Design and Development of Milling Machine for the Production of Adlai (Coix lacryma jobi L) Grains

Asia Pacific Journal of Multidisciplinary Research
Vol. 3 No. 4, 93-99
November 2015 Part IV
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

Ma Jesukristina C. Medina[1], Marielli Katherine C. Untalan[2], Princes Bonnieddie Kay R. Caliva[3], Hazel Ann C. Gayeta[4], Sunshine Lyn C. Guevarra[5]
Batangas State University, Batangas City, Philippines
[1]majesukristinamedina@gmail.com, [2]ryleeryu@gmail.com

Date Received: September 30, 2015; Date Revised: November 2, 2015

Abstract- *The developed prototype was mainly designed for the production of Adlai grains. The purpose of the study was to construct a machine that could help farmers in milling the Adlai seeds (Pulot and Kiboa) for an immediate production of adlai grains. Parameters were considered such as size, water content, hardness and density to determine its effect in the milling process of Adlai. Moreover, Kiboa seed that showed a higher value in analysis of hardness, water content and density which was 6.87%, 11.69% and 566.37g/cm^3 respectively produced a higher yield in production than Pulot variety which exhibit only 9.42%, 11.25% and 476.25 g/cm^3 respectively.*

A comparative study was conducted with a commercial milling machine to test its efficiency in terms of machine productivity. The result showed that Adlai milling machine could mill 57% in 2 min 37 sec for Kiboa and 45% in 2 min 38 sec for Pulot while rice miller machine milled 54% in 4 min 28 sec for Kiboa and 46% in 3 min 11 sec for Pulot. The average percentage yields of both machines are comparable to each other. Based on the statistical treatment conducted, there was no significant difference between the Adlai miller and commercial rice miller in terms of yield and operation time. However, the operation time used as data for rice miller was attained after the seed was reprocessed. Therefore the developed prototype was more applicable in the production of Adlai grains.

Keywords: *Adlai Milling Machine, Rice Miller, Adlai, Pulot, Kiboa*

INTRODUCTION

Rice is the staple for most Asians most especially Filipinos. Some of the Filipinos eat rice at least 3 times a day. It is proven that almost 80 percent of the Filipinos spend one-fourth of their income on rice alone [1].

On the production side, rice is the most extensively grown crop in the Philippines, planted in 30 percent of the total agricultural area in the country [2]. Rice farming also provides more than half of the household income for two million families. Due to its importance in the economy, rice has historically been the focus of the government's food security policy [3].

There are many threats to corn and rice production. To mention, there were few conversion of agricultural lands to other uses, pests and diseases, and the ever increasing price of crude oil that also leads to higher fertilizer prices which, in return, is synonymous to higher cost of production[1]. Moreover, erratic weather condition, farmers faced uncertainty in production. Growing of hybrid palay is not widely adopted despite farmers' knowledge and its availability in the province. The common constraint of farmers was lack of capital, high input cost and prevalence of pests and diseases. The farmers' production problems were related to technology, capital needs and marketing. Due to industrial revolution, many agricultural lands are converted to commercial lands such as subdivision and industrial plants. All of these are the major factors why Philippines is suffering from rice shortage and lead to import rice from other rice-producing country.

These are just a few of the reasons why we need to look for alternatives to the rice and corn crops. Sooner rather than later, we have to find ways to meet the national cereal requirement on top of rice and corn production.

The development of rice varieties involves the use of biotechnology and conventional breeding techniques to create cultivars that are suited to various production ecosystems in the Philippines such as irrigated and favorable rainfed lowlands, rainfed uplands, cool and elevated areas, and saline-prone areas. A nation-wide testing of these varieties is also conducted to assess the yield stability and suitability to the target environment. Recent breeding activities also include biofortification wherein genetically engineered traits such as richness in Vitamin A and iron are transferred to locally adaptable varieties [4].

