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Design and Development of Pet Carrier Travel Box

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Abstract: Pet animal especially chicken usually been carried out in a closed container such as pet cage and special box or bag for travelling and transportation. However, in pet poultry transportation it always concerns about animal welfare, stressful condition exposure, cleanliness, appropriate dimensions, highly price and sustainability of material. Therefore, this study objects is to design and develop a paperboard pet carrier travel box (PTCB) for pet poultry travelling and transportation especially chicken. Different corrugated material namely A-Flute, B-Flute, E-Flute and AB-Flute were evaluated. Design process was conducted through several phase which are concept development, concept selection, CAD model development via Solidworks, finite element analysis (FEA) via Solidworks simulation, functional prototype development, quality testing (drop, lift and transportation) and feedback survey. Results observed that AB flutes corrugated board is the most suitable material for the developed PTCB based on suitability, durability, and flexibility. In conclusion, the developed corrugated board pet carrier box in this study is recommended to be applied in local pet poultry application.

Keywords: Packaging Design, Corrugated Board, Pet Carrier Travel Box, Chicken

1. Introduction

Pet poultry carrier is required when transporting single or small amount of chicken, rooster or broilers for certain travelling functions such as veterinary checkup, show event, aircraft transportation, self-travelling and delivery to customers for breeding. Some commercial pet carriers for certain pet application such cat, dogs, bird and rabbit as shown in Figure 1 were developed to fulfill these requirements. A good pet carrier could protect the pet animal from injury and is easy to transmit without any adverse effects on the animal also can make it easier to make transfers or distributions. With good design, it does not distinguish the very important to prevent tension in the muscles of the animal's joints as the animal must move in a relaxed state. Good ventilation in these carrier should be the correct flow. In broilers and indigenous chicken industry, single big size of chicken or rooster usually transported

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using a steel cage, plastic carrier and wooden box as shown in Figure 2. However, these types of carrier is very costly and heavier in weight. Therefore, the development of less weight and lower price of pet carrier is required on demands. Nowadays, there was increasing demand of paper based packaging carrier box for pet transportation and distribution due to recyclable and lower price. Some commercial paperboard as shown in Figure 3 already rapidly been applied for pet travelling. Cardboard box as a place to hide reduces stress in caged cats [1]. However, there were less Malaysia local manufacturer for these kind of paperboard pet carrier and need to be imported. Therefore, the designed and development of paperboard pet carrier travel box (PCTB) in this study would be beneficial to local packaging manufacturer.

For the problem statement for this project, Pet travelling and transportation always concerns with the impacts to the animal itself due to stressful environment especially in pet poultry industry. Broilers may be subjected to a large spectrum of possible stressors shortly before and after transportation includes capturing, handling, packing, motion, movement, impact, thermal demands enforced by the microclimate of transport, fasting and water removal, behavioral restraint, social disturbance and noise [2]. Chicken handling, packing, shipping and unloading may have very serious impacts on their health [3]. Chickens do not control their body temperature by themselves and are vulnerable to hot and cold stress [4]. Chick weight loss was affected with journey duration and humidity, RH [5]. Gases contributed by chicken manure can cause a decrease in chicken's productivity and affect humans respiratory [6]. Therefore, it requires suitable transportation and distribution carrier box that can reduce the stressful impacts on chicken. By to focusing with the project, the objective for this study is design and develop a paperboard transportation box for a pet and second is to evaluate the quality of the developed paperboard pet carrier travel box. The scope for this study is to cover the evaluation of different types of corrugated board. This study also focused on designing and developing a box for a chicken transportation. Customer requirement survey is conducted. Carrier box is designed and developed through product design and development procedure. CAD modeling and FEA simulation evaluation is conducted via SolidWorks 2020 software. A functional prototype is produced based on actual size and maximum weight of animal is not more than 5 kg. Quality testing were conducted drop test and real transportation test. Feedback survey based on the prototype of pet carrier box is also conducted.

