

**BUSITEMA
UNIVERSITY**
Pursuing Excellence

FACULTY OF ENGINEERING

**DEPARTMENT OF AGRICULTURAL MECHANISATION AND
IRRIGATION ENGINEERING**



Final year project report

**DESIGN AND CONSTRUCTION OF A BANANA JUICE
EXTRACTOR**

BY

MATOVU JOSEPH

BU/UG/2010/17

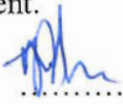
*Submitted in partial fulfillment for requirements of awarding of the BACHELLOR OF SCIENCE
Degree in*

AGRICULTURAL MECHANISATION AND IRRIGATIONENGINEERING

DECLARATION

I **Matovu Joseph** the undersigned put it clearly and declare that this report document and its content as a whole have never been presented before by any one for any academic award or media presentation in any institution.

I have compiled it myself while referring to information from relevant sources as acknowledged in the document.

Signature: 

Name: Matovu Joseph

Date: 11th JUNE, 2014



APPROVAL

This is to approve that this project report for design and construction of a banana juice extractor have been validated for further examination by the project supervisors as undersigned here.

Main supervisor: **Mr. Kavuma Chris**

Signature: 

Date: 12/06/2014

Co-supervisor: **Mr. Ssali Ssajja**

Signature:

Date:

DEDICATION

I dedicate this project report to the **almighty lord God of hosts** together with **Mr. Nsiko Andrew (paternal uncle)** for whatever he has done towards my studies and future.

ACKNOWLEDGEMENT

No man is an island and no one on this earth has ever achieved any of his goals or done anything solely basing on his own effort minus the contribution of the others! So I take this honor to recognize everyone who has contributed his or her efforts towards the execution of 'my final year project'. I respect gratefully whoever encouraged me to go on with the project.

I recognize thankfully **Mr. Nsiko Andrew** (uncle), my father **Mr. Matovu Sam**, Aunts; **Babra, Betty Nabukenya, Mama Lucia** and **Mama Nalubega**, cousins; **Andrew Mutagwanya, Sandra Kagwa** and **Brendah Namagembe**, Grand aunt **Geraldine Kigongo**, Grandmother **Consesa Nabyoolola** and **Rev. Kateregga Friday** for the basic requirements they provided to me.

I appreciate the management of John Lugendo and company limited for having allowed me to use their resources to fabricate the prototype, I thank the Managing director, **Mr. Bukalaamy David**, the General manager, **Mr. Ssozi Richard, Mr. Lubega Solomon, Ssalongo** and **Kifamba Joseph** of the foundry section, **Mr. Nangoni Dalton Stephen** and **Mukisa Vianey** of machining section, **Hamis M** and **Waswa** of the welding and fitting section.

I also recognize and appreciate the corrective assistance offered by Busitema university mechanical workshop staff, I am grateful to **Mr. Okaude Jephtha** and **John** of the welding section, **Mr. Oguma Norman, Mr. Malinga** of the machining section and all others. I recognize **Mr. Bwire Henry** who looked for scarce kayinja banana variety when I urgently needed it.

I also acknowledge my fellow student **Ronald Ssuuna** (AMI 3) for the kindness he showed me in any way I approached him for assistance.

In a special way I thank my dear supervisors; **Mr. Kavuma Chris** and **Mr. Ssali Ssajja** for the guidance, advice, corrections and encouragement they offered me in this vital and crucial final year project task most especially when my prototype developed a mechanical problem before testing it and so in regard to this, **Mr. Mugisha Moses** gave me the first encouragement.

I thank **Mr. Kyagulanyi** of water resources engineering Department for assistance and guidance he offered me when finalizing my project.

May the almighty Lord God of hosts reward you all abundantly!

ABSTRACT

Uganda is the second largest producer of bananas after India but most of these bananas are consumed as a staple food and less is diverted into extraction of banana juice. Banana juice can be extracted either manually or chemically however, in Uganda, manual extraction of banana juice by treading on bananas in a trough in the ground or kneading of the bananas in a large pan is accomplished by addition of turpentine or spear grass to the bananas.

