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Case Study

Product Protection and Packaging Operations Improvement

Benjamin Knighton[1], Alexander Brown[1], Carl Gordy[1], Zachery Tabor[1], Hamoud Alhajri[1], Mona Al Assi[1], Deliya Duckworth[1], Siripong Malasri[1], Eli Cloud[2], Alison Chesney[2], and Leslie McAbee[3]

[1]Gadomski School of Engineering, Christian Brothers University, 650 East Parkway South, Memphis, TN, USA
[2]Thistle & Bee Enterprise, TN, USA
[3]AutoZone Center for Community Engagement, Christian Brothers University, 650 East Parkway South, Memphis, TN, USA

Correspondence should be addressed to Siripong Malasri, *pong@cbu.edu*

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Abstract Thistle & Bee is a non-profit organization. Its mission is to help women who have survived prostitution and trafficking thrive. The goal of this project is three-fold: (1) Product protection, (2) Environmental friendliness, and (3) Process improvement. This was a service-learning project that aligns with CBU's mission. CBU prepares its students with a slogan "Enter to Learn. Leave to Serve."

Product protection was done at both product and packaging levels. Environmental-friendly materials were chosen, and shipping box sizes were optimized. Process improvement included efficiency for manual operations and cost reduction. Various studies were performed, including an impact study of honey jars and a granola tray, as well as shock absorption of different cushioning materials.

The following recommendations were made:

- Using single-faced corrugated wrap around honey jars to separate glass jars.
- Using biodegradable peanuts to tighten up gift packs in shipping corrugated boxes.
- Using an optimum shipping corrugated box.
- Using crinkle paper as cushion in gift pack.
- Using paper labels to secure the lid of granola plastic tray.

Keywords *Packaging Improvement; Sustainability; Protection; Service Learning*

1. Introduction

Thistle & Bee [1] is a non-profit organization with a mission to help women who have survived prostitution and trafficking thrive. It offers a two-year residential program for these women by providing a home environment setting and daily opportunities to practice community living as they heal from histories of physical, emotional, and sexual trauma. Participants help the organization

grow its honey and granola business. Thistle & Bee has several beehives and a great recipe for honey-sweetened granola. The women in the program help care for 80 beehives by assisting with harvesting and bottling honey, as well as baking granola. This social enterprise generates revenue to support programs designed to help women on a journey of healing and hope. The organization is not a business with a mission but rather a mission with a business.

The AutoZone Center for Community Engagement [2] at Christian Brothers University collaborates with communities on and off campus to enhance learning, enrich student life, and promote positive social change in Memphis and beyond. The Center supports programs that respond to defined community goals and social challenges, connecting the knowledge and enthusiasm of both CBU and community partners.

The work presented in this article is a collaboration of Thistle & Bee, the AutoZone Center for Community Engagement, and the Gadomski School of Engineering. Packaging students worked on this project as one of their four projects in PKG 490 Packaging Projects course during the Fall of 2019. The goal is to improve the packaging of Thistle & Bee's products using environmental-friendly solutions.

2. Materials and Methods

The products used in this study, shown in Figure 1, were honey (in 3-oz and 12-oz glass jars), gift box (containing an 3-oz honey jar, a candle bar, a bag of green tea, and a bag of granola), and a tray of granola. Multiple honey jars, gift boxes, and granola trays may be shipped per customer orders in shipping corrugated boxes.

Figure 1: *Thistle & Bee's Products Used in This Study*

Cushioning materials used in the study, shown in Figure 2, include single-face corrugated fiberboard, single-wall C-flute corrugated fiberboard, crinkle paper, biodegradable peanut, and 3/16" and 1/2" bubble wraps.

Figure 2: *Cushioning Materials Used in This Study*

Drop test was performed on individual honey jar, granola plastic tray, and gift box. Based on ISTA test protocols [3] for small items, a 30-inch drop height was used. A 48-inch drop height was also sometimes used to simulate a situation whereby a customer accidentally drops a product after it is removed from a gift box. A 10-drop sequence based on ISTA 1A [4] was performed on the gift box. All single jar drops were done on the side of the jar, while surface/edge/corner drops were performed on the single granola tray. In the shock absorption study, a tri-axial accelerometer was used to measure peak impact acceleration, as shown in Figure 3.