Figure 1: Current commercial pet carrier

Figure 2: Current chicken carrier for transportation

Figure 3: Current chicken carrier for transportation

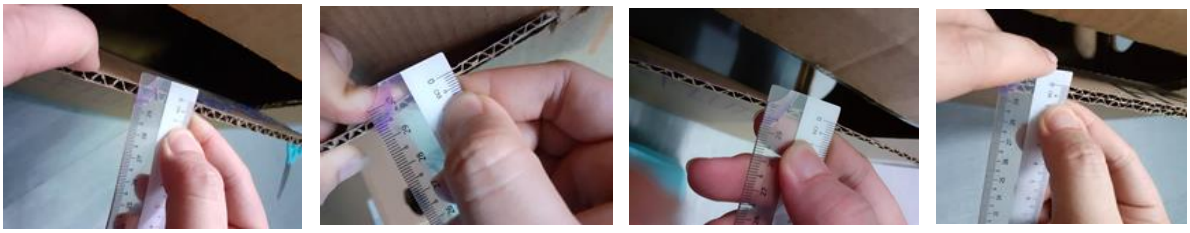
2. Materials and Methods

2.1 Materials and Equipment Preparation

In order to produce a successful PCTB, the material selection is important by considering that it achieves scope and objective. Four (4) different corrugated paperboard types (Figure 4) were selected and evaluated to produced PCTB, namely single wall (A-Flute), single wall (B-Flute), single wall (E-Flute) and double wall (AB-Flute). Corrugated carton box is a packaging transport carton made of corrugated carton, it has light, solid, product protection, easy storage and transport characteristics, it is also a good packaging material and has a good prospect of production due to its recycled characteristics and the green protection of the environment [7]. Functional prototype PCTB also produced using these four (4) types of corrugated board and proceed for comparative quality test. Table 1 shows the characteristics of each corrugated board. In addition, there are several equipment that have been used to make this project a success, namely by using the appropriate tools to be used for cutting, measuring and adhesive materials. The equipment used is measuring tape to measure the paperboard before cutting, using an iron knife to cut on each part of the paperboard and the adhesive material used is double tape. In addition, the materials used are markers for sketching on paperboard.

Table 1: Characteristics of the corrugate paperboard

Type	A-Flute	B-Flute	E-flute	AB-flute	unit
Strengthens	High	Low	Low	High	-
Thickness	4.0	2.1	1.0	7.0	Millimeter (mm)
Wall	Single	Single	Single	Double	-
Weight	692	678	670	700	Gram (g)



(a) (b) (c) (d)

Figure 4: Corrugated board thickness difference

2.2 Design and Development Phase

Six (6) different concept sketches were produced during the concept generation. The final design is selected based on the technical characteristics. Details improvement sketching on the selected idea is conducted. The comparative CAD modeling and finite element analysis (FEA) simulation of the PCTB detailed design is carried out by using Solidworks software for each type of corrugated material. The finite element analysis (FEA) of PCTB is applying to the rigid wall with the force 10 N. The pressure will only be given 10 N because the average weight of a chicken in this study is about 700 g up to 2 kilograms.

2.3 Drop and Lifting Test Procedure

The manual vertical drop test as shown in Figure 5 is conducted as duplication on how was the PCTB should be carried by human, the drop height is varying at three different heights of 200 mm, 400 mm and 800 mm to duplicate the carrying process. The drop height is measured from the floor to the PCTB drop position. Each type of products will be test and observed the damage on the surface of PCTB. For the drop test, has, a dummy weight similar to the chicken weight is placed inside the PCTB as duplication of chicken. PCTB also proceed to lifting test with chicken placed inside to observe any damages occurs on the PCTB.

2.4 Transportation Test Procedure

Real transportation test as shown in Figure 6 is conducted. PCTB is placed inside the car storage booth and visually observed on three different speed impact of 20 km/hours, 40 km/hours and 60 km/hours with emergency break.

