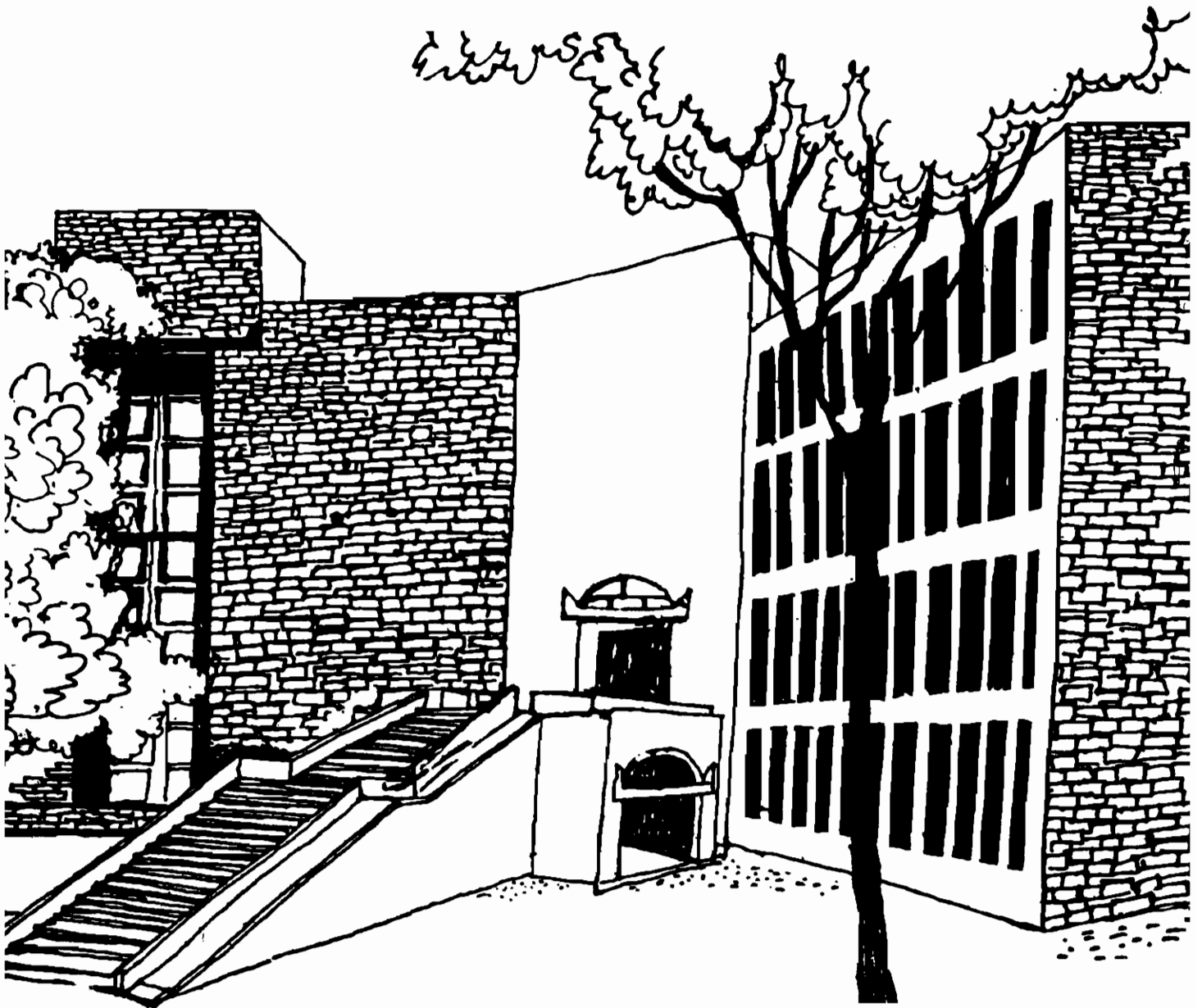




# Working Paper



COMPARISON OF VASTRAPUR CARTONS WITH  
CONVENTIONAL WOOD CARTON BASED ON  
LABORATORY TESTS

By

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## Comparison of Vastrapur Cartons with Conventional Wood Carton based on Laboratory Tests

