/9

E-mail: ggirisomu@gmail.com

Tel.: +256751140681/+256786648391

SUPERVISOR: Mr. KILAMA GEORGE

A final year project report submitted to the Department of Chemical and Process Engineering in partial fulfillment of the requirements for the award of a Bachelor of Science in Agro-Processing Engineering of Busitema University

MAY 2019

ABSTRACT

A Solar Powered and Temperature Controlled Evaporative Cooler of 50 kg capacity was designed and constructed to increase the shelf life of fresh cabbages. The cooler was tested using green fresh cabbage and evaluated. The cooler operates on the principle of DEC. Fresh cabbage is highly perishable. The cooler was made up of a 1mm aluminum sheet and lagged with cotton with one side made of charcoal through which the water flew via a perforated quarter inch steel pipe from the reservoir located at the top of the cooler. A 12 V Lithium battery powered two DC fans inserted on the side opposite to the side of charcoal and a Thermostat controlled the fans. The temperature, RH and weight loss of cabbage were statistically analyzed using ANOVA and the results revealed that there was significant difference in using the cooler for preserving cabbages as compared to the shade. The average COP was 1.75. The temperature in the cooler reduced up to 12.8 °C when compared to the shade and the RH in a cooler chamber went up to 90% . However, the testing of the system disclosed that the cabbages can be stored for a minimum of three weeks with negligible changes in weight, color and no putrefying as compared to the shade which started with notable changes in weight, color and severe putrefying after 9 days. Hence, it is on advisable that market cabbage venders and cabbage processing factories adopt the use of an evaporative cooler for their preservation as this increases their shelf life.

DECLARATION

I **GONANSA GIRISOMU** hereby declare that this project report titled "**Design and Construction of an Evaporative Cooler for the Preservation of Fresh Cabbages**" was done by myself in the Department of Chemical and Process Engineering, Busitema University, under the supervision of Mr. Kilama George. The information derived from the literature has been properly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree or diploma in any institution.

Date: 15TH MAY, 2019 Signature: .....

APPROVAL

This final report was presented and submitted to the Faculty of Engineering through the Department of Chemical and Process Engineering of Busitema University for examination and was approved for its contribution to knowledge and literary presentation.

Supervisor:

Name: .....

Date: ..... Signature: .....

DEDICATION

I dedicate this research report project to my parents, Mrs. Tibiwa Victoria, Late Samson Wuloli and Mr. Mukasa Robert in appreciation for their selfless care and unflinching support provided to me and to the Highest God who is the custodian of all grace.

ACKNOWLEDGEMENT

My gratitude goes to Almighty God for guidance, protection and provision throughout the preparation of this work. I am particularly grateful to my supervisor; Mr. Kilama George and the project coordinator; Mr. Sserumaga Paul for their academic and moral contribution in the completion of this work. This appreciation is extended to all friends and fellow Agro-Processing Engineers, and the Technical staff of the Munyengera Agro-machinery Ltd in Mayuge District, who contributed in helping me to make this work a reality. I am deeply indebted to my mentor and guardian, Galabba Michael for his immeasurable assistance and contribution in my academic pursuit.

I wish to acknowledge the support, love and encouragement from my family; my parents Ms. Tibiwa Victoria, Late Samson Wuloli and Mr. Mukasa Robert, my brothers, Mr. Gonansa Erukana, Mr. Mbulandabi Midadi and Mr. Mukasa George, my sisters Ms. Mantilida Mutesi, Ms. Rakeli Racheal, Ms. Namuicha Easther and Ms. Namugwere Janet and my Uncles and all other family members. You all are dear to me.

Finally, I appreciate my special friend, Ms. Nafula Doreen. who gave me a great deal of encouragement and advice in difficult moments during the course of this work. Thanks for always being there for me.