This manual extraction of banana juice renders the juice to contamination with germs and also blood possibly from cuttings due to sharp edges of spear grass. This calls for provision of a mechanized way of extracting banana juice.

In this project, a machine was designed to adopt the traditional way of extracting juice from bananas using grass and hands. The designed machine was fabricated to demonstrate and test its performance and efficiency. Although it had been designed to be motorized, it was discovered during fabrication that it can well be manually driven while retaining the same designed parameters.

It was tested on two banana varieties, that is; kayinja and bogoya and two grass varieties, namely spear grass and turpentine grass (etteete). It extracted $\frac{1}{2}$ liters of juice from 3kg of bogoya and $\frac{1}{4}$ liters of juice from $\frac{3}{4}$ kg of kayinja. Its efficiency on each of the banana variety used was calculated and found to be 67% while the output capacity could not be established as it depends on the driving power and the variety and conditions of bananas to be processed.

While the proto type cost 829,200Shs to fabricate and test, the designed machine was evaluated to cost 2,025,000Shs and the economic analysis for the viability and feasibility of someone investing in this machine was carried out and found to be viable. The overall project incurred an expense of 1,491,700Shs to execute.

Key words: Bananas, banana juice, construction, designing, economic analysis, efficiency, extractor, kneading, prototype, squeezing mechanism, treading, viability.

TABLE OF CONTENTS

DECLARATION	i
APPROVAL	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
LIST OF FIGURES	x
LIST OF TABLES	x
ACRONYMS	xi
CHAPTER ONE: INTRODUCTION	1
1.1 Background of the study	1
1.2 The problem statement	2
1.3 Rationale	2
1.4 Purpose of the project	2
1.5 Objective of the project study	3
1.5.1 Main Objective	3
1.5.2 Specific Objective	3
CHAPTER TWO: LITERATURE REVIEW	4
2.1 Bananas as crop	4
2.1.1 Classification of bananas	5
2.1.3 Relevant uses of bananas	6
2.1.4 Bananas categories used for juice extraction	6
2.2 Extraction of juice from fruits	7
2.2.1 Types of Juicers	7
2.3 Extraction of juice from bananas	9
2.3.1 Tradition extraction of banana juice	10
2.3.2 Mechanized extraction of banana juice	11
2.3.3 Chemo-extraction of banana juice	12
2.4 The fate of juice extracted from bananas	13

CHAPTER THREE: PROJECT METHODOLOGY.....	14
3.1 Designing of the juice extractor and its components.....	14
3.1.1 General design considerations.....	14
3.1.2 The conceptual design.....	14
3.1.3 Selection of materials.....	16
3.1.4 Specific design of various intended machine parts.....	17
3.1.4.1 Designing for gear parameters and dimension.....	17
3.1.4.1.2 Checking and proving of the design.....	22
3.1.4.2. Design of the connecting arm between the sun and planetary gears.....	23
.....	24
3.1.4.3 Designing for the ring gear parameters	
3.1.4.4 Designing for the main shaft:.....	24
.....	28
3.1.4.5 Designing for the diameter of the counter shafts.	
3.1.4.6 The design for dimensions of the sunken keys on various shafts.....	28
3.1.4.7 The design of the muff coupling between the motor shaft and the machine main shaft.....	29
3.1.4.9Design for the dimensions of the outer pan.....	31
3.1.4.10Designing for the crushing(mastication unit).....	32
3.1.4.11 Designing for the frame of the juice extractor.....	33
3.1.5 Presentation of the design.....	36
3.2 Construction of the machine.....	36
3.2.1 Equipment and tools used.....	37
3.2.2 Construction of the machine frame.....	38
3.2.2 Casting and machining of the gears.....	38
3.3 Testing the performance of the machine.....	40
3.3.1 Preparation of the raw materials for testing the extractor.....	40
3.3.2 Operation of the machine.....	41
3.3.4 Determination of the production efficiency and output capacity of the machine of the machine.....	41
3.4 Handling of results and conduction of economic analysis.....	42