(a) (b) (c)

Figure 5: Drop test set-up (a) 200 mm (b) 400 mm (c) 800 mm

Figure 6: Transportation test

2.5 Customer Feedback Survey

A customer survey has been conducted with 30 respondent via Google Form to evaluate the final prototype of the PCTB. A customer direct feedback also gained in order to determine any future improvement needed.

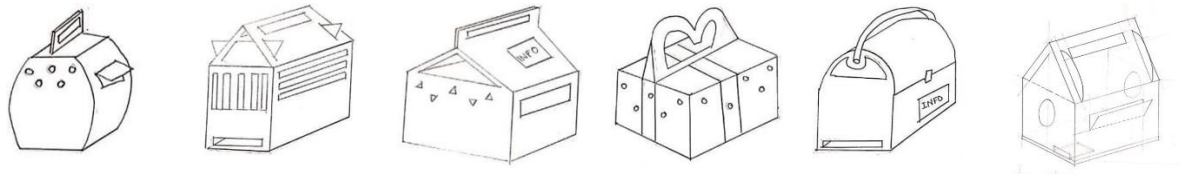
3. Results and Discussion

3.1 Customer needs survey result

Based on surveys that have been conducted and have received more than 50 people they have come up with positive results in terms of usefulness and the importance of PCTB to consumers. Thus, it has laid the foundations for the creation of new PCTB such as creating an invention that is beneficial to society. This questionnaire is very important to produce this project considering that it wants to get a percentage of the people who care for the animals. According to people who keep Pets at home, there are 78.80 % who take care of animals and 21.10 % did not keeps pet for the animals and 81.60 % were aware of the importance of cage for animals and 18.40 % were not aware of the importance of cage to animals.

3.2 Concept generation, selection and details sketching findings

Figure 7 shows six (6) sketch of concepts generated in this study. Each concepts has its technical requirements and characteristics as illustrated in Table 2. Sketching 6 as shown in Figure 7 (f) had been selected because of easy to store in a small space, using the AB- Flute's cardboard and easy to keep and attached.



(a) (b) (c) (d) (e) (f)

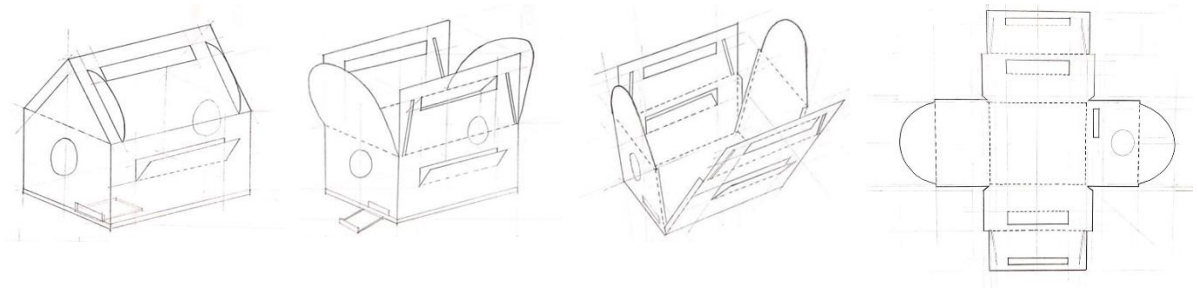
Figure 7: Concept sketches

Table 2: Technical function and characteristics of concept sketches

Sketching	Design Name	Purpose	Type of Cardboard	Easy to keep/fold	Easy to attach
Sketching 1	Curve Shape Cage	Specially for animals with wings	F-Flute	No	No
Sketching 2	House Shape Cage	Big-sized animal	C-Flute	Yes	Yes
Sketching 3	Small Cage	Small-sized animal	A-Flute	Yes	Yes
Sketching 4	Present Pet Carrier Travel Box	In the form of gift box	A-Flute	Yes	Yes
Sketching 5	Handbag Shape Cage	Special design for female animal	E-Flute	No	No