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### **Vastrapur Cartons**

Three different containers have been developed for transport of fresh tomatoes. All three are made of corrugated fibre board (CFB). Specification of these is given in **table 1**. The 10 kg carton will henceforth be referred to as 'Tray', and the other two as **Carton-15** and **Carton-20**. All three are designed for stacking strength of 350 kg. The Tray is designed for long distance transport of about 2000 km. and the cartons for distances less than 1000 km. These are meant for growers who send produce to APMC markets within Gujarat or in immediate neighbourhood such as Udaipur and Mumbai. The Tray is for those who send produce to as far as Delhi and even Bangalore from Gujarat.

### **Sample Cartons**

Fifty pieces of each of the three cartons were fabricated in the factory of Core Emballage as per the specifications given in **table 1**. These were put through compression, drop and vibration tests in the laboratory of Core Emballage Limited, Ahmedabad. All cartons used in the test were pre-conditioned in a room for 72 hours prior to test. Relative humidity of 50 per cent and temperature of 20°C was maintained in the conditioning room.

<b>Table 1</b>			
<b>Specification Details Recommended by Core Emballage for Newly Developed CFB Cartons</b>			
<i>Specifications</i>	<i>Types of Packages and Capacity</i>		
	<i>Tray (10 kg)</i>	<i>Carton (15 kg)</i>	<i>Carton (20 kg)</i>
1. Material of Construction	CFB, 3 ply	CFB, 5 ply	CFB, 5 ply
2. Internal Dimensions (mm)	467 x 284 x 118	363 x 192 x 373	430 x 205 x 390
3. Style of Box	Tray	RSC 0201	RSC 0201
4. Direction of Flutes	Vertical	Vertical	Vertical
5. Type of Flutes	B	B/C	B/C
6. Grammage of Plies (g/m.sq) (Outer to Inner)	150 all	150 all	150 all
7. Bursting Strength (kg. cm sq)	6.5± 0.5	11± 1	11± 1
8. Compression Strength (kgf)			
9. Cobb Value (30 minutes) g/m sq	140 gsm	140 gsm	140 gsm
10. Type of Adhesive	Starch based	Starch based	Starch based
11. No of Pieces per Box	1	1	1
12. Joints	Glued	Glued	Glued
13. No of Ventilation Holes	8	8	8
14. Diameter and Position of Holes	61 x 30 mm (edges)	24.5 mm (long walls)	24.5 mm (long walls)

## **Sample Tomatoes**

Tomatoes used in tests were procured each day in the morning from APMC market at Jamalpur, Ahmedabad. These had been brought to market from growing areas around Ahmedabad, with typical transport distance of about 50 km. Tomatoes were thus, not farm-fresh. From APMC market, crated tomatoes were brought in a car to the laboratory of Core Emballage which is only 3 km from the market. Here these were uncrated. Tomatoes with skin rupture severe bruise and cracks were removed. The remaining were sorted using an improvised sorter--a wood template with holes of several different sizes. Tomatoes for test had equatorial diameter of 5 to 8 cm. Tomatoes were of *Rashmi* variety, and were mostly red ripe on arrival.

## **Test Protocol**

### **Compression Test**

Empty trays were placed in between the platens of the BCT machine. As the upper plate moved down, deformation and load were displayed on the read-out panel. Deformation was noted at intervals of 25 kg. Six replications were made for each container. Tests were terminated when load reached 350 kg (desired stacking strength) or when failure occurred.

### **Drop Test**

Two types of drop test--straight and angular--were conducted. Drop height in straight test was 20 cm. A sequence of 6, 12 and 15 drops were made. In angular drop, one edge of the tray bottom was placed gently on platform, opposite edge lifted so that the bottom made an angle of 25° with platform. Higher edge was then allowed to drop. A sequence of 15 drops were made in each replication.

Drop surface was the platform of the drop testing machine. But actual dropping of carton from a specified height and angle was done manually. This was because the drop tester did not have provision for height of drop lower than 70 cm.

