Performance Evaluation Of Melon De-Husking Machine

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***Abstract*— In this paper, performance evaluation of melon de-husking machine is presented. Some performance parameters of this machine were investigated which include the de-husking efficiency, the likelihood of damaging seeds, and the critical spreading time. The impact of these parameters on the melon de-husking efficiency and the likelihood of damaging the melon seeds are examined through empirical experiments and analytical computations based on the experimental results. The results of the preliminary experiments show that the untreated melon (not soaked in water) with moisture content of 7.99 % had 66.6 % de-husking efficiency and 6.6 % partially de-husked but broken (damaged) melon seeds while the treated melon with moisture content of 10.17 % had 73 % de-husking efficiency and 3.3 % partially de-husked but broken (damaged) melon seeds. The results of the further tests show that melon seeds with 12.30%, 13.78%, 15.23%, 17.25% and 18.53% water content had 5%, 4%, 3%, 2%, 6% of damages to the melon seed and also 11%, 6%, 6%, 4%, 14% of not useable melon seed respectively which are important values to the melon marketers and the consumers. Importantly, the results show that the higher the water content in the melon seeds to be shelled, the more difficult it becomes for the machine to perform its desired function of de-husking the seeds and vice-versa. More so, the results show that the higher the melon seed loss or damage the machine generates when the melon water content increases above the optimal value. In all, the results show that the moisture content of 17.25% produced the lowest damaged melon seeds and also gave the highest de-husking efficiency of the machine.**

***Keywords*— Melon De-Husking Machine, Hopper, De-Husking Chamber, Melon Moisture Contents, Likelihood of Damaging Seeds, Soaking Time**

1. INTRODUCTION

Melon has for several decades remained one of the most widely cultivated seedling in the various regions across Nigeria [1,2,3]. Due to the several uses of melon seed and the husk, the Nigerian farmers both at the subsistent and industrial scale invest their resources yearly to turn out several tons of the melon seed [4,5,6]. The challenges with regards to melon include post-harvest preservation and de-husking of the processed melon seed [7]. There is inadequate post-harvest processing infrastructure for melon seed in many regions in Nigeria [8,9,10]. As such a good percentage of the harvested seedlings are lost after harvest. Moreover, the manual de-husking approach is predominant in Nigeria. Such approach is not suitable for industrial scale processing of melon seed [11,12,13,14].

Consequently, studies have shown that there are several mechanized melon de-husking devices that have been developed over the years [15,16,17]. Further , studies have also examined the performance of these melon de-husking machines and concluded that there performances are effected by a number of parameters and the de-husking efficiency presently attained by these machines are around 60 % [18,19,20]. This has led to further studies to improve on the de-husking efficiency of the machine [22,23,24]. Therefore, in this paper, the focus is on evaluating the performance of a melon de-husking machine. The evaluation will examine the impact of moisture content and

other parameters on the de-husking efficiency of the machine.

2. METHODOLOGY

a) 2.1 DESCRIPTION OF THE MELON DE-HUSKING MACHINE

The main components of melon de-husking (MD-H) machine are hopper, electric motor, de-husking chamber, supporting base and the separation chamber/blower. The hopper receives the melon seeds from where they are fed into the de-husking chamber. The de-husking process takes place within the de-husking chamber. The electric motor is used to transmit rotational motion to the de-husking shaft. The mainframe is the support on which all other machine components are mounted on. The separation chamber comprises of the electrical blower installed in a certain angel of inclination which blow the blown chaff out and the white melon seed will drop into the finish product chamber.

2.2 MACHINE PERFORMANCE EVALUATION

Some performance parameters of this machine will be investigated which include the de-husking efficiency, the likelihood of damaging seeds, and the critical spreading time.

b) 2.2.1 DE-HUSKING EFFICIENCY

The melon de-husking efficiency of the machine is expressed as;

$$\textbf{De-husking Efficiency} = \frac{\text{Total weight of melon de-husked}}{\text{Total melon Fed}} \times 100 \quad (1)$$

$$\%E = \frac{W1}{W0} \times 100 \quad (2)$$

W0 represents the weight of melon seeds is a given sample while W1 represents the weight of De-husked melon and the unbroken melon seeds.

