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Rice Hulls as a Cushioning Material

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Abstract Rice hulls are a by-product of rice production. It is light, bio-degradable, difficult to burn and less likely to allow moisture to propagate. In this study, rice hulls were used as a cushioning material inside a plastic tote. Its impact absorption property was compared to a 3/16-inch bubble wrap and a 0.129-inch anti-vibration rubber pad. From the same baseline, 1-inch thick rice hulls reduced impact acceleration by 25% as compared with 39% and 42% of bubble wrap and anti-vibration pad with the same thickness, respectively. When wet, rice hulls became denser. Thus, the impact increased at the rate of 0.054% per 1% increase of water per hull weight. To make the use of rice hulls practical, rice hulls were placed in sealed plastic bags. Sealed bags containing rice hulls reduced impact acceleration by 41%, which was comparable with the bubble wrap case due to trapped air inside the sealed plastic bag. Using bubble wraps would be more economical and practical. However, bubble wraps could burst and cushioning property would be lost. A sealed plastic bag with rice hulls inside could burst, but the rice hulls would provide another line of protection. In addition, rice hull is a good thermal insulating material and would be useful in protecting some temperature-sensitive products during the distribution by placing bagged rice hulls in all sides of a tote or box.

Keywords *Rice Hulls; Impact Acceleration; Sustainability*

1. Introduction

Agricultural waste products, such as cotton and rice hulls, are sustainable and compostable. Rice hulls have been used as cushioning materials in mushroom packaging [1]. Some other natural products, such as coconut fiber and wood straw, have been used to prevent damages to papayas and mangoes during the distribution [2]. Banana leaves and Teak leaves were used as wrapping materials for guava while Neem leaves, rice straw, and bamboo leaves were used as cushioning materials for guava fruits during storage [3]. These are examples of the sustainability movement.

Rice hulls are the coating of rice grains. They were removed from raw grains in the making of brown rice. With further milling, white rice was produced. Rice hulls are relatively light with a unit weight of 20-21 pounds per cubic foot [4]. Rice hulls have been used in the production of Portland cement, tooth cleaning substance, beer, fertilizer, and fuel [5].

In this study, the shock absorption property of loose rice hulls was compared with two common cushioning materials, i.e., bubble wraps and anti-vibration rubber pads. The impact property of loose wet hulls and bagged hulls were also investigated.

2. Materials and Methods

Three materials were used in this study; (1) 3/16-inch bubble wrap, (2) 0.129-inch anti-vibration rubber pad, and (3) loose rice hulls, as shown in Figure 1. A 100-g tri-axial shock record was used to measure impact acceleration. It was housed in a single-wall corrugated box. Thick viscoelastic foam was placed at the bottom of the box to ensure the impact accelerations would not exceed the recorder's capacity. This was considered as the study baseline. Each of the three cushioning materials was placed above the viscoelastic foam and underneath the recorder. One-inch thickness of rice hulls was used while up to three layers of bubble wraps and anti-vibration pads were used and results were projected for an one-inch thickness. Figure 2 shows the setup of the shock recorder with 1-inch thick rice hulls over thick viscoelastic foam at the bottom. Viscoelastic foam (the white part in Figure 2) was also used on the sides and top (not shown in Figure 2) to prevent the movement of the recorder. The corrugated box was taped to the bottom of a plastic tote (commonly used in medical device industry) which was dropped at 18-inch drop height as shown in Figure 3. Water was added to loose rice hulls and a similar drop test was performed. Loose rice hulls are hard to handle and not practical. Thus they need to be confined in a container as a unit. In this study rice hulls were placed loosely in plastic bags to obtain different bag thicknesses. An impulse sealer was used to seal these bags. This is shown in Figure 4.