Pursuing Excellence

TABLE OF CONTENT

Pursuing Excellence

LIST OF TABLES

LIST OF FIGURES

LIST OF UNITS

kg = kilogram

m^3 = cubic meters

°C = degrees Celsius

Wkg^{-1} = watts per kilogram

W = watts

m = meters

kgm^{-3} = kilogram per cubic meter

$Wm^{-1}K^{-1}$ = watts per meter per kelvin

m^2 = square meter

K = kelvin

$kghr^{-1}$ = kilogram per hour

m^3hr^{-1} = cubic meter per hour

J/kg dry air = joules per kilogram dry air

Jhr^{-1} = joules per hour

N = newtons

cfm = cubic feet of air per minute

A = amperes

AH = ampere-hour

V = volts

Nm^{-2} = newtons per square meter

Pa = pascals

mm = millimeters

% = percent

g = grams

s = seconds

kgs^{-1} = kilogram per second

m^3s^{-1} = cubic meter per second

mmHg = millimeters of mercury

Shs. = shillings

Kg/year = kilogram per year

hr. = hour

LIST OF ABBREVIATIONS

FAO	-	Food and Agriculture Organization
NARO	-	National Agricultural Research Organization
DEC	-	Direct evaporative cooling
COP	-	Coefficient of performance
RH	-	Relative humidity
DC	-	Direct current

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Cabbage (*Brassica oleracea*) is one of the most important vegetables grown for commercial purposes (Contribution, Indigenous and Food, 2002) due to the increased interest in fresh cabbage that has increased in the World as a result of enlarged consumer awareness about their health benefits (Ambuko *et al.*, 2017) leading into improved production of cabbages to meet the increasing demand because of the widespread use of mechanization, improved quality inputs (such as seeds and fertilizers) and farming technological advances (Agarwal, 2017). According to Food Agricultural Organization of United States (FAO), cabbage play an important role in providing essential vitamins (especially A, C and B), minerals (especially calcium and potassium) and proteins that are necessary for growth, development and a healthy immune system like weight management to the populations in both developed and developing countries (MAAIF, 2003) and (Turcan and Bene, 2017). It also provides the roughage (dietary fiber) that prevents constipation (Dhaliwal, 2017). Fresh cabbage juice also promotes rapid curing of peptic ulcers (Marketing, 2016).

Currently in Uganda, cabbage farmers harvest them and sell to the market venders of fresh cabbages who poorly handle and store them in un controlled storage environments facilitating high rate of respiration leading to the chemical, bio-chemical and physiological changes which frequently results in loss of quality and spoilage of fresh cabbages. The market venders are not sufficiently informed on how to make technical choices for better control of temperature and humidity of the storage environment of leafy green cabbages (Mrema, Support and Division, 2009). So, high productivity of cabbages during the high season causes oversupply in the market to venders and they end up compiling them in their stores resulting in increased post-harvest losses due to high temperatures and reduced relative humidity in the storage room. According to (Ambuko *et al.*, 2017), if fresh cabbage loses more than 11% of its original fresh weight, it is rendered unsalable. So, it is necessary to control the temperature and humidity of the cabbages on shelves in the markets (Siriwattananon and Maneerate, 2016).

REFERENCES

'20) CONTROLLED ATMOSPHERE STORAGE' (no date), pp. 1–9.

'ABSTRACT (not yet worked on the abstract)' (no date).

Agarwal, S. (2017) 'Post-Harvest Losses in Agri-Food Supply Chain : a Literature Review', *International Journal of Advance Research in Science and Engineering*, 6(4), pp. 400–407. Available at: www.ijarse.com/images/fullpdf/1491494167_IF2020ijarse.pdf.

Agblor, S. and Waterer, D. (2001) 'Cabbage - Post-Harvest Handling and Storage', pp. 3–4.

Aked, J. (2002) 'Maintaining the post-harvest quality of fruits and vegetables'.

