# DESIGN OF MANGOSTEEN FRUIT PULPER MACHINE AS AN INNOVATIVE SOLUTION TO INCREASE THE VALUE-ADDED OF MANGOSTEEN

**[1]ROSYID RIDHO, [2]WAWAN HERMAWAN, [2]USMAN AHMAD**

[1]School of Business IPB (SB-IPB), Bogor Agricultural University
[2]Department of Agriculture and Biosystem Engineering, Faculty of Agricultural Technology
Bogor Agricultural University, Jl. Flora No.1 Bulaksumur, Indonesia
Email: [1]rosyid.data@gmail.com, [2]wawanhermawan, [3]rosyid.data@gmail.com

**Abstract:** Research procedure includes identification of physical characteristic of mangosteen seeds, development and evaluation of mechanisms for separating pulp and seeds of mangosteen fruit, engineering design, manufacturing, and performance testing. Three mechanisms were developed and analyzed in order to separate the seeds and pulp of the mangosteen fruit: 1) a horizontal cylinder mechanism with a rotating brush, 2) a mechanism of a vertical cylinder with a rotating brush, and 3) a vertical cylinder with a stationary brush. These three mechanisms use four brushes. The separating cylinder has a length of 40 cm and a diameter of 20 cm. The separating cylinder and cylinder cover and the shaft are made of stainless steel. This mechanism is manually moved by crank. The material used in the model test is a large group of mangosteen fruit category with fruit diameter> 6.5 cm; fruit weight> 140 and medium group with fruit diameter 5.5-6.5 cm; weight fruit 70-140 g. Test material for model is a mangosteen fruit without peel. The evaluation result using Analytic Hierarchy Process showed that the horizontal cylinder mechanism with a rotating brush was the best mechanism for separating process to be implemented. The results of analysis using AHP showed that the mechanical separation horizontally with spinning brush blade is the best mechanism of the three existing models. This is expressed as a percentage of 47.5% for the mechanism. The model is reference for made a prototype. A prototype of a separating machine using the mechanism was made and tested. Performance testing on the prototype using mangosteen fruit obtained from the mangosteen peel processing industry in Bogor From the test results are known capacity proces is 157.3 kg / hour while the ouput capacity is 93.5 kg / hour. The process of separation of seeds and pulp of mangosteen fruit successfully done without the broken seeds.

**Index Terms:** Machine, Mangosteen Fruit, Pulp, Seeds, Separation.

## I. INTRODUCTION

Mangosteen (Garcinia mangostana L.) is one of Indonesia's main fruit commodities. Since the 1970s until now export demand continues to increase, so it can be said that the mangosteen fruit is a leading export that became the mainstay of Indonesia. The contribution of mangosteen fruit exports is enormous in order to increase the country's income and farmer's income (Qosim 2007 in Qosim 2013). In 2008 the export volume reached 6 million tons of mangosteen fruit worth US $ 3 611 995. But the amount is considered not to 10% of total production (Yatman 2012). In 2014 mangosteen production reaches 114 755 tons with an average of 7.55 tons / ha (Directorate General of Horticulture Ministry of Agriculture 2015). The mangosteen production rate from 2010-2014 amounted to 13.82% (Ministry of Agriculture 2015).

Mangosteen fruit consists of components such as fruit seeds, fruit flesh (pulp) and fruit peel. Utilization of mangosteen flesh is quite a lot, among them as raw material for making syrup, juice, jam, jelly, and puree (Utami, 2008). Examples of high-value processed products include: mangosteen juice (US $ 20 per liter); Extract mangosteen (US $ 12.64 per 60 tablets); Mangosteen tablet (US $ 3.59 per 30 tablets); And mangosteen xanthone rich (US $ 12.98 per 60 tablets) (Kastaman 2007).

Separation of seeds and pulp in general has not been done mechanically and systematically. In fact, if we look further, there is a need for a separation system of meat and pulp to produce mangosteen juice that can be consumed and high economic value. The nutrient composition of the mangosteen pulp per 100 grams includes 79.2 grams of water, 0.5 grams of protein, 19.8 grams of carbohydrates, 0.3 grams of fiber, 11 mg of calcium, 17 mg phosphorus, 0.9 mg of iron, 14 IU of vitamin A, 66 mg vitamin C, vitamin B (thiamine ) 0.09 mg, vitamin B2 (riboflavin) 0.06 mg, and vitamin B5 (niacin) 0.1 mg (Kwatiningsih 2009).