Figure 1: *Cushioning Materials Used in This Study: 3/16-inch Bubble Wrap (left), 0.129-inch Thick Anti-Vibration Pad (center); and Rice Hulls (right)*

Figure 2: *Shock Recorder Setup*

Figure 3: *Plastic Tote and Drop Test*

Figure 4: *Bagged Rice Hulls*

3. Results and Discussion

3.1. Comparing Rice Hulls with Bubble Wrap and Anti-Vibration Pad

First, the tote with the shock recorder attached on thick viscoelastic foam was dropped 20 times. The average impact acceleration was determined to be 77.53g with a standard deviation of 4.12g. The 77.53g was used as a base value. The shock recorder was then placed on 1, 2, and 3 layers of 3/16” bubble wrap with thicknesses of 0.1875", 0.375", and 0.560", respectively. Twenty drops were made for each case and average impact accelerations were computed as 58.85g, 57.98g, and 53.08g which yielded -24.09%, -25.22%, and -31.54% changes from the base value. These percent changes were plotted against thicknesses and a trend line equation was developed and used to estimate the percent change at 1-inch thickness. The same procedure was used with anti-vibration pads. Two sets of 20 drops were performed with 1" thick loose rice hulls. The average change of the two sets was -24.95%. Results are summarized in Table 1 and Figures 5 and 6. At the same 1-inch thickness, bubble wrap, anti-vibration pads, and rice hulls reduced the impact acceleration by 41.51%, 39.45%, and 24.95%, respectively.

Table 1: *Drop Test Results*

	Base	**3/16" Bubble Wrap**			**Anti-Vibration Pad**			**Rice Hulls**	
Number of Layers		1	2	3	1	2	3	1	1
Thickness		0.1875"	0.375"	0.560"	0.129"	0.258"	0.516"	1"	1"
Average Impact Acceleration	77.53g	58.85g	57.98g	53.08g	66.85g	62.90g	52.28g	57.08g	59.30g
Standard Deviation	4.12g	2.51g	2.57g	2.13g	2.75g	1.41g	2.05g	2.60g	5.06g
% Change from Base Value		-24.09%	-25.22%	-31.54%	-13.78%	-18.87%	-26.13%	-26.38%	-23.52%
Trend Line Equation		y = -31.356x - 10.156			y = -19.971x - 19.481			N.A.	
At x = 1"		**-41.51%**			**-39.45%**			**-24.95%**	

Note: x = thickness (inch), y = change from base value (%)