Figure 3: *Tri-Axial Accelerometer*

3. Data & Results

Glass Jar Partition

When multiple glass jars are shipped in a box, they are separated by partitions, typically made from cardboard as shown in Figure 4. Empty glass jars often come with these cardboard partitions. However, honey-filled jars may be shipped in different quantity and the cardboard partitions that come with the empty jars may not fit. Cardboard partitions are not practical to make when packing is done manually as in the Thistle & Bee case. It is more practical to use single-face corrugated fiberboard to wrap around individual jars, as shown in Figure 5. The two ends of the fiberboard are connected by a paper label, in which a company logo can print on. This serves not only as partitions to protect a jar from its neighboring jars, but also protect the jar when it is accidentally dropped after taken out from a box.

Figure 4: *Cardboard Partition*

Figure 5: *Single-Face Corrugated Partition*

Gift Box Cushioning

Crinkle paper and biodegradable peanuts were used to secure the gift box products in place. Crinkle paper was recommended over the peanut due to its easy arrangement and classy appearance as shown in Figure 6. It should be noted that the biodegradable peanut is a plant-based product that can dissolve in water, as shown in Figure 7. Biodegradable peanuts are made from crop-based sources rather than petroleum-based materials [5]. Thus, it is non-toxic and more environmental-friendly.

Figure 6: *Crinkle Paper (left) versus Biodegradable Peanuts (right)*

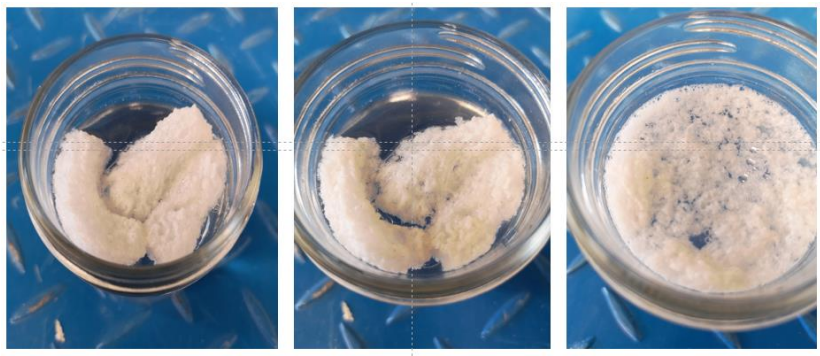

Figure 7: *Biodegradable Peanuts in Water*

Shock Absorption of Cushioning Materials

Corrugated fiberboard and biodegradable peanuts were used in this study. Their shock absorption abilities were compared with bubble wraps, 3/16" and 1/2". A tri-axle accelerometer, Figure 3, was placed at the bottom of a 5"x5"x5" corrugated box without added cushioning material. The box was then dropped 35 times and its average peak impact acceleration was used as a baseline. The process was repeated for each cushioning material mentioned above with 1 ¾" thickness. Impact acceleration data was summarized in Table 1 and Figure 8.

Table 1: *Peak Impact Acceleration Summary*

Drop (30")	Peak Impact Acceleration (G)				
	No Cushion	Corrugated	Peanut	Bubble - S	Bubble - L
1	78.32	44.73	32.64	11.19	15.26
2	66.89	44.72	40.81	10.71	17.75
3	79.51	63.06	37.02	11.96	11.63
4	59.12	47.84	40.34	17.90	12.80
5	56.96	49.14	31.78	19.01	14.80
6	54.33	60.13	32.75	13.24	17.17
7	55.51	47.29	31.23	10.99	16.42
8	67.16	63.27	35.09	14.99	14.07
9	57.27	56.17	32.63	11.00	17.32
10	71.80	41.23	29.36	15.51	16.61
11	58.51	49.56	30.01	17.96	10.84
12	71.45	53.17	30.70	10.27	13.40
13	65.05	49.37	30.37	26.21	11.58
14	54.51	51.43	37.81	21.95	12.23
15	73.34	50.17	32.96	11.43	13.16
16	78.06	47.78	36.43	17.86	17.03
17	67.95	50.36	33.60	10.15	14.80
18	78.48	52.73	29.37	26.94	12.92
19	58.94	40.76	30.21	19.75	12.63
20	72.03	45.58	33.98	19.24	13.17
21	80.07	50.80	33.26	24.94	14.62
22	69.39	56.23	33.97	16.73	15.42
23	75.66	43.65	41.98	22.41	16.22
24	65.32	41.75	36.78	32.87	14.47
25	77.07	44.56	31.55	28.09	12.66
26	68.09	51.81	28.89	18.26	15.49
27	70.14	60.34	34.73	16.38	11.64
28	71.36	58.38	35.74	30.43	16.68
29	65.02	40.81	29.68	26.44	14.51
30	76.79	49.92	38.67	24.23	14.00
31	65.87	41.63	31.90	17.84	18.96
32	70.91	38.63	33.52	31.30	14.36
33	54.26	39.79	31.62	31.96	15.24
34	60.35	56.51	32.06	18.61	11.98
35	70.12	53.05	30.21	17.93	18.54
Avg =	*67.59*	*49.61*	*33.53*	*19.33*	*14.58*
Min =	*54.26*	*38.63*	*28.89*	*10.15*	*10.84*
Max =	*80.07*	*63.27*	*41.98*	*32.87*	*18.96*
% of Base	***0.00***	***-26.60***	***-50.39***	***-71.40***	***-78.43***