Sketching 6	Pet Carrier Travel Box	Easy to store in a small space	AB-Flute	Yes	Yes

Figure 8 shows the detail improvement of the selected of sketching 6 with addition of ventilation and observation holes, appropriate sizing and handle



(a) (b) (c) (d)

Figure 8: Detail Sketching

Figure 10 shows the CAD model constructed via SolidWorks 2020 software. PCTB prototype dimension is determined by referring to the chicken measurement in Table 3.

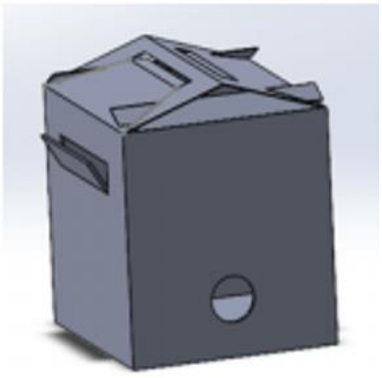


Figure 9: SolidWorks CAD modeling

Table 3: Chicken measurement for PCTB prototype

Characteristics	Rooster	Hen
Height (From leg to head)	385mm	330mm
Height (From leg to body)	168mm	140mm
Width (From beak to tail)	429mm	320mm
Width (Chest)	235mm	280mm
Mass	400g	1500g

Description	Chicken
Height (From leg to head)	400mm
Height (From leg to body)	180mm
Width (From beak to tail)	450mm
Width (Chest)	300mm
Mass	1700g

3.3 Mock-up and functional prototyping

Figure 11 shows the first mock up prototype of PCTB. This mock-up prototype has been produced without actual size and function to observe any abnormality before the functional prototype is produced.

Figure 10: PCTB first mock-up

A die cut detail drawing for the final design of PCTB is generated using Adobe Illustrator software as shown in Figure 11. This die cut drawing is referred to the prototype construction. As a result, final

functional prototype of PCTB for each corrugated material type is cut, assembles and produced as shown in Figure 12.

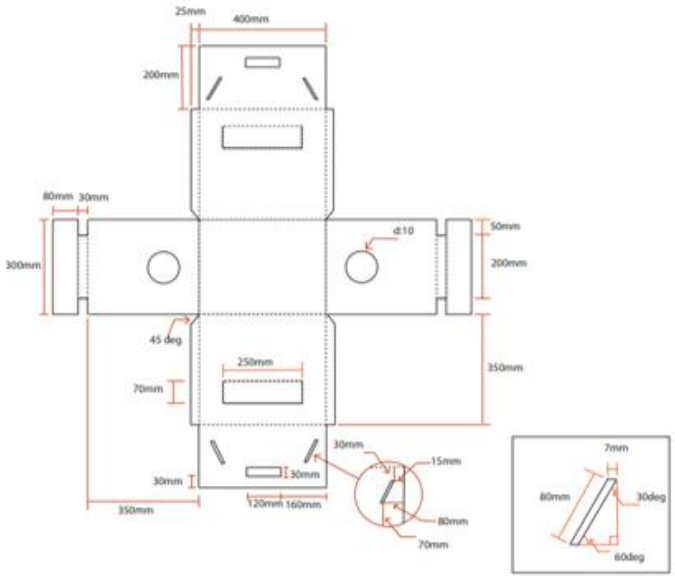


Figure 11: Die cut drawing of PCTB

(a) (b) (c) (d) (e)

Figure 12: PCTB functional prototype (a) die cut (b) A-Flute (b) B-Flute (c) E-Flute (d) AB-Flute

3.4 Drop and lift test result and discussion

Table 4 shows A-flute and AB-Flute type of PCTB had no defects after the drop test. However B-Flute and E-Flute type of PCTB had defects after dropped as shown in Figure 13