2.1.2 LIKELIHOOD OF DAMAGING SEEDS

Likelihood of damaging seeds is analyzed to estimate the amount of melon seeds that are damaged during the de-husking process. where;

$$\textbf{Seed Damaged} = \frac{\text{Total melon De-husked broken \& crushed}}{\text{Total melon Fed}} \times 100 \quad (3)$$

$$\%D = \frac{W4}{W0} \times 100 \quad (4)$$

W4 represents the weight of partially De-husked melon seed which are broken while W0 represents the weight of melon seeds is a given sample

2.2 MELON MOISTURE CONTENTS

This is gravimetric measurement of moisture content in the melon, it is expressed as a percentage of the initial sample weight. Moisture content is also defined as the percentage of the weight of a saturated object that is associated with water, it is a percentage of the total weight of an object that is due to moisture within the object. The percentage moisture contents (M_c) is determined as follows;

$$M_c = \frac{Wi-Wd}{Wi} X\ 100 \quad (5)$$

Where, Wi represents the weight of melon obtained before drying and Wd represents the weight of melon after the seed is dried.

3. RESULTS AND DISCUSSION

c) Some performance parameters of this machine were investigated which include the de-husking efficiency, the likelihood of damaging seeds, and the drying time with a specific temperature, total usable seed and not usable seed.

3.1 MELON MOISUTURE CONTENTS TREATMENT

After the construction of the melon de-husking machine, series of testing were performed. From prior published researches, it has been noted that the moisture content of the melon seed was found to positively affect the performance efficiency of the melon De-husking machine (Okon & Udom 2018).

Therefore, to get the highest efficiency of the machine, melon was treated to know the best moisture content that will give the highest efficiency, the soaking time and the drying time and the specific temperature of the drying was taken into consideration.

d) The results of the de-husking efficiency and the damaged melon seed performance for the treated and untreated melon seeds are presented in Table 1. Further results for the treated melon are presented in Figure 1 and Figure 2.

e) The results show that the untreated melon with moisture content of 7.99 % had 66.6 % de-husking efficiency and 6.6 % partially de-husked but broken (damaged) melon seeds while the treated melon with moisture content of 10.17 % had 73 % de-husking efficiency and 3.3 % partially de-husked but broken (damaged) melon seeds.

Table 1: Machine test result evaluation for the for the treated and untreated melon seeds

	Percentage of Moisture contents (MC %)	Percentage of Melon De-husked but Unbroken (Efficiency) (%E)	Percentage of Melon De-husked but Broken (%B)	Percentage of melon partially De-Husked but Broken (Damaged) (%D)	Percentage of melon partially De-Husked but Unbroken (%NOT-B)	Total Percentage of Useable (%E + %B) (%U)	Total Percentage of Not usable (%D + %NOT-B) (%NOT-U)
Untreated melon	7.99	66.6	13.3	6.6	6.6	66.6+13.3 = 79.9	6.6+6.6 = 13.2
Treated melon	10.17	73	10	3.3	6.6	73+10 = 83	6.6+3.3 = 9.9

