Mechanization of Growing Media Preparation and Poly Bags Filling In Oyster Mushroom (*Pleurotus ostreatus*) Cultivation

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Abstract
Preparation of saw dust as the growing media and filling it into poly bags are the most laborious operations of mushroom cultivation in Sri Lanka. Saw dust is used as the main substrate; it should be sieved well to get fine particles and mixed properly with the other essential nutrient ingredients and water. The purpose of this research was to find an appropriate mechanical solution to prepare the saw dust based growing media and filling of growing medium into transparent poly bags for artificial cultivation of Oyster mushrooms. A power operated machine with three separate units; saw dust sieving unit, ingredient mixing unit and mixture filling unit were designed and fabricated. An electric motor was used as the power source for all three units. The integrated filing and compaction of the mixture filling unit is the most salient feature of this machine. The performance of the machine was evaluated compared against the manual preparation by a skilled laborer using well dried mango saw dust and other recommended ingredients. Machine capacity of the sieving unit and sieving efficiency were 212 kg/hr and 84%, respectively while the corresponding figures of manual sieving were 145 kg/hr, and 76% respectively. The capacity of the mixing unit and the mixing efficiency were 323 kg/hr and 67%. In manual mixing, the corresponding values were 162 kg/hr and 70 %. The capacities of the mixture filling unit and filling efficiency were / 81 bags/hr and 83%, respectively compared to the manual filling where those corresponding values were 32 bags/hr and 72 % respectively. According to the results, this machine can effectively replace the manual sieving, mixing and filling of mushroom growing medium in oyster mushroom cultivation.

Keywords: Integrated filling and compaction, Mechanical mixing, Mechanical preparation, Mushroom production
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Introduction

Farming of various kinds of mushroom has become popular in Sri Lanka which gives a profitable self-employment. Most of the mushroom growers in Sri Lanka use saw dust based media filled poly bags in oyster mushroom cultivation (Ranathunge *et al.*, 2010). Preparation of saw dust as the growing medium and filling into poly bags are the most difficult operations of the mushroom cultivation process and quality of the filled bags is highly effected by the skill of the person. As mushroom cultivation is a self employment in Sri Lanka, almost all the activities of the cultivation process are undertaken by the owner and family members without hiring labor in order to reduce the production cost. On the other hand, it is very difficult to find out laborers on temporary basis for high labor intensive activities. Therefore, the production has been limited to a certain extent according to the capacity of family members who can manage the activities. Due to all these problems, most of the mushroom enterprises of Sri Lanka have been categorized as small scale enterprises. Despite of bringing lot of problems with the manual mixing and filling, there is no any designed device available in Sri Lanka for growing media preparation and bag filling. Therefore, by appropriately mechanizing the mushroom cultivation, young generation can be attracted to the industry and there is a potential for popularizing it as a suitable self employment for educated people as well. Therefore, the general objective of this study was to mechanize the media preparation and poly bag filling in oyster mushroom cultivation in order to increase the profitability by reducing the labor cost. The specific objectives were to design, develop, fabricate, test and evaluate the performance of the saw dust sieving unit, ingredient mixing unit and mixture filling unit compared with manual methods and to carry out an cost benefit analysis.

Materials and Methods

Designing and fabrication of the machine were carried out at the engineering workshop of the Faculty of Agriculture, Rajarata University of Sri Lanka. It was decided to mechanize the media preparation process in three separated units;

saw dust sieving unit, ingredient mixing unit and poly bag filling unit. Affordability, durability, high efficiency, easiness for maintenance and repairs at village level and ergonomics principles were considered when designing each unit (Khurmi and Gupta, 2006). Some physical properties of saw dust and other ingredients were considered for the determination of optimum dimensions of the components.

Performances of the machine were evaluated, compared with manual methods using well dried mango saw dust and other ingredients. According to the recommendations of the Department of Agriculture, 200 g of powdered soya bean, 40 g of Magnesium sulphate, 400 g of Calcium carbonate, 2 kg of rice bran were used with 20 kg of saw dust for the preparation of growing medium. Five replicates for each mechanical methods and manual methods were used. A manually operated sieve which is equal to the area of the mechanical sieve was used to compare with the performance of the mechanical sieve. A skilled labor with 4 years experience in mushroom production was used for the experiment. At each and every trial, time taken to sieve 4 kg of saw dust (t_1), time taken to sieve 20 kg of saw dust (t_2), time taken to mix the ingredients with 20 kg of saw dust (t_3) and 100 kg of saw dust (t_4), time taken to fill one poly bag (t_5) and number of poly bags filled within one hour (n_1) in both mechanical and manual methods were recorded. Average values of every trial were calculated and following equations were used to calculate the actual and theoretical capacities and efficiencies of each method (Roth *et al.*, 1975).