Table 4: Drop test visual defect findings

Type's Material of cardboard	Volumetric Weight (mm^3/kg)	Max Weight Applied	Circumstances of Box surface	Damage	Suitable for use
A-Flute	4.836	4-5	Good	No	Yes
B-Flute	5.757	4-5	Not Good	Yes	No
E-Flute	6.409	4-5	Not Good	Yes	No
AB-Flute	3.757	4-5	Good	No	Yes

The defects occurs after placing the chicken inside the PCTB (Figure 14) varies according to the type of corrugate product. Based on the study that has been done, the strength for corrugate product E-Flute is not strong after lift it up because the thickness of the corrugate product is very thin at 1.0 mm compared to other types of corrugate box. The weak part is the handle part and also the bottom of the

product because when lifting the box on the handle, there is a torn effect as Figure 13 (b) on the part and this indicates corrugate E-Flute is not suitable to be used as a PCTB. The same condition goes for corrugate B-Flute because the B-Flute has a thickness of 2.1 mm. The results for A-flute and AB flute indicates these two types of corrugated material suitable for PCTB raw material.

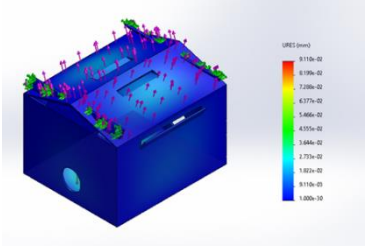
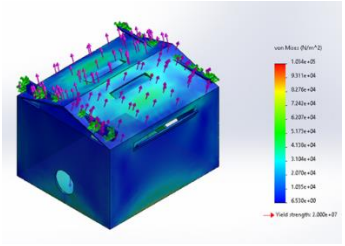
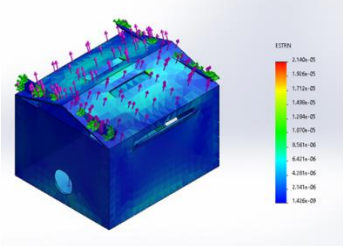
(a) (b)

Figure 13: B-Flute and E-Flute drop and lift test defects (a) drop (b) lift-handle area

Figure 14: PCTB lifting test with chicken

3.5 SolidWorks FEA simulation result

Figure 14 and Table 5 shows Solidworks Simulation diagram for PCTB in terms of total displacement, equivalent stress and static strain. The result of Solidworks simulation for B-Flute and E-Flute were significant with drop and lifting test result which had defects at handle and bottom area. B-Flute and E-Flute had higher total displacement, equivalent stress and static strain compared to A-Flute and AB-Flute. Overall results for each type of PCTB has increment in total displacement, equivalent stress and strain at top handle area and bottom side of the box. Compared to acceptable simulation results of A-flute, AB flute has better total displacement, equivalent stress and static strain. AB flute type diagram, shows less effected by the pressure applied on the box due to its high thickness and double wall condition. Based on this results, AB flute is proposed as selected material for PCTB.

	Total Displacement (TD)	Equivalent Stress (EV)	Static Strain (SS)
(a)			
	TD: 9.110e-02 mm	EV: 1.034e+04 N/m^2	SS: 2.140e-05