### **Vibration Test**

One each of Tray, Carton-15, and Carton-20 were filled with tomatoes from the common lot. All three were placed simultaneously on the vibration table. The machine was turned on. It was turned off after 20 minutes, and all three were removed. Similar runs were made for exposure time of 40, 60 and 120 minutes. During the test, the frequency of vibration remained at  $300 \pm 2$  cycles per minute. Thus, the tests were conducted at identical frequency and with similar tomatoes.

### **Measure of 'Damage'**

Tomato used in test had already incurred some mechanical damage in transit. In this work 'damage' is, therefore, defined to mean only rupture, burst, crack and any other skin discontinuity. This was done because such damage was easy to observe visually. For this reason, values of damage reported here should be used only for comparison of the cartons and not in absolute sense.

## **Results**

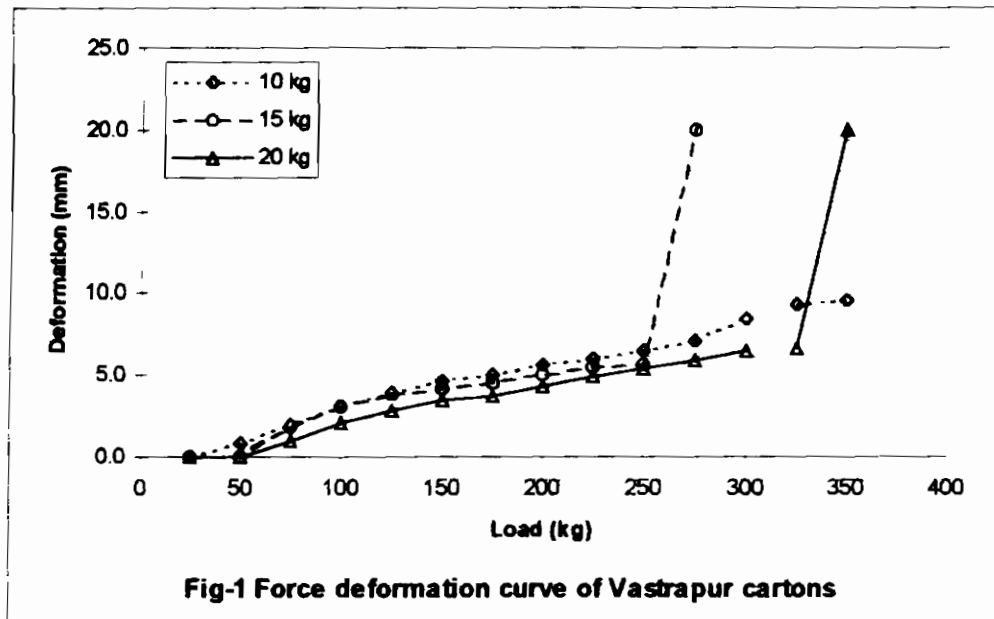
### ***Stacking Strength***

Result of compression tests are given in **appendix table A1, A2, and A3**. Summary of the results is given in **table 2**. **Figure 1** shows the results graphically.

The Tray has the stacking strength of 350 kg as stipulated in the design specifications. Carton-15 and Carton-20 have stacking strength of 256 kg and 325 kg respectively. Carton-15 may need modification on the aspect.

<b>Table 2: Summary of Compression Tests</b>			
<b>Load (kg)</b>	<b>Deformation (mm)</b>		
	<b>Tray</b>	<b>Carton-15</b>	<b>Carton-20</b>
25	0.0	0	0
50	0.9	0	0
75	1.9	1.9	1
100	3.1	3.1	2.1
125	3.9	3.8	2.8
150	4.7	4.1	3.4
175	5.1	4.6	3.7
200	5.6	5.1	4.3
225	6.0	5.6	4.9
250	6.5	5.7	5.4
275	7.2	Failure	5.9
300	8.5		6.5
325	9.3		6.6
350	9.7		Failure

**Tray** : Average of 6 replications and rounded off, no failure upto 350 kg  
**Carton-15** : Values up to 225 kg are mean of 6, and 250 kg value of 4 replications  
**Carton-20** : Values up to 300 kg are mean of 5, and 320 kg value of 4 replications





When the three cartons are loaded up to their respective stacking strength, the deformation does not exceed 10 mm (**figure 1**). This is satisfactory.