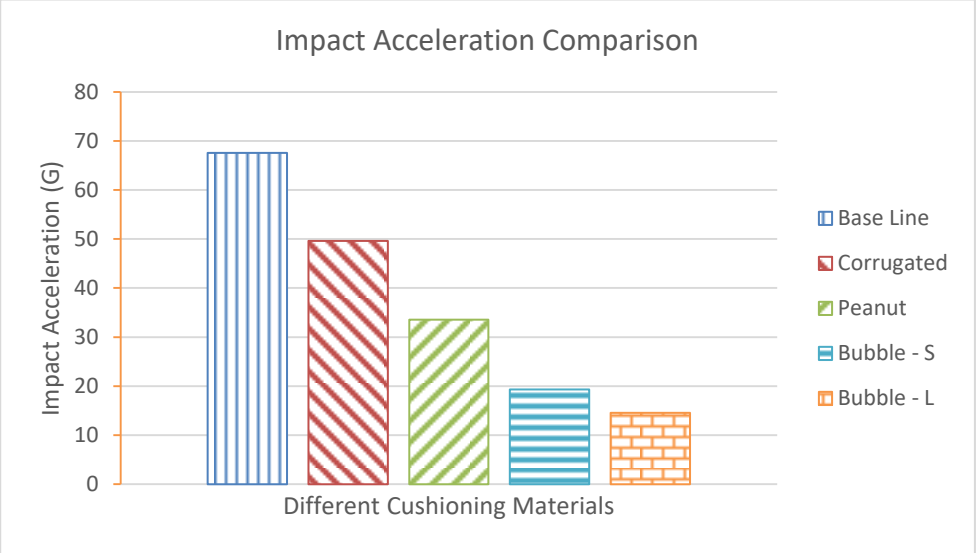

Figure 8: *Comparison of Different Cushioning Materials*

Optimum Shipping Box Size

Shipping cost typically depends on package product weight and volume. Using an oversize shipping box does not only cost more but uses more shipping materials, from boxes to cushioning materials and fillers. Table 2 below provides recommended box sizes to minimize the box volume and arrangements of multiple gift boxes. Biodegradable peanuts were used to fill the space around the products and for the interior surface of the shipping box as shown in Figure 9.

Table 2: *Optimum Shipping Box Sizes*

Number of Gift Box	Recommended Shipping Box	Packing Arrangement
1	9x7x4	
2	9x8x8	
3	11x9x9	
4	16x8x8	
5	10x10x14	

Figure 9: *Biodegradable Peanuts as Filler and Cushioning Material*

Drop Test

Similar glass jars were dropped at a 48-inch height with and without single-face corrugated wrap. As shown in Figure 10, the unprotected bottle (left) broke while the protected bottle survived with a little dent on its lid. Drop tests were performed on 3-oz honey jars with corrugated wrap at 48-inch and 30-inch drop heights. Cracks were observed as shown in Figure 11. However, no shattering of jars occurred. The same 30-inch drop was performed on a 12-oz honey jar with corrugated wrap. Unfortunately, it shattered. The 12-oz jar was heavier, thus had more mass. From Newton's second law of motion, F=ma, the impact force on 12-oz jar was greater than the 3-oz jar.

Figure 10: *Preliminary Drop Test of Similar Glass Jars*

Figure 11: *3-oz Honey Jar with Single-Face Corrugated Wrap: 48-Inch Drop (Left) & 30-Inch Drop (Right)*

A few solutions were attempted to protect 12-oz honey jars from individual jar drop, including protecting the jar bottom with corrugated fiberboard and bubble pouches, as shown in Figure 12. Damages are shown in Figure 13. While bubble wraps have shown greater impact absorption in Figure 8, the honey jar in the small-bubble pouch broke from a 30-inch drop. In the pouch case, only one layer of bubble wrap was under impact as opposed to several layers used in the impact absorption study. The weight from the 12-oz honey jar crushed and broke bubbles in the only layer of bubble pouch. When bubbles broke, they no longer absorbed impact which resulted in broken jar.