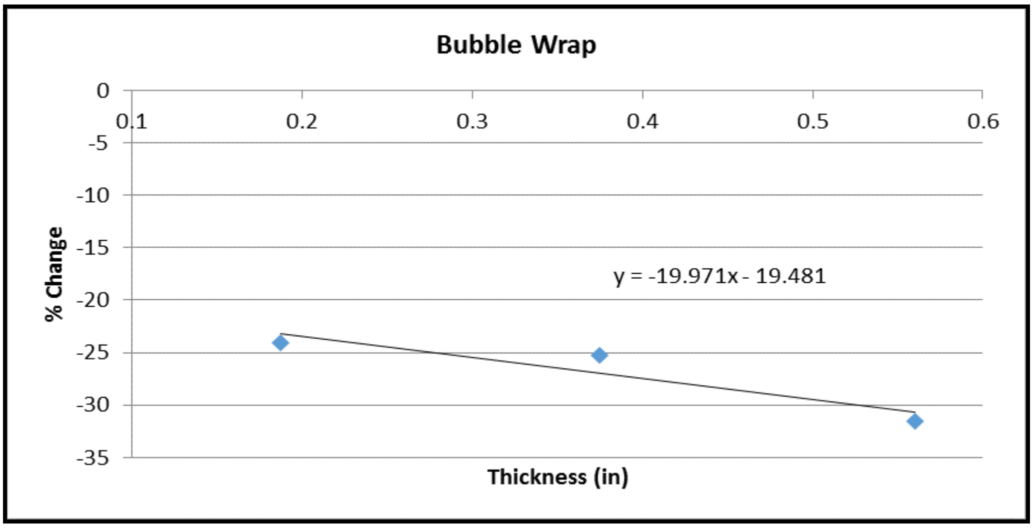

Figure 5: *Drop Test Using Bubble Wrap as Cushioning Material*

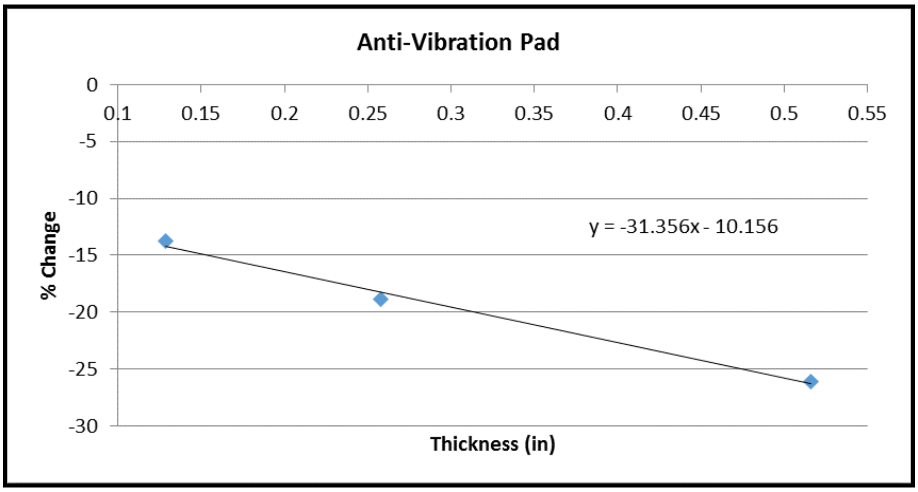

Figure 6: *Drop Test Using Anti-Vibration Pad as Cushioning Material*

3.2. Wet Rice Hulls

When loose rice hulls were subjected to moisture or water, they became denser and the impact absorption ability reduced, as can be seen in Table 2 and Figure 7. As in previous experiments, twenty drops at 18-inch drop height were made for each case. It should be noted that the percentage of water added to the rice hulls were high due to the low unit weight of rice hulls of about 20 pounds per cubic foot compared to much higher unit weight of water of 62.4 pounds per cubic foot. However, the reduction of absorption ability was not significant in most cases, i.e., 13.46% increase in impact acceleration from 0% water to 250% of water per hull weight (or 0.054% increase per 1% increase of water per hull weight). It should be noted that the 0% baseline used in this study was room dry condition at about 50% relative humidity.

Table 2: *Wet Rice Hull Drop Test Results*

Water (% of Hull Weight)	0%	50%	100%	200%	250%
Average Impact Acceleration	57.26g	56.95g	59.16g	61.18g	64.97g
Standard Deviation	5.10g	1.38g	1.55g	1.37g	1.40g

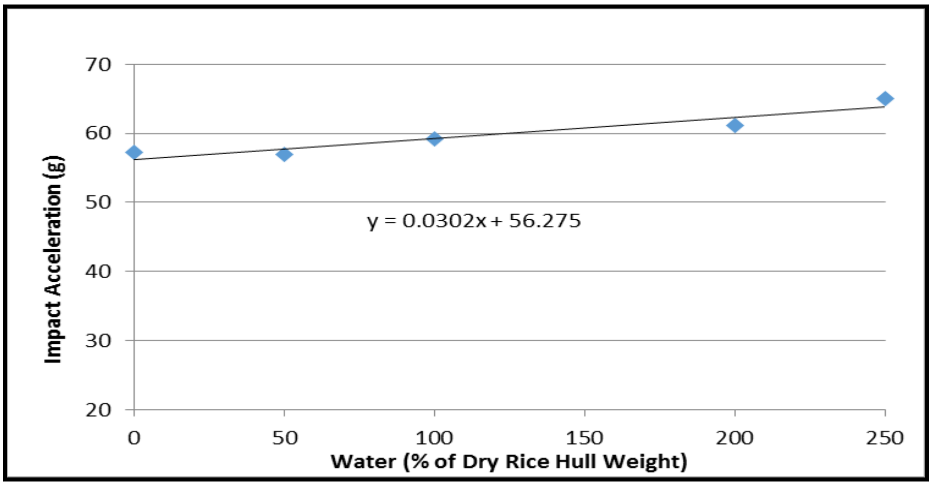

Figure 7: *Wet Rice Hull Drop Test Result*

3.3. Bagged Rice Hulls

For easy handling and waterproofness, rice hulls were placed in sealed plastic bags. These bags were placed under the shock recorder with total thickness of 0.32”, 0.50”, and 0.63”. Twenty drops at 18” drop height were made for each thickness. Results are summarized in Table 3 and Figure 8. From the trend line equation, the change from base value was estimated at -41.04%. This is comparable with the bubble wrap case due to the trapped air inside the bag.