The Bureau of Agriculture Research (BAR) is studying the possibility of introducing *adlai* as an alternative crop to rice and corn and not just a material for beads, necklaces and curtains [1].

Adlai is more nutritious than rice and corn, for it is high in protein and also contains calcium, phosphorus, iron, Vitamin A, thiamine, riboflavin and niacin. It helps enhance/increase food biodiversity. It is tolerant to pest and diseases. It only requires a single land preparation and planting but you can harvest 3-5 times, and there is no need for irrigation. It is resilient to drought and flood. One round of weeding is enough and does not require chemical synthetic fertilizer application. Farmers will be empowered with the introduction of a new low input-requiring crop [5].

Since Adlai plantation was recently launched, there are certain difficulties in the production of Adlai products regarding to the equipment that can be used. They use the rice miller to separate the coating of the grains. Unfortunately, it would take 3-4 times to remove the hull from its grain. The purpose of this study is to construct a machine that could help farmers in milling the Adlai seeds to have an immediate production.

A comparative study was conducted with a commercial milling machine to test its efficiency in terms of machine productivity. This study is mainly focused on the design and development of Adlai milling machine. Different factors were considered in conducting the design including the cost, capacity, economic aspects, and availability of the material. Specifically, the study aimed to determine the comparison of the physico-chemical properties of the two varieties of adlai seeds (pulot and kiboa) in terms of density, hardness, moisture content of adlai seeds to determine its effect on milling. Also, moisture content and size was determined after the grain was produced .There is a statistical analysis that can prove the effectiveness and efficiency of the prototype. A comparative discussion about the difference of the designed prototype and the commercially available rice miller in their end products in terms of the operation yield and operation time [6].

OBJECTIVES OF THE STUDY

This study aimed to design and develop an Adlai Miller machine. Specifically, it aimed to determine how do the properties of two varieties of Adlai (Kiboa and Pulot) compare in terms of size, water content, hardness and density; to determine the design parameters to consider in the development of a Adlai Miller machine based on System components, Material specifications, and Energy requirement; to determine how do the end product of the rice miller machine and Adlai miller machine compared in terms of Operation time and Percentage yield. The study also tested the difference as to the acceptability of the milled Adlai using the developed prototype in terms of Size and Moisture content. It also determined the operating and maintenance procedures that can be developed for the Adlai milling machine.

METHODS

Research design

The developed prototype was mainly designed for the production of Adlai grains. The important factors that were considered for the development are the materials of construction and its production rate as determined by the yield. A comparative study was conducted with a commercial milling machine to test its efficiency in terms of machine productivity.

General Considerations

There were many properties of seed that was considered for the developed prototype. Different parameters are considered such as moisture content, hardness, density and its size. Grains respond differently to applied forces depending on their moisture content. When a grain is dry, it is hard and brittle, and applied forces break it into angular-shaped pieces and very fine particles. The grain starts to deform in an elastic manner as more force is applied. Further force causes some deformation before the grain fractures or breaks. This is caused by the propagation of cracks which are normally the points of contact.

When the level of moisture content is high, the result would make the grains relatively soft and deforms to some extent elastically when pressure is applied. As the force on the grain is increased, a moist grain is capable of retaining more plastic deformation than a dry grain before it breaks.

Fractures are caused by cutting, sawing, tearing and abrasion they are only a combination of cut and compression. A dry grain shatters in a random matter when compression and cut is applied. The grain then breaks into coarse chunks, some fine particles and very fine dust. Dry grains do not deform when grinding forces are applied, but they produce cracks that eventually lead to grain failure. [7]