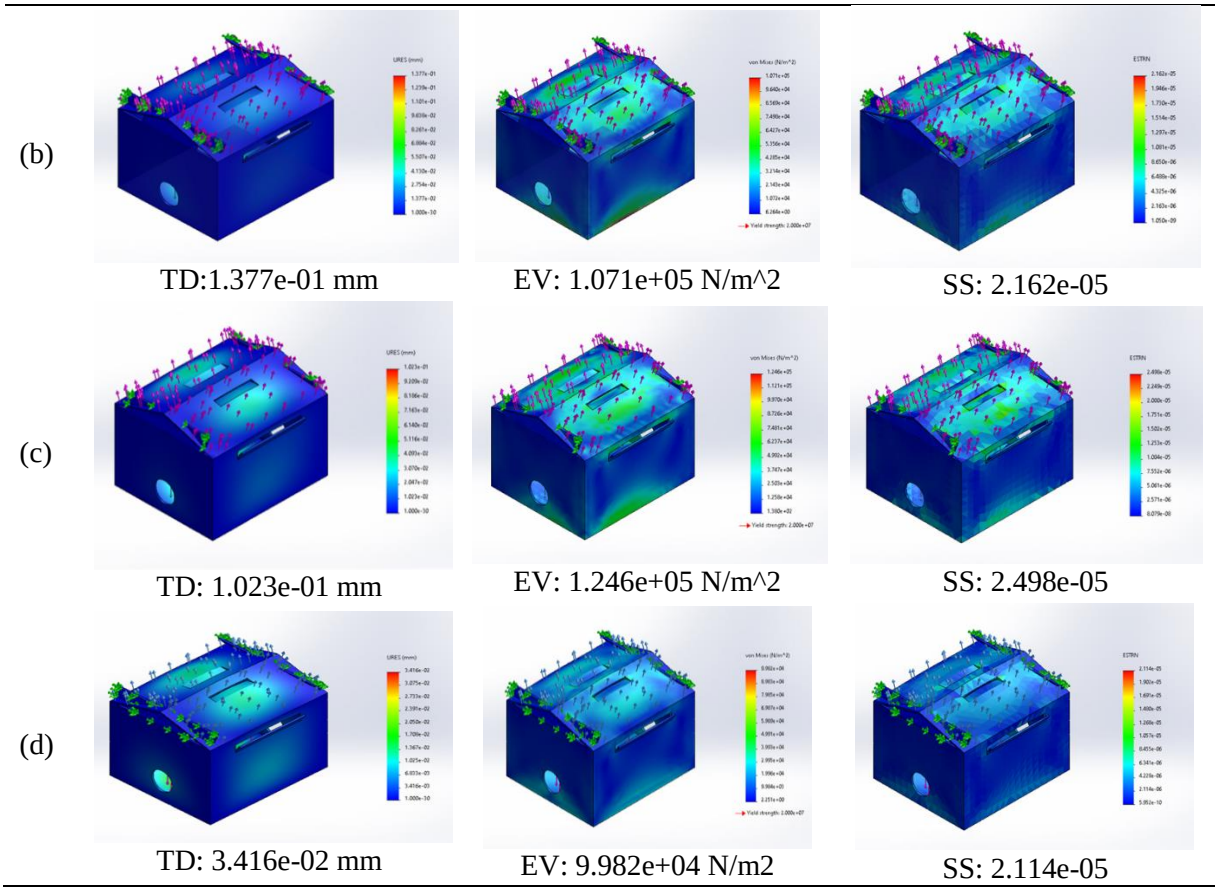


Figure 14: Solidworks FEA simulation diagram (a) A-Flute (b) B-Flute (c) E-Flute (d) AB-Flute

Table 5: SolidWorks FEA simulation results of PCTB

Type's Material of cardboard	Volume Weight (mm^3/kg)	Force (N)	Total Displacement (mm)	Equivalent Stress (N/m^2)	Static Strain
A-Flute	4.836	10	9.110e-02	1.034e+05	2.140e-05
B-Flute	5.757	10	1.377e-01	1.071e+05	2.162e-05
E-Flute	6.409	10	1.023e-01	1.246e+05	2.498e-05
AB-Flute	3.757	10	3.416e-02	9.982e+04	2.114e-04

3.6 Transportation test result and discussion

Based on the Table 6, the test for transportation had been done by using a PCTB to observe the condition with the effect of different speed and emergency break of transportation. The conditions of all PCTB had shown that each speed has a certain limit to determine the condition of the paperboard. At the speed of 20 km/h all type of PCTB are in good condition while in emergency break. For a speed of 40 km/h, the condition of all PCTB is in good condition. For 60 km/h, the condition of the PCTB is in good condition except for the condition of the E-Flute paperboard. The E-Flute paperboard shows a side effect in the middle of the surface that is the inside effect (Figure 15).