3.4.1	Conduction of analysis of the results	42
3.4.2	Conduction ^{of} Economic analysis	43
3.4.2.1	Evaluation of the machine to come up with the price worth it.	43
3.4.2.2	Economic analysis of the investment venture in the machine.	43
CHAPTER FOUR: RESULTS AND DISCUSSION		47
4.1	Design results	47
4.1.1	Selected material	47
4.1.2	Specific design of various intended machine parts.....	48
4.1.2.1	Designing for gear parameters and dimension.....	48
4.1.4.2.	Design of the connecting arm between the sun and planetary gears.	53
	53
4.1.4.3	Designing for the ring gear parameters	
4.1.4.4	Designing for the main shaft	53
	57
4.1.4.5	Designing for the diameter of the counter shafts.	
4.1.4.6	The design for dimensions of the sunken keys on various shafts.	59
4.1.4.7	The design of the muff coupling between the motor shaft and the machine main shaft:.....	60
4.1.4.9	Design for the dimensions of the outer pan	60
4.1.4.10	Designing for the crushing(mastication unit).....	61
4.1.4.11	Designing for the frame of the juice extractor.	62
4.1.5	The artistic impression of the juice extractor.	66
4.3.2	Test and performance results.	68
4.3.3	Analysis and discussion of the results.	69
4.3.4	Determination of the production efficiency and output capacity of the machine of the machine.....	69
4.4	Results and Economic analysis.	70
4.4.1	Analysis of the results methodology	70
4.4.2	Economic analysis results.....	70
4.4.2.1	The evaluation of the machine cost (designed machine not prototype)	70
4.4.2.2	Economic analysis of the investment venture in the machine.	71

4.5 The overall project expenditure as per the prototype;	72
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS	74
5.1 Conclusion	74
5.2 Recommendations	74
REFERENCES	75
APPENDIX A	78
A-1; The 2D transverse appearance of the machine design	78
A-2; The design of fastening details of the ring gear shell	79
A-3; The details of the gear unit	80
A-4; The details of the crushing pans/ vessels	81
A-5; The details of the crushing assembly	82
A-6; The details each of the legs of the frame	83
A-7; The details of spike alignment onto the blades	84
APPENDIX B	85
B-1; Table 1 showing the various classes of carbon steels, their compositions and uses	85
B-2; Table showing the standard dimensions of sunken key	86
B-3; Table showing the recommended design values of combined torque and fatigue factors	86
B-4; Table showing the standard values of modules of spur gears	87
B-5; Table showing the Lewis form factor for standard number of teeth of gears	87
B-6; Table showing the values of end condition constant C	87
B-7; Table showing some of the mechanical properties of given materials	88
B-8; Table showing the structural properties of a steel angle bar	89

LIST OF FIGURES

Fig 1 A family extracting banana juice in a sauce pan	2
Fig 2.2.1: The centrifugal juicer	7
Fig 2.2.2: The masticating juicer	8
Fig 2.2.3: The Triturating juicer.	8
Fig 2.2.4: The screw juice extractor.....	9
Fig 4.1: The different views of machine artistic impression.....	66
Fig 4.2: The labeled view of the extractor.....	67
Figure 4.3; the various views of the fabricated machine.....	67
Figure 4.4; The operation of the extractor.....	68

LIST OF TABLES

Table 3.2; Details of bananas for testing the proto type.....	40
Table 3.3; The juice content of selected bananas	42
Table 4.0 ranking of materials for gears	47
Table 4.1; The selected materials.....	47
Table 4.2; The results of hit and trial for the main shaft	56
Table 4.3; The results of hit and trial for counter shafts	59
Table 4.4; The overall design results	63
Table 4.5; The test results.....	68
Table 4.6; The evaluation of designed machine cost.....	70
Table 4.7; The estimation of production cost.....	71
Table 4.8; The pricing of raw juice	71
Table 4.9; The computation of annual benefit from investment in the extractor	72
Table 4.10; The NPV analysis	72
Table 4.11; The cost of fabricating the proto type.....	72
Table 4.12; other project related costs	73
Table 4.13; The overall project expenses	73