Even though other solutions protected or partially protected the 12-oz honey jar, none of them have deemed practical. Dropping a honey jar without a shipping box is too extreme. The main purpose of packaging is to protect products from damages during distribution. These honey jars would be in a gift box and another layer of shipping box during the distribution. Crinkle paper and biodegradable peanuts provided additional protection on the top of the single-face corrugated wrap on the jar.

Figure 12: *Various Solutions to Protect 12-oz Honey Jar from Breakage of 30-Inch Drop*

Figure 13: *Damages of 12-oz Honey Jar from 30-Inch Drop*

Granola Plastic Tray

Granola was packed in a plastic tray as shown in Figure 1. The tray lid appeared to be tight under normal circumstances. However, a drop test, such as the side drop shown in Figure 12, at a 48-inch height caused lid popping. Four paper labels were used to secure the lid to the tray. Side and corner

drops were made at 48-inch height. The labels were able to prevent the lid from popping off. However, the sides of the tray were pried open slightly, especially with the corner drop test. Regardless, the granola was still well secured within the tray as shown in Figure 13. This could be a problem with insects and/or moisture getting into these small openings. However, these small openings would not occur during shipment since these trays would be packed in a shipping box with biodegradable peanuts similar to the gift box packing method mentioned earlier.

Figure 12: *48-inch Side Drop of Granola Tray Caused Lid Popping*

Figure 13: *48-inch Corner Drop of Granola Tray with Lid Secured by Four Paper Labels*

Gift Box Drop Test

A gift box went through the 30-inch 10-drop sequence as specified in ISTA 1A as shown in Figure 14. A small scratch was found on the candle as shown in Figure 15. The 3-oz honey jar was not protected with single-face corrugated wrap and it was placed next to the candle. If the jar was protected with a wrap or placed away from the candle with crinkle paper in between, the scratch would not have occurred.

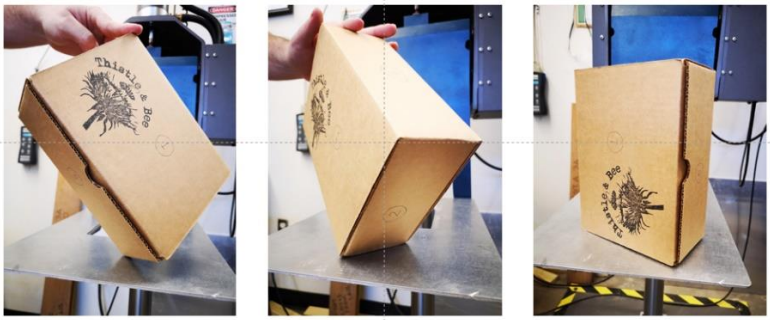

Figure 14: *30-inch 10-Drop Sequence of Gift Box*

Figure 15: *A Small Scratch on Candle in the Test Gift Box*

4. Discussion & Conclusion

Various aspects of packaging were investigated in this case study. Single-faced corrugated wrap is recommended for multi-pack honey jar packaging to provide cushion from jar-to-jar impacts during shipping. However, the corrugated wrap is not necessary in a gift pack since the honey jar is already protected by crinkle paper (which is recommended over biodegradable peanuts) and the gift box. A honey jar in a gift box looks better without a corrugated wrap. Also, packers need to place the jar away from the candle. An optimum size of shipping box should be used to minimize the packaging material utilization, which would benefit the environment. This includes less paper for the corrugated shipping box and less biodegradable peanuts in the shipping box. Paper labels are recommended for securing the lid to the granola plastic tray to prevent lid popping possibilities during drops. Bubble wraps are not recommended due to the impact plastic has on the environment. Wraps with big bubbles provide good protection from impact, but they are bulky. Small bubbles can be broken easily due to impact from the weight of the honey jar. Once broken, the bubble wrap can no longer provide protection.

This project gave packaging students at Christian Brothers University an opportunity to explore various aspects of packaging. Several recommendations as discussed in this article were given to Thistle & Bee. These solutions are practical and friendly to the environment. This is an excellent service-learning project that also helps a non-profit organization. The partnership with Thistle & Bee is on-going. As their social enterprise grows, more packaging needs will pose new challenges.

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