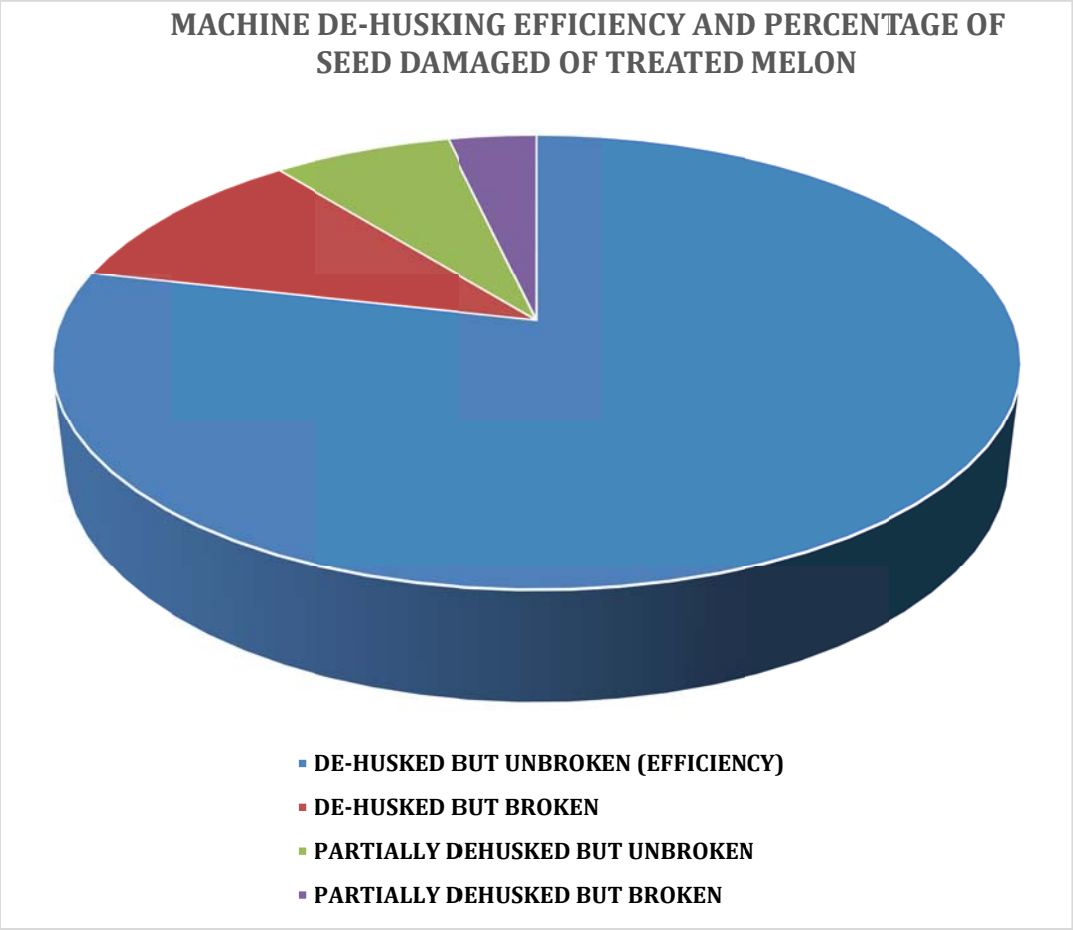

Figure 1: Machine test result evaluation of treated melon

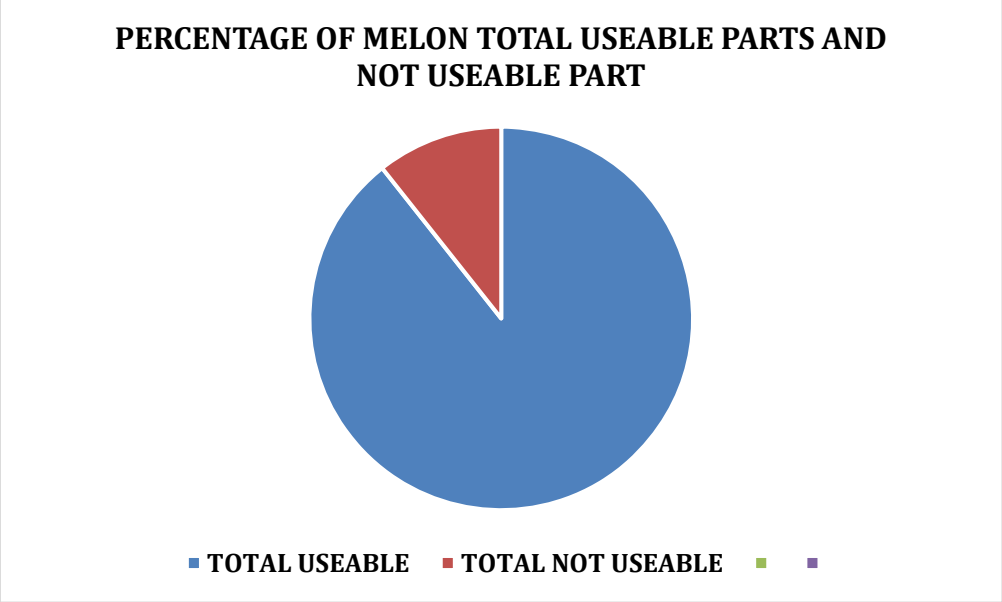

Figure 2: Machine test result evaluation of useable melon seed for the treated melon