***Table 3:** Bagged Rice Hull Drop Test Results*

Thickness of bag(s)	0.32"	0.50"	0.63"
Average Impact Acceleration	77.20g	70.30g	62.45g
Standard Deviation	9.35g	4.19g	2.72g
% Change from Base Value	-0.43%	-9.32%	-19.45%
Equation	y = -60.595x + 19.556		
At x = 1"	**y = -41.04%**		

Note: x = thickness (inch), y = change from base value (%)

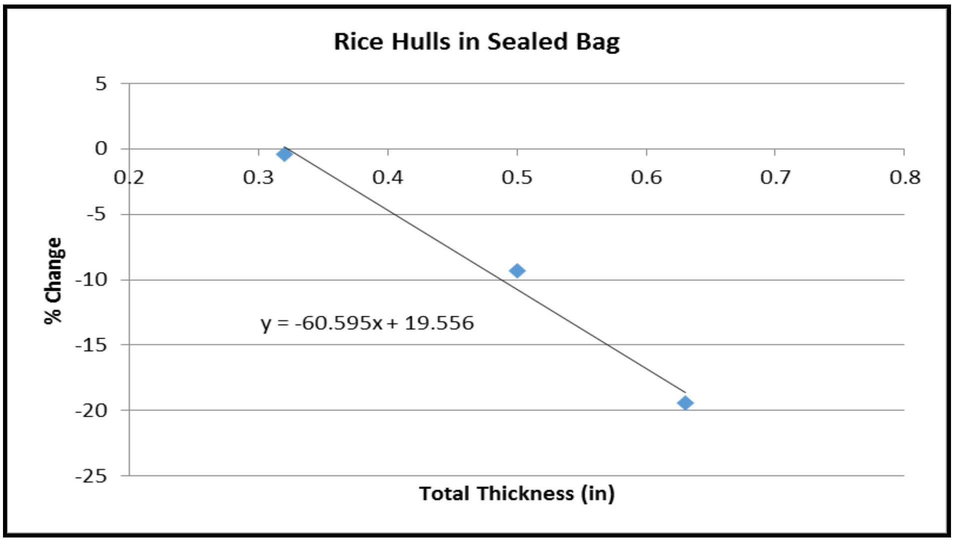

***Figure 8:** Bagged Rice Hull Drop Test Result*

4. Conclusion

It was shown in this study that loose rice hulls reduces the impact acceleration about 25% from a base value which was not as effective as bubble wrap and anti-vibration pad. Rice hulls are a natural waste product, which are more environmental friendly than the other two cushioning materials used in this study. However, there are two problems with loose rice hulls:

- They are subjected to moisture, especially if there are liquid product leakages. When wet, they become denser thus less effective in shock absorption.
- They are harder to handle due to its small grain and light weight. In addition they tend to stick to the products inside the tote.

Bagged rice hulls solve the two problems above as well as increase the shock absorption to the level of performance of bubble wrap. When a plastic bag is introduced as part of the solution, the environmental advantage diminishes. In addition, it would be more cost effective in using bubble wrap. However, bagged rice hulls provide double protection when a bag bursts the rice hulls remain to absorb shock. When bubbles in bubble wrap burst, the shock protection disappears. In addition, rice hulls are a class A insulating material, which are difficult to burn and are more resistance to mold or fungi [5]. Anti-vibration pads are much more expensive and not recommended for this application. Its shock absorption ability is also comparable to much less expensive bubble wrap. The pad was included in this study for comparison purpose only.

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