Table 6: Transportation visual condition observation

Speed km/hours	Condition of the container			
	A-Flute	B-Flute	E-Flute	AB-Flute
20	Good	Good	Good	Good

40	Good	Good	Good	Good
60	Good	Good	Not Good	Good

Figure 15: Defects on E-Flute PCTB at 60 km/hours

3.7 Optimum PCTB design corrugated board material

Table 7 shows that AB-flute is the most suitable corrugated material to produce PCTB after consider overall testing results. However, A-flute PCTB still could be applied for small and less weight of chicken and short distances of transportation.

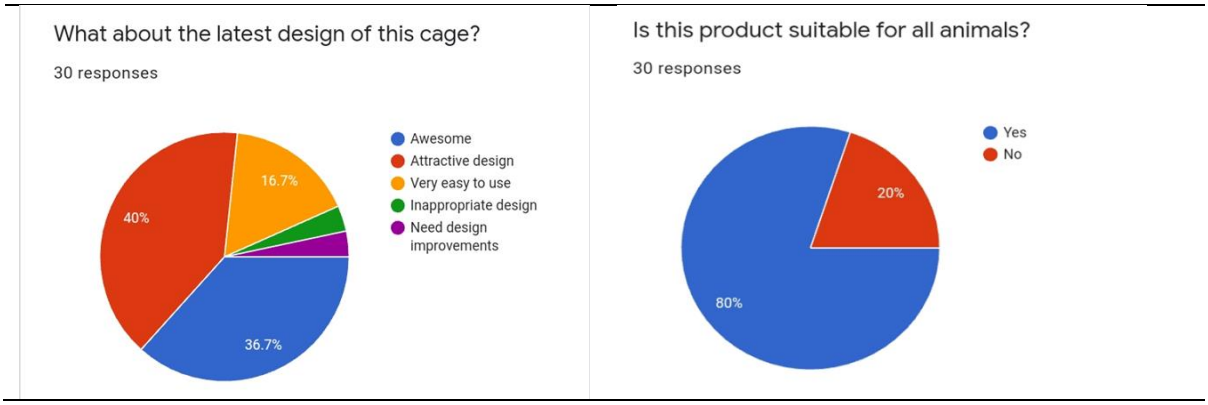
Table 7: Optimization of PCTB corrugated board material

PCTB type	Drop Test	Lifting Test	Transportation Test	Simulation Test
A-Flute	O	O	O	X
B-Flute	X	X	O	X
E-Flute	X	X	X	X
AB-Flute	O	O	O	O

O = ok and X = reject

3.8 Customer feedback survey findings

A poultry farmer has given a direct feedback to this PCTB prototype because this project could benefit in carrying chicken for transportation without using a rope, iron cage or any methods. Other feedback indicates that the locking area need to be improved in future to ease the closing procedure. Majority of 30 respondent feedbacks that the developed PCTB is awesome and attractive, suitable paperboard material, suitable for any pet animals, good product and idea, sustainable and willing to buy as illustrated in Figure 16.