3.2 DETERMINATION OF THE APPROPRIATE SOAKING TIME FOR OPTIMAL PERFORMANCE

Additional tests were conducted on the melon de-husking machine to determine the best soaking time that will give the highest efficiency. Then Table 2 showcase tested parameters that influence water soaking time on the shelling performance of this machine. The acquired result from Table 1, Table 2, Table 3, Table 4and Table 5 showed that 3 minutes gave the best shelling efficiency in this study.

3.3 CRITICAL DRYING TIME

In oven method of drying, drying time simply explains the time taken for a melon seed to dry off its moisture contents at a particular temperature. After melon seeds have been treated (soaked) in water, then a drying period was regulated as critical drying time. During this time, the melon seeds have absorbed sufficient amount of water to adequately moisten the shells. To obtain this measure, a sample of 3 kg of melon seed were washed with 1 litre of water and dried in oven for about 2 minutes at 110^{o}C temperature before they were shelled. The results in Table 1, Table 2, Table 3, Table 4and Table 5 show the shelling efficiency, percentage of usable melon seed, percentage of seed damage and percentage of usable melon seed performance of the machine as a function of the moisture content.

3.3.1 FIRST EXPERIMENTAL TEST EVALUATION

The first experimental test evaluation of the de-husking machine was carried out using untreated melon seed with a moisture content of about 7.99 % (Okokon 2005) and then another test was conducted with treated melon seed with a moisture content of about 10.17 % in the de-husking machine and the results are presented Table 1.

Then another test was conducted with treated melon seed that was soaked in 1 liter of water for 4 minutes and partially dried within an oven for about 5 minutes with a temperature of 110^{o}C. The moisture content of these samples were determined using Equation 5. The melon de-husking machine was fed a known initial quantity of melon seeds (W0) and de-husking experimental test were performed using the following variables as shown in Table 1 and 2.

After each experimental test run, considering all the performance indicators, the seeds were carefully collected from the outputs and divided into de-husked and unbroken seed (W1), De-husked but broken seeds (W2), partially De-husked and unbroken seeds (W3), partially De-husked but broken seeds (W4), the weight of melon seeds De-husked chaff (W5) and later weighed. From the results obtained the percentage of the damaged seed and machine efficiency were evaluated using Equation 4 and Equation 2 respectively.

3.3.2 SECOND EXPERIMENTAL TEST EVALUATION

The melon de-husking machine operates at a speed of 1000 rpm and the testing of all the melon seeds used for this experiment were done at that speed. Melon seeds of five (5) different water contents were tested to evaluate the machine's performance. Table 2, Table 3, Table 4and Table 5 show the results of the test conducted on the designed machine using melon seed containing 12.30%, 13.78%, 15.23%, 17.25% and 18.53% water content respectively.

The efficiency of the machine was calculated from the experiment of the five (5) tests conducted with different percentage of water content contained in the melon seeds.

The results showed that at 12.30% water content of the melon seeds tested, an efficiency of 74.0% was recorded (as shown in Table 2), while 82.0% efficiency was recorded at 13.78% melon seeds water content (as shown in Table 2), and efficiency of 82.0% at 15.23 % (as shown in Table 4), efficiency of 90.0% at 17.25% of water content contained in the melon seed (as shown in Table 4), and at 18.53% water content of the melon seeds, an efficiency of 66.0% was recorded (as shown in Table 6). This indicates that the machine designed performs better when the water contained in the melon seeds is 17.25%, thus, the more the water contained in the melon seeds the lower its performance as shown in the in Table 3 , Table 3, Table 4, Table 5 and Table 6 as well as in Figure 3, Figure 4, Figure 5, and Figure 6. However, testing revealed that it takes approximately 3 minutes to de-husked 5 kg of melon seeds irrespective of the amount of water contained in it.