ACRONYMS

AISC:	American Institute of Steel Construction
ASD:	Allowable Stress Design
ASME:	American Society of Mechanical Engineers.
EU:	European Union
FAO:	Food and Agricultural Organization.
FHIA:	Fundación Hondureña de Investigación Agrícola,
INIBAP:	International Network for Improvement of Bananas and Plantains.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Uganda is the world's second largest grower of bananas (*musá spp*) after India producing as many as 11.1 million tons of the fruit each year, but the banana market is under-exploited, (FenBeed, 2013). Its potential to act as a bastion of food-security and create lucrative openings for ambitious entrepreneurs requires innovation in the way the fruit is produced, marketed and consumed.

Currently, African bananas make up only 4% of the bananas sold in the European Union, the world's largest banana importer, and this figure is set to decrease further as the EU will imminently abandon its reduced import tax for African bananas (FenBeed, 2013). Today, banana juice is one of devoured refreshment juice amongst the lower working class of Ugandans in urban areas and majority of rural dwellers of banana producing and consuming areas of Uganda mainly in the central

Enshrined in Ugandan tradition, the banana is boiled and steamed to make matooke, a crucial staple food; it is drunk as juice, which is fermented for beer and refined further to make waragi spirit. The traditional technology of banana juice extraction used in Uganda involves pressing, folding and turning the pulp mash mixed with spear grass or turpentine grass over and over again and it is done from a bucket or source pan by bare hands.

However, the extraction on relatively large scale is done from a pit lined very well with material obtained from the banana pseudo stem and thigh muscles are made use of as bare feet are used to do the extraction in the pit. The role of the added spear grass is to modify the rheological properties of the pulp thus its use is a must if banana pulp mass is to release the juice. Kyamuhangire (1998) observed that the changes that take place in the banana pulp mass that lead to juice release involve breaking and building of new bonds between the different pulp constituents.

REFERENCES

- Adesoji M. Olaniyan, Damilola E. Adeyemi and Felix O. Ajala: *Design, Development And Testing Of A Chopping-Expression Device For Pineapple Juice Extraction*; Department of Agricultural and Bio systems Engineering, Faculty of Engineering and Technology , University of Ilorin, P. M. B. 1515, Ilorin 240003, Kwara State, Nigeria
- Apollo Segawa, *Analysis Of A Tropical Banana Juice And Effects Of Heat Processing Using Hplc*. A dissertation to the faculty of health Sciences, Technikon Witwatwersrand for master's degree of technology in food technology
- Budynas-Nisbett; *Shigley's Mechanical Engineering Design*, Eighth Edition. McGraw-Hill Primis ISBN: 0-390-76487-6. <http://www.primisonline.com>. Copyright ©2006 by The McGraw-Hill Companies, Inc. All rights reserved. Printed in the United States of America.
- Byarugaba-Bazirake GW, Van Ransburg P and Kyamuhangire w, *characteristics of enzyme-treated banana juice from three cultivars of tropical and subtropical Africa*; African Journal of Food Science and Technology (ISSN: 2141-5455) Vol. 3(10) pp. 277-290, December, 2012 Available Online <http://www.interestjournals.org/AJFST>. Copyright©2012 International Research Journals
- Egor P. Popov; *Engineering Mechanics of solids*, 2nd edition. Professor in the graduate school university of California- Berkely 1998.
- Julia Davidsson and Elisabeth Malm: *Development of a defferentiated high-end juice extractor for house hold use*; Department of Product and Production Development, Division of Design and Human Factors, Chalmers University of technology. Gothenburg, Sweden, 2012
- G. Kasozi& L. L. Kasisira: *Design And Performance Of a Banana Juice Extractor*; Department of Agricultural Engineering Makerere University, P. O. Box 7062, Kampala, Uganda, African Crop Science Conference Proceedings, Vol. 7. pp. 1381-1384. Printed in Uganda. All rights reserved ISSN 1023-070X/2005 \$ 4.00, © 2005, African Crop Science Society
- Gareth Davies: *domestic banana-beer production in Mpigi district, Uganda*