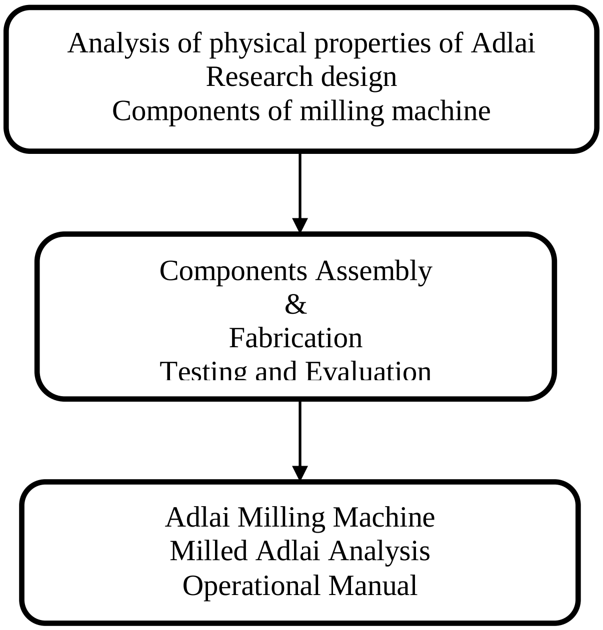

Fig. 1 Process Flow Diagram

Preparing the Adlai Miller Set up

The researchers considered the following procedures to operate the prototype.

- Check all the parts of the machine. Be sure that will all parts are tightly screwed.
- The roller's axis must be in perfect line with then of center and shaft.
- The roller surfaces must be aligned and must be keep equal distance while rotating.
- Check the electrical wiring before starting the operation.

Design Methodology

General Functions of the Prototype

The major function of the prototype is the milling of Adlai. It is made to improve the digestibility of the grain for human consumption. The aim of milling for human consumption is to produce a whiter polished grain which was more appealing to the consumers. The machine works by breaking the coat of the seeds to remove the hull and polished for consumption

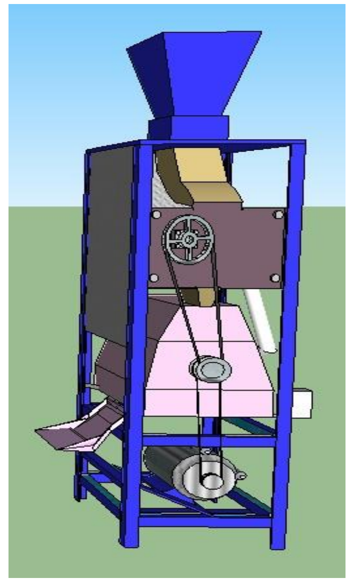

Fig. 2 Front view

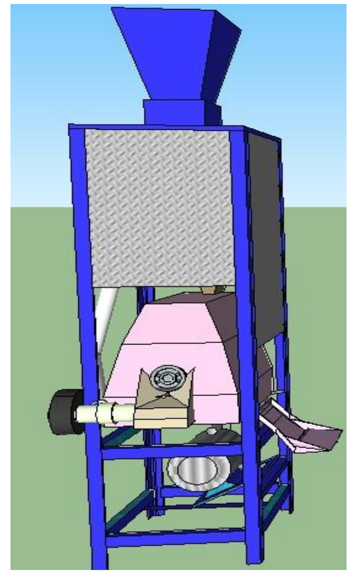

Fig 3. Back view

Parts of the Prototype

Electric Blower - The ½" electric blower used for the prototype and produces flow of air inside the machine. It is highly efficient, energy saving, has low noise, light and very convenient to use. [8]

Motor used for the prototype has ½ hp. It produce right amount of power the machine needed [8].

Grain Polisher - The polisher used for the prototype is 160 x 116 mm. Used to polish the rice to remove the remaining hull [9].

V-belt - prevents ply separation of the belt composition due to flexing over small pulleys [10].

Fabrication and Assembly

The machine fabricated was constructed at G-Force machine shop where an expert fabricator was hired to build while the researchers observed the machine fabrication to ensure that the proper set –up of the Adlai miller was followed.

Testing and Operation

Testing of the machine was immediately followed after the fabrication of the prototype. Testing was done to determine the efficiency of the miller.