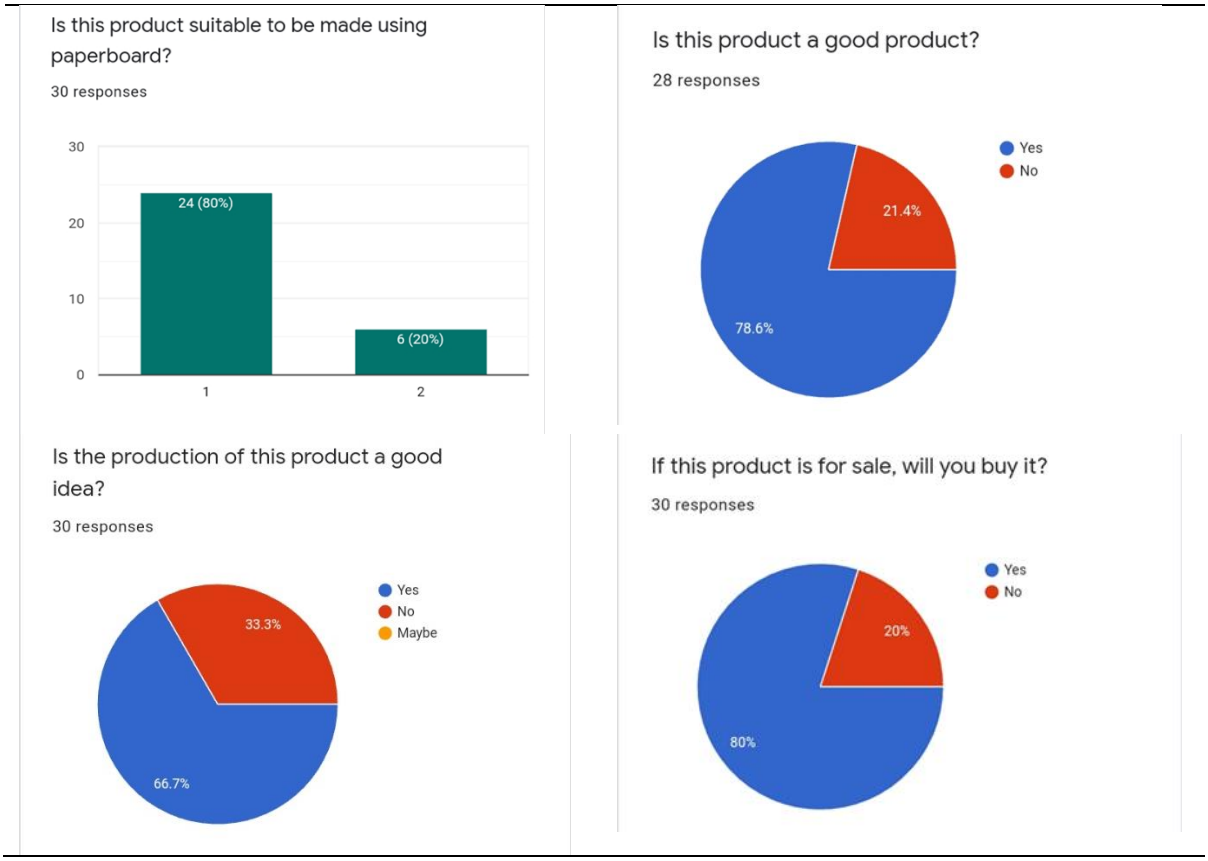


Figure 16: 30 respondent feedback survey results

4. Conclusion

In conclusion, the project has gained a positive and successful results where all objectives are achieved. A final design and prototype of PCTB is successfully developed and produced. The study has observed the various types of corrugated paperboard namely A-Flute, B-Flute, E-Flute and AB-Flute for the PCTB raw material. Based on the drop and lift test, transportation test and FEA simulation, PCTB with is AB-Flute corrugated material is the optimum design recommended to be applied in carrying chicken. It has high durability, easy to form and fold, recyclable and lower cost. Positive feedback also gained from the feedback survey. Therefore, the Pet Carrier Travel Box (PCTB) developed in this project could benefit pet poultry industry in transportation and distribution function and could be applied to other types of pet animal too.

In recommendation, standard packaging test such as vibration test and paperboard mechanical characteristics test should be carried out in future research. Standard drop and transportation test using simulator also recommended. Customer also feedback on the locking area should be improve to ease open and close process. Additional graphic should be added and printed on the PCTB packaging to ease the communication and marketing of the pet animal product.

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