The need of mangosteen processing machine is important considering the increasingly widespread of creative industries processing mangosteen fruit is more profitable than just selling the fruit. Through the optimum fruit and mangosteen separator machine is expected to grow the creative industries of the producers of household mangosteen juice. Thus, the mangosteen fruit is no longer consumed in the form of fresh fruit that produces waste and is exported in the form of raw materials, but can already be processed into high-value processed products.

Separation of seeds and mangosteen pulp became one of the problems in increasing the development of the utilization of mangosteen fruit for household scale industries. One of the innovations in solving this problem is the presence of fruit and mangosteen fruit separator machine. Difficulties in the process of separation of seeds and mangosteen pulp caused by

the characteristics of the flesh that is attached to the seed of the mangosteen fruit. The fruits and mangosteen fruit separator machines are still producing broken seeds in the process of separation. This will decrease the quality of the resulting pulp. Therefore, a mechanism capable of separation of mangosteen seeds and pulp is required without damaging the seeds of mangosteen fruit and high yield. The objectives of this research were 1) to analyze and obtain the best mechanisms for separation of seeds and pulp of mangosteen fruit, and 2) to manufacture and test a prototype of the separating machine.

A machine for separated mangosteen seed and pulp was created, but it still has several things to be developed including low capacity and in the process of separation of mangosteen seeds and pulp still contained high percentage of broken seeds. The existence of the broken seeds mixed with the pulp will reduce the quality and content of pulp nutrients. Therefore, it is necessary to find a better mechanism for the separation of pulp and seed of mangosteen, which can be obtained by design of separator machine which has better performance.

## II. METHODE

The best model selection process is selected by using Priority Estimation Tool (Priest) software for decision making using AHP (Analytic Hierarchy Process) method. The criteria used in decision making using AHP are 1) power used, 2) manufacturing time, 3) complexity, 4) manufacturing cost, and 5) pulp percentage. Weighting on AHP is done on a scale of 1-5. Weight of 1 means equally important, weight 3 means a little more important, weight 5 means very important, and weight 2 or 4 is adjacent assessment.There are three mechanisms performed by the test are 1) The horizontal mechanism with the blades of the brush spinning, 2) the vertical mechanism with the blade of the rotating brush, and 3) the vertical mechanism with the silent brush blade.From the results of analysis using AHP found that The horizontal mechanism with the blades of the brush spinning is the best mechanism of the three existing models

Performance testing is done by using the material in the form of mangosteen fruit stripping results, with the amount of processing materials are: 1 kg, 2 kg, 3 kg and 4 kg. The material is put into the machine, then the engine is operated with 148 rpm. Rotation speed is measured using a digital tachometer. The resulting pulp is accommodated in the container, as well as the outgoing seeds are accommodated in different containers. Then, measured: 1) the length of time required for the separation process, 2) the weight of pulp and seed produced per process, and 3) the effectiveness rate of separation of the pulp was calculated. Each treatment was tested with three replications. The separation capacity is obtained by measuring the weight of the material successfully processed and the time required.

The weight of potential contained pulp is done by measuring the pulp content in one kilogram of seed and the mangosteen flesh. The seeds and flesh of the mangosteen that has been peeled weighed weighing 1 kg as total weight. Mangosteen meat is then cleaned from the seeds so that the remaining seeds of mangosteen fruit is clean without meat. The seed of the mangosteen is weighed. The difference from the total weight by the weight of the seed is the weight of the potential pulp contained. This potential weight measurement was performed using small group mangosteen fruit. Seed quality greatly affects the effectiveness of separation and quality of the pulp produced.

## III. RESULTS AND DISCUSSION

This separation process takes place due to the friction between the mangosteen fruit and the friction with the inside of the separating cylinder and the friction between the brush and the mangosteen fruit. The machine successfully produces the mangosteen pulp through the process of separation of seeds and mangosteen pulp. The mangosteen pulp exits through small holes in the separating cylinder and exits through the output door which has been designed for the mangosteen pulp. As for the seeds of mangosteen fruit pushed toward the output door which is designed for the seed of the mangosteen fruit.The separation data can be observed in Figure 1.