To operate the machine the Adlai grains must be dried first under direct sunlight until it contains only 13% moisture [11]. The grain that will be loaded in the feeder must be controlled depending on the adjustment of the rubber rollers. Rubber rollers are adjusted based on the way the grain should be mill. Proper attachment of screw to the polisher must be done to assure the appropriate cleaning of the grains.

Cleaning and Maintenance

- In cleaning the machine, detachment of the roller box is needed to remove the brans that are blocked inside the box.
- When cleaning the polisher housing it is recommended to use air compressor to easily eliminate all the brans inside the polisher housing.
- While changing the rolls, the bigger roll should always be mounted to the fast moving shaft.
- The huller should not be run with the rolls engaged without feed on the huller.
- When turned off there should be no grains between the rollers because they would deform the rubber.
- When rubber rollers are replaced, it should make sure that their end faces are in line.
- The miller should be cleaned after every day of operation.

Design Computations

The study involved the milling yield of the prototype to produce Adlai grains. These will be constructed from these data.

Milled Rice Yield (MRY) refers to the amount of polished white rice obtained from unhusked rough rice [12]. It is calculated as follows:

$$\text{MRY} = \frac{M_{milled}}{M_{rough}} X100 \qquad \text{(Eq.1)}$$

Where: Mmilled rice = all kernels in a sample, includi ng head rice and broken, after milling (removal of bran); Mrough rice = all kernels in sample, prior to dehulling.

Density

The mass density or density of a material is its mass per unit volume. The symbol most often used for density is ρ (the lower case Greek letter rho). Density of adlai seed is computed using the following formula:

$$\rho = m/v \qquad \text{(Eq. 2)}$$

Where ρ is the density, m is the mass of the adlai grains contained in a specified volume (v) of the beaker [13].

Statistical treatment

The study utilized two sample t-test for independent samples for the comparison of the percentage yield and operation time of commercially available rice miller and the designed Adlai miller using the two varieties of Adlai[14]. Results obtained in the study were subjected to the statistical analysis mentioned for their mean difference. Results of the analysis were interpreted for the acceptance or rejection of the hypothesis.

RESULTS AND DISCUSSION

Physicochemical Characteristics of Adlai Seeds

Table 1. Determination of physico-chemical properties of adlai seeds

Adlai Seeds	Mean Values			
	Density (kg/m3)	**Hardness (%)**	**Size (mm)**	**Water Content (%)**
Pulot	476.25	9.42	7.7 x 6	11.25
Kiboa	566.37	6.87	6.4 x 5	11.69

Size

Size is an important component of grain yield and quality. This refers to how big or small the seed is. Measurement is the process or the result of determining the magnitude of a quantity such as length and width relative to a measurement such as meter or kilogram [15].

Based on table 1 the average size of the Pulot seed is 7.7mm x 6mm and the average size of Kiboa seed is 6.4mm x 5mm. The result shows that the Kiboa seeds are smaller than the Pulot seeds which could be used to determine their physical differences. The results are obtained by using Bernier Caliper. In samples stratified for grain size, there was consistent positive correlation between seed size and milling time. The larger the seed size the greater the force exerted,

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 4, November 2015

increases the speed of the miler and longer period of time to mill the seeds.

Water Content

Water content or moisture content is the quantity of water contained in a material. It is used in a wide range of scientific and technical areas, and is expressed as a ratio, which can range from zero (completely dry) to the value of the materials' porosity at saturation. It can be given on a volumetric or mass (gravimetric) basis [15].

The average water content of Pulot seeds is 11.25 percent while the Kiboa seeds contain an average water content of 11.69%. The value obtained shows that the seeds are applicable for milling since the required water content is 12%. The values are obtained by using oven method on dry basis and Halogen lamp moisture analyzer at the laboratory of JetStar Manufacturing Corporation. The Paddy is at its optimum milling potentials at water content of 12%. Grains with higher moisture content are too soft to withstand hulling pressure which will result in grain breakage. Grain that is too dry becomes brittle and has greater breakage. Some problems may occur to incomplete drying of seeds such as heat build up in the grain, mold development, insects infestation, discoloration or yellowing, loss of freshness, odour development and reduce yield. Based on the statistical treatment conducted, there is no significant difference between the two varieties on their moisture content.