Theoretical sieving capacity(kg/hr)(TS)	$= \{4/ t_1\} \times 60$
Actual sieving capacity (kg/hr) (AS)	$= \{20/ t_2\} \times 60$
Theoretical mixing capacity (kg/hr) (TM)	$= \{20/ t_3\} \times 60$
Actual mixing capacity (kg/hr) (AM)	$= \{100/ t_4\} \times 60$
Theoretical filling capacity (bags/hr)(TF)	$= \{1/ t_5\} \times 60$
Actual filling capacity (bags/hr) (AF)	$= n_1/ 60$
Sieving efficiency (SE)	$= (AS/TS) \times 100$
Mixing efficiency (ME)	$= (AM/TM) \times 100$
Filling efficiency	$= (AF/TF) \times 100$

Results and Discussion

Although, the machine comprise of three separate units, each unit can be coupled with the same power source when it is required. Belt and pulley power transmission system support to connect with the electric motor easily and protect the motor from adverse loadings. The working principle of the sieving unit is converting angular motion of motor into linear motion of the sieve by the mean of a crank shaft. Mixing unit is equipped with a rotating drum comprised with mixing plates and it is coupled with the electric motor. Mixture filling unit is working with a hammer moving up and down which help to convey the mixture from hopper to poly bags and apply required force to compact the mixture. A spring loaded stage provide a top to place the poly bag while filling and it help to control the degree of compaction. The production cost of the machine without labor cost was Rs. 67000.00. The performance parameters during the machine evaluation of both mechanical and manual methods are given in Table 1.

Because of the sieving process is a continuous process, operator has only to fill the unsieved saw dust on to the mesh. But in manual method, operator has to fill, agitate and unload the residual particles. Therefore, the capacity and efficiency of manual sieving are much lower than mechanical sieving due to time wastage for unproductive work in manual sieving. But mechanical mixing is a batch type process and only 20 kg of saw dust can be mixed in a one batch. After every batch, mixture should be unloaded and ingredients should be filled again into the container. Therefore, in spite of having higher mixing capacity, the efficiency is somewhat lower than the manual mixing due to higher unproductive work in mechanical mixing. Filling the mixture into poly bags by mechanical method has shown higher capacity and efficiency. It took only 37 seconds to fill one bag where manual filling had taken 82 seconds.

According to the actual capacities of both methods, the labor and electricity cost for preparation of 1000 filled bags were calculated to find the most economical method. In mechanical method, it has taken only 19 hours while manual method took 42 hours to complete the task. Based on the capacity of the motor (3

Table 1: Comparison of mechanical and manual methods of growing media preparation

	Mechanical method using the machine	**Manual method**
Theoretical sieving capacity (TS)	252 kg/hr	190 kg/hr
Actual sieving capacity (AS)	212 kg/hr	145 kg/hr
Sieving efficiency (SE)	84 %	76 %
Theoretical mixing capacity (TM)	480 kg/hr	230 kg/hr
Actual mixing capacity (AM)	323 kg/hr	162 kg/hr
Mixing efficiency (ME)	67 %	70 %
Theoretical filling capacity (TF)	97 bags/hr	44 bags/hr
Actual filling capacity (AF)	81 bags/hr	32 bags/hr
Filling efficiency (FE)	83 %	72 %

hp) and present electricity charges, the electricity cost to operate the motor was calculated as Rs. 335.00. Including the labor cost (assuming Rs. 800.00 for 8 hour work), the total cost in mechanical and manual methods were Rs. 2235.00 and Rs. 4200.00, respectively to complete filling of 1000 bags.

Conclusion

According to the results of this study, it can be concluded that, the developed machine can be used efficiently with higher working capacities and efficiency as a solution for the scarcity of skilled labor in mushroom industry. It gives 55 % time saving and 47 % money saving compared to the manual method. As, the required forces to loading, unloading and operating the machine is very low, it can be concluded that, the machine can be used by any labourer whether skilled or unskilled and an adult or a child.

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