The results of the further tests show that melon seeds with 12.30%, 13.78%, 15.23%, 17.25% and 18.53% water content had 5%, 4%, 3%, 2%, 6% of damages to the melon seed and also 11%, 6%, 6%, 4%, 14% of not useable melon seed respectively which are important values to the melon marketers and the consumers.

Importantly, the results show that the higher the water content in the melon seeds to be shelled, the more difficult it becomes for the machine to perform its desired function of de-husking the seeds and vice-versa. More so, the results show that the higher the melon seed loss or damage the machine generates when the melon water content increases above the optimal value. In all, the results show that the moisture content of 17.25% produced the lowest damaged melon seeds and also gave the highest de-husking efficiency of the machine.

Table 2: Result from 12.30% moisture content De-Husking of treated melon seed

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
12.30	3	5.00kg	3.70kg	0.50kg	0.30kg	0.25kg	0.25kg	0.74	0.05

Table 3: Result from 13:78% moisture content De-Husking of treated melon seed

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
13.78	3	5.00kg	4.00kg	0.60kg	0.10kg	0.20kg	0.10kg	0.80	0.04

Table 4: Result from 15:23% moisture content De-Husking of treated melon seed

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
15.23	3	5.0kg	4.1kg	0.4kg	0.15kg	0.15kg	0.2kg	0.82	0.03

Table 5: Result from 17:25% moisture content De-Husking of treated melon seed

MC (%)	Time (Min)	W0	W1	W2	W3	W4	W5	%E	%D
17.25	3	5.0kg	4.5kg	0.2kg	0.1kg	0.1kg	0.1kg	0.9	0.02

Table 6: Result from 18:53% moisture content De-Husking of treated melon seed

Percentage of Moisture contents (MC %)	**Percentage of Melon De-husked but Unbroken (Efficiency)(%E)**	**Percentage of Melon De-husked but Broken(%B)**	Percentage of melon partially De-Husked but Broken (Damaged) (%D)	**Percentage of melon partially De-Husked but Unbroken (%NOT-B)**	Total Percentage of Useable (%E + %B)(%U)	Total Percentage of Not usable (%D + %NOT-B) (%NOT-U)
12.3	74	10	5	6	74+10= 84	5+6 = 11
13.78	80	12	4	2	80+12 = 92	4+2 = 6
15.23	82	8	3	3	82+8 = 90	3+3 = 6
17.25	90	4	2	2	90+4 = 94	2+2 = 4
18.53	70	10	6	8	70+10 = 80	6+8 = 14