Grape Wine, *Practical Action Technical Brief Banana Beer*,
<http://www.xs4all.nl/~westher/recepten/BANANA%20BEER.htm> Traditional Foods:
Processing for Profit, Edited by Peter Fellows, ITDG Publications 1997

http://en.wikipedia.org/w/index.php?title=East_African_Highland_bananas&oldid=549333357

http://en.wikipedia.org/w/index.php?title=Cooking_plantain&oldid=580733392"

<http://en.wikipedia.org/w/index.php?title=Banana&oldid=579342339>

K. K. Surendranathan, N. K. Ramaswamy, P. Radhakrishna and J. S. Nair; *value added products from ripe banana: banana juice and ripe banana powder*; Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre. BARC newsletter, Issue No.249

K. Nowakunda and W. Tushemereirwe, *Farmers acceptance of introduced banana genotypes in Uganda*: African crop science journal volume 12 No. 1 pp1-6, 2004

Ndubisi A. Aviara, Abubakar A. Lawal, Davou S. Nyam & Jesuto funmi Bamisaye: *Development and performance evaluation of a multi-fruit juice extractor*; Department of Agricultural and Environmental Resources Engineering, University of Maiduguri, Maiduguri, Nigeria. Global journal of engineering, design and technology (published by global institute for research and technology)

Olaniyan A. M: *Development of a small scale orange juice extractor*: Revised: 16 October 2008 / Accepted: 13 June 2009. Association of Food Scientists and Technologists (India), Mysore

Ouma, Emily and Jagwe, John; *Banana Value Chains In Central Africa: Constraints And Opportunities*; Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.

P.R. Rubaihayo and C.S. Gold: *Rapid Rural Appraisal Of Highland Banana Production In Uganda*.

R.C. Hibbeler; *Mechanics of materials*, 7th edition. ISBN;978-0-13-220991-5. Published by Prentice hall, Pearson Education South Asia. 23/24 first Tandf Road Jorong, Singapore 629733. Copy right© 2008.

R.M. Gensi, W.Kyamuhangire and J.F. Carasco: *Traditional Production And Characteristics Of Banana Juice In Uganda*, Department of food science and technology and department of biochemistry, Makerere University, African journal of science conference proceedings, Vol.1, pp356-359. Printed in Uganda. ISSN 1023-070X \$25.00. 19994 African Crop Science society.

R.S. Khurmi and J.K. Gupta; *A text book of machine design (SI units) FIRST MULTICOLOUR EDITION*. [A Textbook for the Students of B.E. / B.Tech., U.P.S.C. (Egg. Services); Section 'B' of A.M.I.E. (I)] 2005.Eurasia Publishing House (PVT.) ltd. ram nagar, new delhi-110 055

Shamsiah Shahadan and Aminah Abdullah; *Optimizing Enzyme Concentration, PH and Temperature In banana Juice Extraction*

Suzanne Sharrock: *Uses Of Musa*; Annual report 1996; focus paper

Sylvester A. Aye, and Abugh Ashwe, *Design And Construction Of An Orange Juice Extractor*; Proceedings of the World Congress on Engineering 2012 Vol III WCE 2012, July 4 - 6, 2012, London, U.K.

V. B. Bhandari: *Design Of Machine Elements*; department of mechanical engineering, Vishwakarma institute of Technology; the MacGraw-Hill companies., ISBN: 978-0-07-081141-2, ISBN:007-061141-6 (pg4-15).

Z.C. De Beer and A. Sigawa, *Banana (musa spp.) Juice production in South Africa*