Alimentar, E. (2016) 'Chlorophyll and Green Color Stabilization on Vegetable Homogenates Cristina Efimovna do Couto Dissertação para a obtenção do Grau de Mestre em Engenharia Alimentar'.

Ambuko, J. *et al.* (2017) 'Preservation of Postharvest Quality of Leafy Amaranth (Amaranthus spp.) Vegetables Using Evaporative Cooling', *Journal of Food Quality*, 2017, pp. 1–7. doi: 10.1155/2017/5303156.

Analysis, S., Column, L. and Page, C. E. (no date) 'CBE2027 Structural Analysis I Chapter 6 – Long Column', pp. 1–24.

Bahrami, M. and Mixtures, G. V. (no date) '□ □ □ □ 0 . 622', 461(S 11), pp. 1–12.

'Chapter 8 . Harvesting and Postharvest Handling' (2017), (March).

Contribution, T., Indigenous, O. and Food, S. (2002) 'The Contribution Of Indigenous V egetables to Household F ood Security Food', (44).

Control, R. H. (1986) 'LOOKING PRODUCE', pp. 1–29.

Davis, R. A. (2011) 'Pacific Gas and Electric Company', *Federal Register*, 76(84), pp. 24465–24466. doi: 10.3938/jkps.50.567.

Description, P. *et al.* (2012) 'Date: November 2012', (1), pp. 0–1.

Dhaliwal, M. S. (2017) 'Cole crops', (January).

Dias, J. S. (2015) 'Nutritional Quality and Health Benefits of Vegetables : A Review', (January 2012). doi: 10.4236/fns.2012.310179.

Diepen, P. Van and Wales, A. (2007) 'Organic Vegetable Storage in Wales – Opportunities and Constraints', (July).

Van Dusen, M. S. and Finck, J. L. (1930) 'Heat transfer through building walls', *Bureau of Standards Journal of Research*, 6(3), pp. 493–522. doi: 10.6028/jres.006.033.

El-ramady, H. R. *et al.* (2015) *Postharvest Management of Fruits and Vegetables Storage*. doi: 10.1007/978-3-319-09132-7.

Evans, J. (2007) 'Cold storage of food: Review of available information on energy consumption and energy savings options', *University of Bristol, UK*, 44(0), pp. 1–25. Available at: http://www.grimsby.ac.uk/documents/defra/stor-coldstorescasestudy.pdf.

'Fabrication Matematics - mass, weight, volume.pdf' (no date).

Guidelines, P. (2013) 'Chinese cabbage', (August), pp. 40–42. doi: 10.3865/j.issn.1001-3547.2011.12.015.

Hand-in-hand, L. S. G. and Confetti, C. (no date) 'Exploring California Cabbages : Taste Testing'.

Highway, F. (1995) 'Ar ch i ve d Ar ch ed', 4(November).

Humphreys, F. R. and Ironside, G. E. (1980) 'Charcoal from New South Wales', p. 15. Available at: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0015/390003/Charcoal-from-NSW-Species-of-Timber-3rd-Edition.pdf.

Khurmi, R. et al.; Theory of Machines , 14th ed.; S. Chand & Co. Ltd., New Dehli 2005; ISBN 9788121925242 (2005).

Kitinoja, L. and Kader, A. A. (2015) 'Measuring postharvest losses of fresh fruits and vegetables in developing countries', *The Postharvest Education Foundation*, (September), pp. 1–26. doi: 10.13140/RG.2.1.3921.6402.

Lou, Z. (2014) 'Quality Evaluation of Dehydrated (Sun and Solar Drying) Cabbage and Rehydration Properties Quality Evaluation of Dehydrated (Sun and Solar Drying) Cabbage and Rehydration Properties', (September).

Ma, Y. *et al.* (2015) 'Spectrum sharing in RF-powered cognitive radio networks using game theory', *IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC*, 2015–Decem(4), pp. 992–996. doi: 10.1109/PIMRC.2015.7343442.