Hardness

Using the AACC Method 55-30, the value obtained by the Kiboa seeds is 6.87% and for Pulot is 9.42%. Based on the table of Relative Hardness Scale, Kiboa is extra hard while Pulot is very hard because the lower the value that the seed will obtain result to a harder texture of the seed. The analysis was conducted by using the machine of San Miguel Mills Laboratory. Cleanliness of separation of endosperm from bran, moisture level tolerance, and the reduction of endosperm are the reasons in determining the hardness of the seeds. The harder the seed the more energy the machine will consume due to its resistance to cracking.

Based on table 1, the value obtained by the Pulot is greater than that of the Kiboa Seeds but based on the Relative hardness Scale, the lower the value the harder the seed was.

Density

The average density of the Pulot seed is 476.25 kg/m^3 and Kiboa seeds are 566.36 kg/m^3. The values of density are obtained by dividing the weight of the seeds by the volume of the tare beaker in the analytical balance [13]. The obtained densities are in g/ml, conversions are applied to obtained density value. The density is directly proportional to hardness thus higher the density the harder the seed was. Based on the statistical treatment conducted, there were no significant differences between the two varieties on their density.

Physicochemical Characteristics of Adlai Grains

Table 2 Size and Moisture Content of Adlai grains

Variety	Mean Values	
	Size (mm)	**Moisture Content (%)**
Kiboa	5.8 x 4.03	9.98
Pulot	5.7 x 4.1	14.99

Size

Using Bernier caliper to measure grain size after milling seeds in the developed prototype, Pulot variety had an average size of 5.7mmx4.1mm and Kiboa variety is 5.8mm x 4.03mm. The grain size of both variety are similar. Even though the size of Kiboa seeds are smaller it produces grains that have the same size with Pulot seeds.

Moisture Content

The average moisture content of the grains after it was milled is 14.99% for Pulot while for Kiboa grains is 9.98%.As the seeds undergo milling process the average moisture content of the produced grains for Kiboa is lower at the same time as for the Pulot is higher. Based on the statistical treatment conducted, there was no significant difference between the two varieties on their moisture content.

Energy requirement

The energy needed of the machine to mill the Adlai will consume is 1.5 Hp motor of 2200W where the rubber roller consume 0.04 Hp of power while the polisher consume 0.06Hp of power.

Table 3 shows the comparison of Adlai Miller to Commercial Rice Miller. The result shows that there is a discrepancy between the yield produced by the adlai miller and rice miller.

Table 3 Comparison of adlai miller and Commercial Rice Miller

	Mean Values			
	Adlai Miller		Rice Miller	
Adlai Grains	Operation time (s)	Percent yield (%)	Operation time (s)	Percent yield (%)
Pulot	158.67	45	191	46
Kiboa	157	57	267.67	54

The adlai miller produced a smaller yield in milling Pulot variety while it produced a greater yield in milling Kiboa variety. In terms of percentage yield, the adlai miller produced an average of 57 percent for Kiboa and 45 percent for Pulot while the rice miller produced of 54 percent and 46 percent respectively. As a result in operation time, Adlai miller had recorded an average time of 2min 37sec for Kiboa and 2min 38sec for Pulot compared to the rice miller that had an average operation time of 4min 28sec and 3min 11sec respectively. The time recorded for rice miller is after the Adlai undergo milling twice to remove the third coating. As a result the Adlai miller machine consumed less time to produce Adlai grains than that of rice miller. Based on statistical treatment conducted, there was no significant difference on the percentage yield and operation time between the Rice miller and the Adlai Miller.