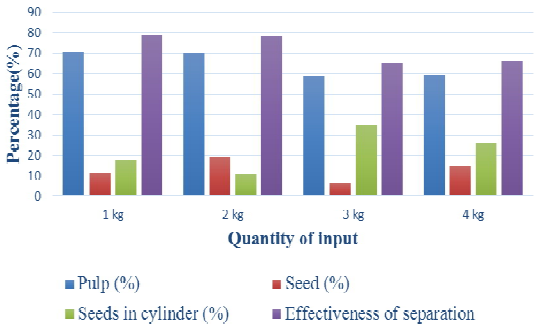



**Figure 1: Results of separation**

From Figure 1 it can be observed that the pulp generated from the separation process has a value of> 50%. The highest percentage of pulp was produced at the time of separation by using 1 kg material that is equal to 70.6%. The maximum potential that should be obtained is 89.5%. This can be seen with the presence of pulp attached to the seeds. The maximum potential pulp obtained due to the lack of maximum cleanliness of the separated pulp. It can be taken from the amount of slimy seeds that still exist by 62%. The workable solution to solve this problem is by extending the separator cylinder and accelerating the speed of play. Thus, the friction that the material will receive will be higher. The time taken to separate the

seeds and meat of the mangosteen fruit with a 1 kg feed is 22.8 s, 2 kg takes 46.2 s, 3 kg takes 66.3 s, and 4 kg for 89.2 s. The time is measured when the seeds and the meat of the mangosteen are inserted into the separator until all the pulp is out of the output door.

The remaining seeds are retained in the cylinder and the brush separator for the working process ≥ 3kg is ≥ 1 kg. This is caused by the attachment of the seeds in the separation brush cavities. So the modification of brush shape and estrangement becomes important to consider. Some modifications that can be done are to increase the size of the brush, using a brush with a more flexible material, and reduce the thickness of the brush. Brush modifications also need to be done in the slope, so the brushes not only serve to separate the fruit and flesh of mangosteen fruit, but also to direct the seed of the mangosteen fruit to the output door. The material used and the separation pulp can be observed in Figure 2.

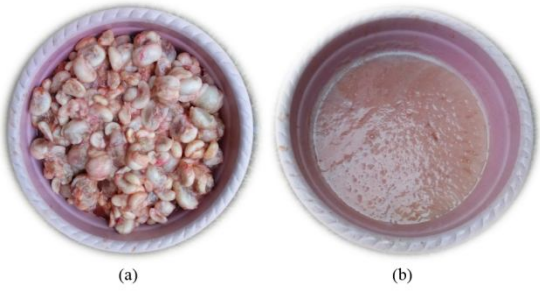



**Figure 2 (a) Material and (b) Pulp of the mangosteen fruit of the separation result**

The average time required to separate 3 kg of mangosteen fruit is 68.6 s, so the capacity is 22.8 kg / s (157.3 kg / hour). The effectiveness rate of separation ranges from 66% to 78%. Mangosteen fruit seeds separation results are divided into two, namely the seeds are perfectly clean and the seeds are still covered with pulp. In this separation process there are no broken or split seeds, so the resulting pulp is not polluted by the seed chips. This can increase the quality of the resulting pulp. The percentage of pulp-covered seeds is 62% while the perfect clean pulp is 38%, and no seeds are broken.

## CONCLUSION

Three separation mechanisms are modeled and tested are: 1) horizontal cylinder with rotary brush, 2) vertical cylinder mechanism with rotary brush, and 3) vertical cylinder mechanism rotating with a silent brush. The three models succeeded in the process of separation of beans and mangosteen fruit flesh. The separation mechanism with the horizontal model and the rotating brush is the model with the highest recommendation of 47.5% using the Hierarchy Process Analysis method. The model became the basis for making prototype of mangosteen pulper machine. The prototype of mangosteen pulper machine has engine capacity of 157.3 kg / hour while the ouput capacity is 93.5 kg / hour. The process of separation of seeds and meat of mangosteen fruit successfully done without the existence of the beans. The resulting pulp color difference is caused by the time difference of the material before the test and at the time of measurement. This machine can be a technology to support the development of household-scale mangosteen processing industry.

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