MAAIF, M. (no date) 'the Republic of Uganda the Uganda Food and Nutrition Policy'.

Marketing, D. (2016) 'A PROFILE OF THE SOUTH AFRICAN CABBAGE MARKET VALUE CHAIN', pp. 1–35.

Mrema, G. C., Support, A. and Division, S. (no date) 'No Title'.

'No Title' (no date).

Pereira, L. F. C., Savić, I. and Donadio, D. (2013) 'Thermal conductivity of one-, two- and three-dimensional sp2carbon', *New Journal of Physics*, 15(May 2014). doi: 10.1088/1367-2630/15/10/105019.

Prabodh Sai Dutt R and Thamme Gowda C.S (2015a) 'An Investigative Review on Recent Developments in Refrigeration by Evaporative Cooling', *International Journal of Engineering Trends and Technology (IJETT)*, 23(6), p. 6. doi: 10.14445/22315381/IJETT-V23P254.

Prabodh Sai Dutt R and Thamme Gowda C.S (2015b) 'An Investigative Review on Recent Developments in Refrigeration by Evaporative Cooling', *International Journal of Engineering Trends and Technology (IJETT)*, 23(6), p. 6. doi: 10.14445/22315381/IJETT-V23P254.

Prajzner, J. (2006) 'No Title', pp. 1–19.

R. A. Bucklin, J. D. Leary, D. B. McConnell, and E. G. W. (2004) 'Fan and Pad Greenhouse Evaporative Cooling Systems 1', *Water*, pp. 1–7. Available at: http://en.scientificcommons.org/2061080.

Saatcioglu, B. M. (no date) 'Chapter 4 Design of Slender Columns'.

Scient, A. and Circumstantiae, I. A. E. (2004) '(Brassica Oleracea) 陈世宝', 25.

Sharan, G. and Rawale, K. (2003) 'Physical Characteristics of Some Vegetables Grown in Ahmedabad Region', pp. 1–15.

Singh, S. (2018) 'Stewart Postharvest Review', (March). doi: 10.2212/spr.2011.1.5.

Siriwattananon, L. and Maneerate, J. (2016) 'EFFECT OF DRYING METHODS ON DIETARY FIBER CONTENT IN DRIED FRUIT AND VEGETABLE FROM NON-TOXIC AGRICULTURAL FIELD', 11(28), pp. 2896–2900.

SPGS (2007) 'Plantation Guidelines Nos. 5&6 - June 2007', (June).

Students Learning Centre (2013) 'Future and present values', *Flinders University*, pp. 4–5. Available at: http://www.flinders.edu.au/slc_files/Documents/Red Guides/Future and Present Values.pdf.

Tooley, M. J. (1980) 'Book reviews : Geography, Volume 63, Part 4, No. 281, November 1978. Papers on Physical Geography, pp. 251-361, £1.50', *Progress in Physical Geography*, 4(2), pp. 308–311. doi: 10.1177/030913338000400219.

Turcan, L. and Bene, T. (no date) 'A review of policies for improving human nutrition in Uganda and the use of evidence for making policy'.

Wang, C. Y. (2006) 'Reducing chilling injury and maintaining quality of horticultural crops with natural products and their derivatives', *Acta Horticulturae*, 712 I, pp. 285–290. doi: 10.17660/ActaHortic.2006.712.31.

Warke, D. A. and Deshmukh, S. J. (2017) 'Experimental Analysis of Cellulose Cooling Pads Used in Evaporative Coolers', 3(4), pp. 37–43.

wikipedia (2013) 'Heat capacity', *Wikipedia*. doi: 10.1111/j.1467-9922.2010.00586.x.

Zakari, M. D. *et al.* (2016) 'Design and construction of an evaporative cooling system for the storage of fresh tomato', *ARPN Journal of Engineering and Applied Sciences*, 11(4), pp. 2340–2348. doi: 10.13140/RG.2.1.4748.4569.