CONCLUSION AND RECOMMENDATION

Based on the result and the data acquired from the performed tests analysis on the physical properties including density, size, hardness, moisture content of Adlai seeds the proponents concluded that Kiboa is smaller in size, harder, higher in moisture content and density than Pulot. It is more suitable in milling than Pulot using the designed Adlai Milling Machine. Upgrading the machine by adding a sensor for the Adlai grains, that can separate each Adlai with the same size, weight, and hardness. Then the reject will be discarded was recommended.

The Adlai milling machine was designed by taking into consideration the system components, material specifications, energy requirement, these factors are required to be used by the machine. By testing the machine, the proponents concluded that the chosen materials used were applicable in the designed equipment. The proper use of each component contributes to the efficient performance of the whole machine. The use of 1.5 hp motor supplies enough electrical power to run the machine and crack the seeds simultaneously thus a switch of the motor to control the speed of the Adlai miller.

Adlai miller produced a greater number of yields in Kiboa than that of the rice miller but lower in number of yield in Pulot. The yields prove that the Adlai miller machine milled was 57% in 2min 37sec. and 45% yield in 2min 38sec. And the rice miller machine milled was 54% in 4min 28 sec and 46% in 3min 11 sec. The average percentage yields of both machines are comparable to each other. However, the, operation time in using rice miller was attained after it was reprocessed. Adjustment of screw blade for better polishing was recommended.

In terms of sizes of the grain produced by the developed machine, it says that there was no differences in the size of the grains. The amount of their moisture content in the grains differs. As a result, the Pulot has higher moisture level after milling while Kiboa results to lower moisture level in grains. Therefore, it is proven that Kiboa is better to use in our machine to mill. For an increase in the percentage yield of the Pulot, the two free wheel rubber roller should have an individual adjustor.

REFERENCES

[1] Velasco, A. A. (2010). Exploring the Potentials of rice-like Adlai, BAR Digest , 12 Nos. 3-4

[2] Dawe, D.(2006). "The Philippines imports rice because it is an island nation." In Why does the Philippines imports rice?, by D. Dawe, P.F. Moya and C.B. Casiwan, 3-8. Manila: International Rice Research Institute.

[3] David, C., & Balisacan, A. (1995). Philippine rice supply and demand: Prospects and policy implications. Discussion Paper Series No.95-28, Makati: Philippine Institute of Development Studies.

[4] Sebastian, L.S., Bordey, F.H. & Alpuerto, V.L.E.B. (2006). Research and development." In Securing rice, reducing poverty: Challenges and policy directions, by A.M. Balisacan and L.S. Sebastian, 39-69. Los Banos: Southeast Asian Regional Center for Graduate Study and Research in Agriculture

[5] Alenton, A.B., Unpopular yet Vital: The Agkod and the Aglay/Adlai of the Higaonons 2013/www.businessweekmindanao.com/

[6] Wimberly, J. (1983). Technical Handbook for the Paddy rice Postharvest Industry in Developing Countries p115-140

[7] Huelgas, R. R., Manuel, P. C., & Gabriel, E. S. (1990). Socioeconomic study on peanut production in the Philippines. *Book Series-Philippines Council for Agriculture, Forestry and Natural Resources Research and Development*, (90).

[8] Mechanical design of a desktop milling machine for fabrication in an introductory machining class, Schneider, 2010
[9] Non-intrusive Monitoring of Milling Process, Su, 2010
[10] Waste Minimisation and Cleaner Production in Rice Mills, Kumar
[11] Guide Book for Rural Cottage Small and Medium Scale Industries Paddy Rice Cultivation, Vol. 1
[12] Comparison of different rice milling methods, Afzalinia et al., 2002
[13] ASA (American Soybean Association), Manual of Feed Microscopy and Quality Control, 3rd edition, 1999
[14] RNAM Test Codes & Procedures for Farm Machinery BAR, 2010
[15] Webster, M. (2005), 21st Century Encyclopedic Dictionary