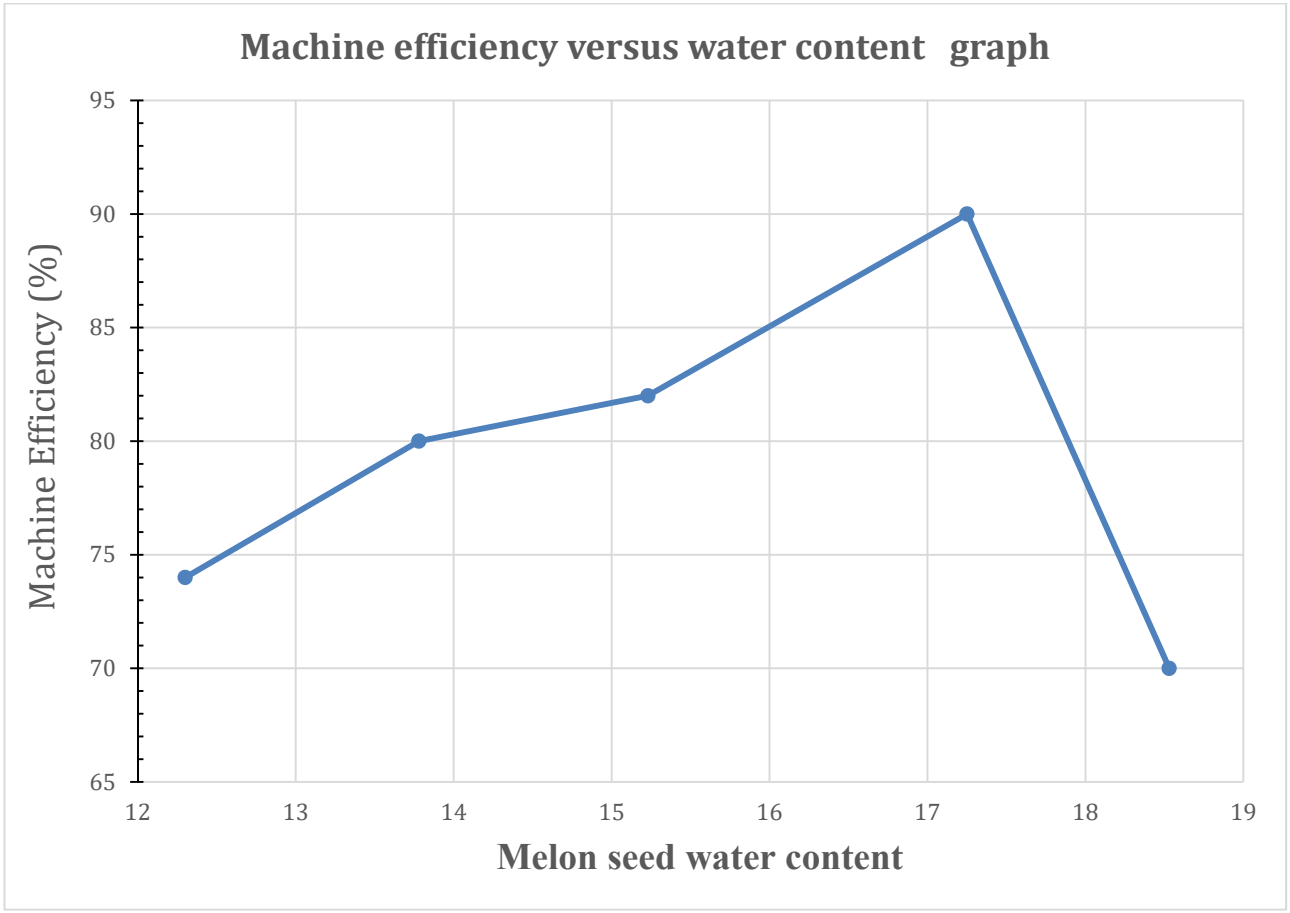

Figure 3 Machine Efficiency against water content

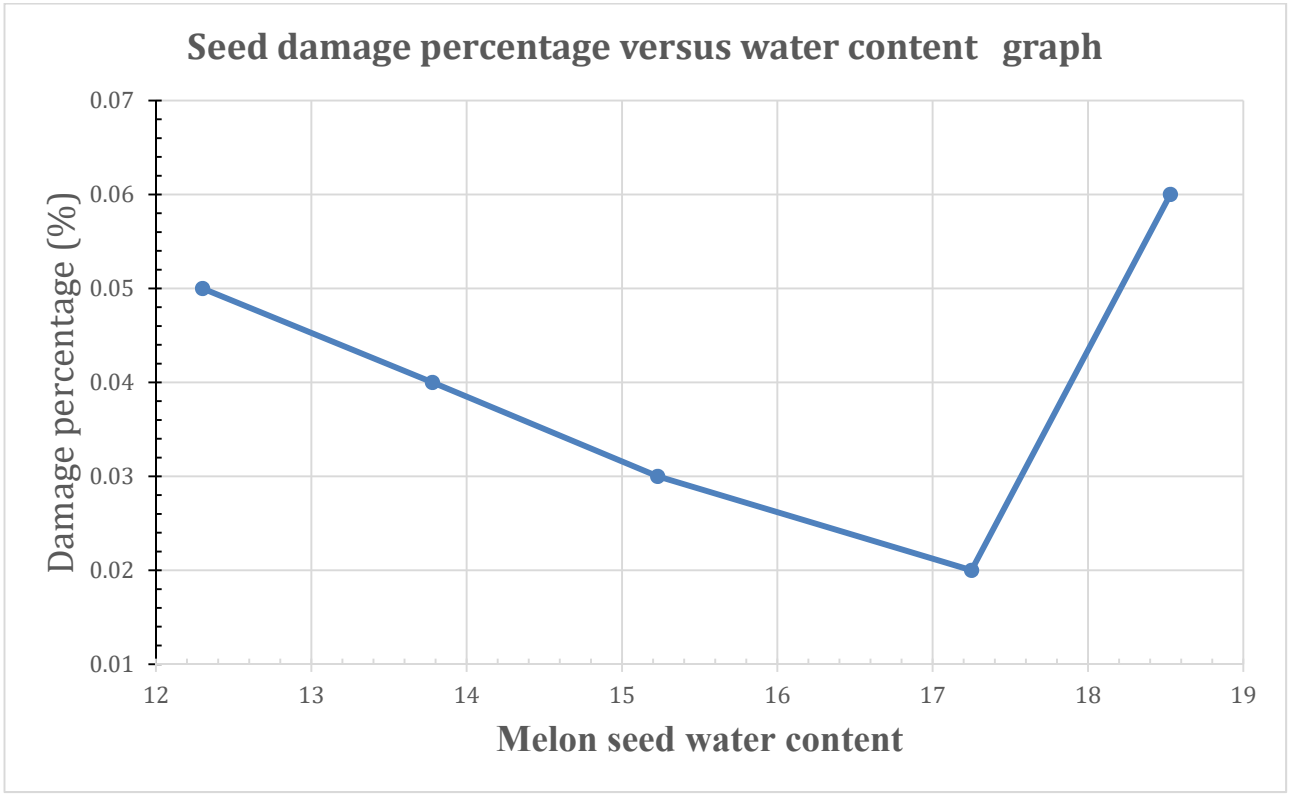

Figure 4: Seed damage against water content

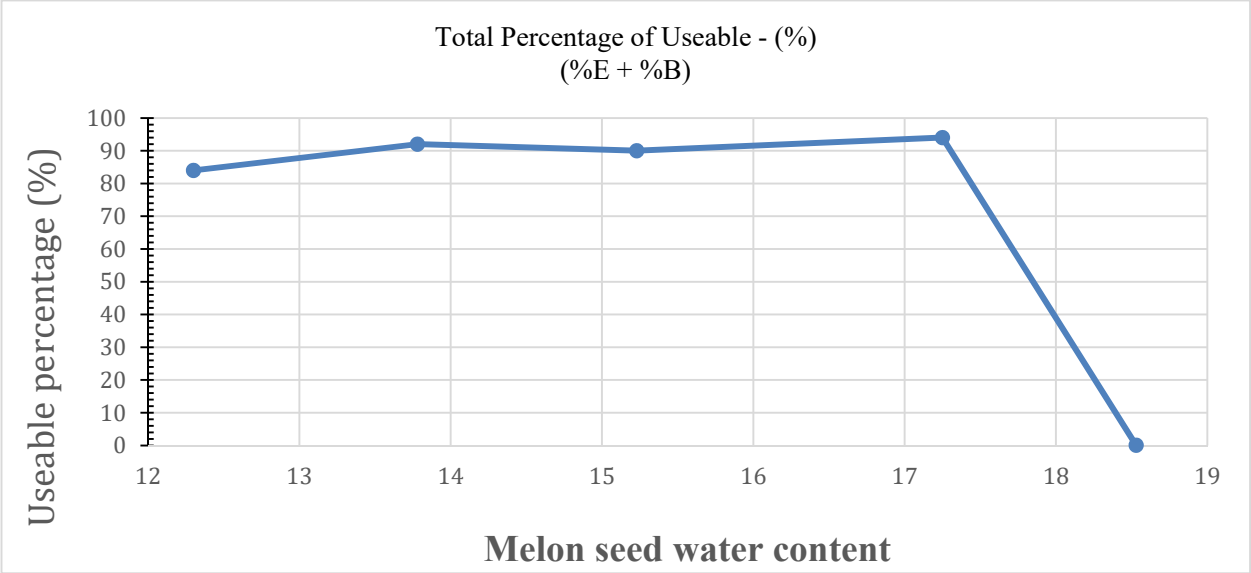

Figure 5: Useable percentage against water content

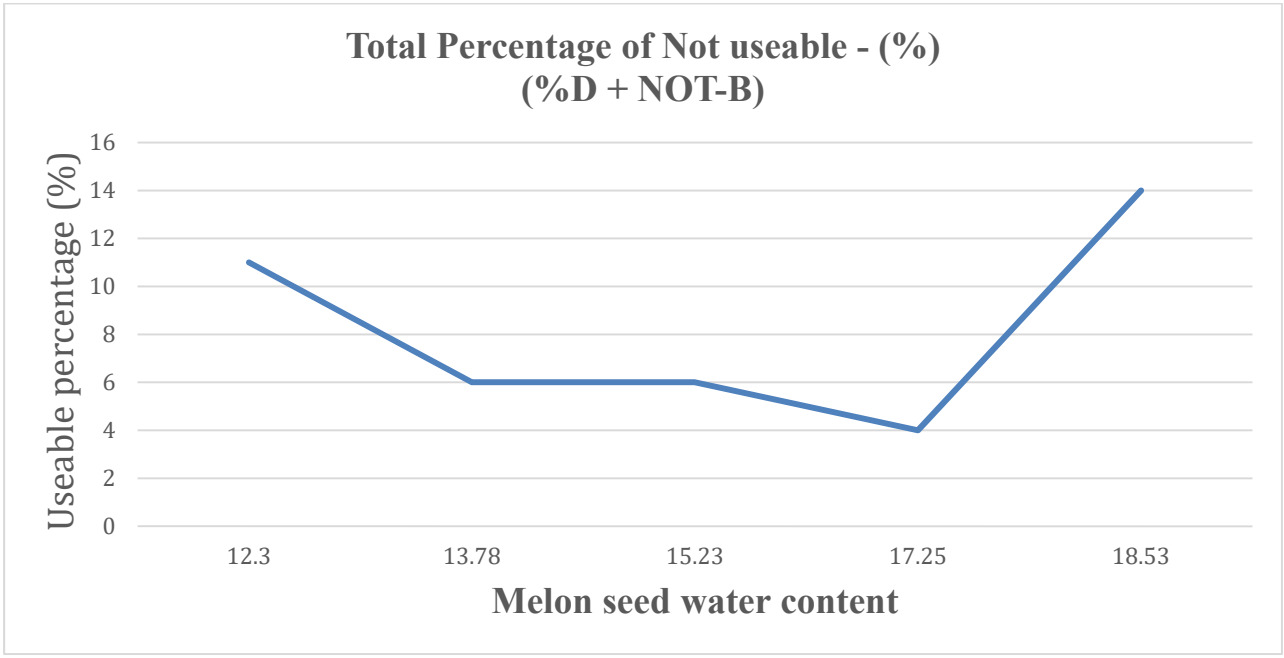

Figure 6: Useable percentage against water content

4 CONCLUSION

The focus in this paper is to examine some key parameters that influence the performance of a melon de-husking machine and use empirical test to determine the best values of such parameters for optimal performance of the machine. Among the parameters examined are the moisture content, the water soaking time and the critical drying time. These parameters are examined on how they influence the melon de-husking efficiency and the likelihood of damaging the melon seeds. Analytical models and empirical experiments were presented and the optimal moisture content value was determined for maximum melon de-husking efficiency and minimum percentage of damaged melon seeds. The study is therefore useful for the operation of melon de-husking machine as it will increase throughput and minimize cost of melon de-husking process.

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