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*Pursuing Excellence*

**FACULTY OF ENGINEERING**



**DEPARTMENT OF CHEMICAL AND PROCESS ENGINEERING**

**AGRO-PROCESSING ENGINEERING PROGRAMME**

**FINAL YEAR PROJECT REPORT**

**Design and construction of a motorized multi-grain cleaner.**

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## ABSTRACT

Grains contribute an important element in food industry and food security in Uganda. They are consumed in homes, schools, hospitals, among the armed forces, rehabilitation centers, refugee camps institutions, health centers due to the large quantity of carbohydrates, proteins, vitamins and fats contained in the kernels. According to FAO, 10% grain losses occur due to poor post-harvest handling. Harvested grains have straw, chaff, sand, rocks, dust, damaged seed, stones, cobs, husks and many others. The foreign matter in grains adversely affects subsequent storage and processing conditions affecting the nutritional and market value. Cleaning by traditional winnowing technology leaves the grain contaminated with foreign matter posing a reduction in farmer's income.

Smallholder farmers in Uganda use traditional post-harvest handling methods that expose grain to contamination by foreign matter. Manually grain cleaning methods are inefficient, labor intensive and depend on natural wind which leaves the grain contaminated.

To overcome this problem, this study chose as its main objective to design and construct a multi grain cleaner as well as testing of the constructed machine and the economic evaluation of the multi grain cleaner. It is aimed to enable the small holder farmers to enhance the quality and quantity of their consumable grain and enhancing the nutritional and market value, with significant reduction in the quantitative post-harvest losses thus enhancing the country's food security status. The grains considered in this study were rice, sorghum and maize.

Various components of multi grain cleaner were designed using basic engineering principles and some physical properties of grains such as size, density, ( $760\text{kg/m}^3$ ), moisture content, (7.6% dry basis), angle of repose, ( $29.5^\circ$ ) and weight of the grain. The trays, sieves perforations were obtained to be 12mm and 4.0mm for first and second sieves respectively.

The performance of the multi grain cleaner was evaluated in terms of machine output, cleaning efficiency, cleaning loss and mechanical damage for machine output. The machine was found to be viable after the economics analysis with a projection of three years. Addition of a cyclone for preventive collection of chaff during cleaning was recommended to prevent pollution of the environment.

## DEDICATION

I dedicate this report to my beloved parents Mr. Rwomushana Fred Kifaaru and Mrs. Deborah K, brothers (Isaiah, Emmanuel, Godwin and Hannington), sisters (Chloe and Clara) for the support and the financial assistance rendered to me during the research period.

## DECLARATION

I, Tarihare Grace, do hereby declare that this project report is the original record of my personal research carried out under serious supervision. And has never been submitted in for the award of any degree of Busitema University or any other institution of learning.

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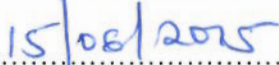


## APPROVAL

This project report was compiled and submitted to the department of Chemical and Processing Engineering of Busitema University under the supervision and approval of:

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## **CHAPTER ONE: INTRODUCTION**

### **1.0 INTRODUCTION**

This chapter presents the background to the study, problem to be addressed by the study, justification of the study, the objective and the scope of the study.

#### **1.1 BACKGROUND OF THE STUDY**

Traditional grains such as sorghum, finger millet, maize and cowpeas are some of the major grain foods grown and consumed in Uganda. Most of the traditional grains produced are consumed as food and also sold to buyers who use them for different purposes (FAO, 2005). Traditional products made from grains include beers, thick porridges, gruels and a variety of sauces; these products are made at household level using technologies such as drying, malting, roasting, milling and fermentation (Byaruhanga and Auko, 2002). One of the popular fermented traditional products produced for home consumption is obushera, a non-alcoholic gruel made from malted finger millet and/or sorghum (Tenywa *et al.*, 1999). Effective demand for clean grains is gaining potential in the urban areas, the local market for grains is growing due to increase in rate of urbanization. For grains to be utilized in any form they need to be cleaned, poor methods of cleaning lead to high loss and low quality of grain seeds plus low market value (Greeley, 1982).

In Uganda, the local farmers usually clean their grains by winnowing using direct wind to blow off the chaff and then hand picking the other wastes such as stones. This method is time consuming and does not remove all wastes from the grain and also causes diseases like flu to the operators. Furthermore, the existing cleaning machines on market do clean a specific grain and cannot be used to clean other categories of grains. Research on grains has focused on increasing yield but issues of post-harvest losses, value addition and market accesses have not been adequately addressed. (Tenywa *et al.*, 1999). There is increasing demand for the clean grains by various grain dealers and consumers in Uganda.

#### **1.2 PROBLEM STATEMENT**

Grains grown in Uganda are harvested in various seasons and threshed. The major challenges of grain cleaning at both small and large holder levels in Uganda is the lack of an appropriate threshing machine that can clean a variety of threshed grains, save time, and reduce drudgery in cleaning. Cleaning of the threshed grains is often achieved

## REFERENCE

- Bhandari V.B., (2007), Design of Machine Elements, Second Edition, ISBN 0-07-061141-6,9780-07-061141-2, Published by McGraw-Hill Companies
- Budynas–Nisbett (2006), Shigley’s Mechanical Engineering Design, Eighth Edition, ISBN: 0–390–76487–6, published by McGraw – Hill.
- FAO (2005) Analysis of an FAO survey of post-harvest crop losses in Developing countries AGPP MISC/27 pp.148
- Henderson, S.M and Perry, R.L (1976) Agricultural process Engineering Third Edition. The avi publishing company, incorporated, West-port, Connective, New York.
- Huq F. and Greeley M. (1982) Rice in Bangladesh: An empirical analysis of farm level food losses in five post-harvest operations. In Grain quality improvement - Proceedings of the 3rd annual workshop on grains postharvest technology. Kuala Lumpur, Malaysia, 29-31 January 1980. 245-262. - also see - Greeley M. (1982) Pinpointing post-harvest losses. Ceres 15 (1), 30-37
- Hall, A.S ,Holowenko, A.R., and Laughlin, H.G. (2001) : Shaum’s outline of theory and problems of machine design. McGraw hill, New York, Pg.290-300
- Khurmi,R.S., and Gupta, J.K. (2005) A textbook of machine design. Eurasia publishing House (PVT)Ltd. New Delhi, Pg728-758
- Marcel D., (2003), Bearing design in machinery, ISBN: 0-8247-0703-6, published by Marcel Dekker, Inc. Available: <http://www.dekker.com>
- [www.aphlis.net/downloads/Postharvest-losses-report.pdf](http://www.aphlis.net/downloads/Postharvest-losses-report.pdf) 14<sup>th</sup> October, 2013.
- Shigley, J. E. and Mischke, C. R(2008): Mechanical engineering design(9<sup>th</sup> ed). McGraw-Hill Companies, Inc.New York, Pg860-878.
- The Case of Postharvest Grain Losses in Sub-Saharan Africa 2011, the International Bank for reconstruction and development.

Virgilio Rodriguez and Asociados, (2011): Tamil Nadu Agricultural University

Y.B. Byaruhanga and J.C. Auko, (2002): Challenges and prospects for processing and utilization of traditional grains in uganda