The compressive strength of each was obtained from the graph and is given below. As can be seen in the **figure 1**, the force-deformation is nearly linear after 50 kg until failure. The compressive strength given below is the slope of this part of the figure.

Tray	36 kg/mm
Carton-15	35 kg/mm
Carton-20	42 kg/mm

#### ***Ability to Withstand Handling Abuse***

**Appendix tables A4, A5, and A6** give the results of drop tests. **Table 3** shows the summary of results. **Figure 2** shows the summary graphically. As expected, the damage increases with increase in the number of drops. It is also seen that the damage increases with the size (capacity) of carton. In practice a carton is estimated to undergo 12 to 15 drops, some straight, some angular. The damage remains less than 4% in all cases.

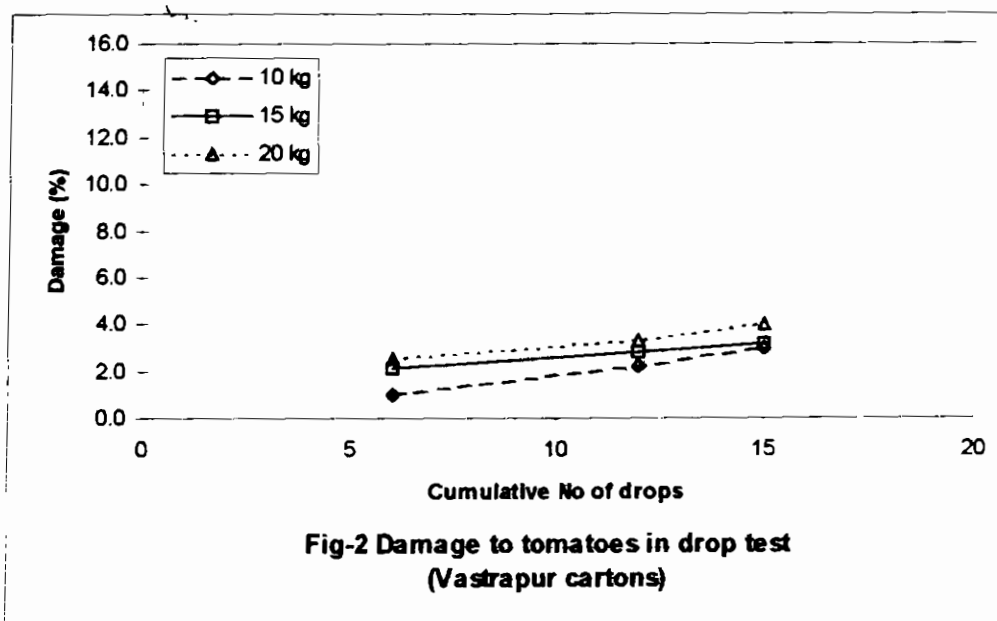
#### ***Ability to Withstand Transport Induced Shocks***

**Appendix tables A7, A8, and A9** give the results of vibration tests. These are summarised in **table 4**. **Figure 3** shows the summary of damage to tomato graphically. The Tray was tested for exposure time up to 2 hours. Carton-15 and Carton-20 were tested for exposure time of only up to 1 hour. As expected, the extent of damage increases with increases in exposure time. In this machine, the exposure time of one hour, as per the claim of manufacturers, represents 1000 km of road travel.

Tray did not fail in the entire two hour exposure. The extent of damage at the end of one hour was 3%. At the end of two hours, it rose sharply to 12.5%. As stated before, the Tray was designed for travel up to 2000 km. Thus, the Tray is expected to retain its structural integrity during a single journey of 2000 km.

<b>Table 3</b>				
<b>Damage to Tomato due to Drops</b>				
	<i>Straight drops (20 cm)</i>			<i>Angular drop (25°)</i>
	6 nos.	12 nos.	15 nos.	15
Tray	1.0 %	2.2 %	3.0 %	2.7 %
Carton-15	2.1 %	2.8 %	3.2 %	2.9 %
Carton-20	2.6 %	3.3 %	4.0 %	2.3 %

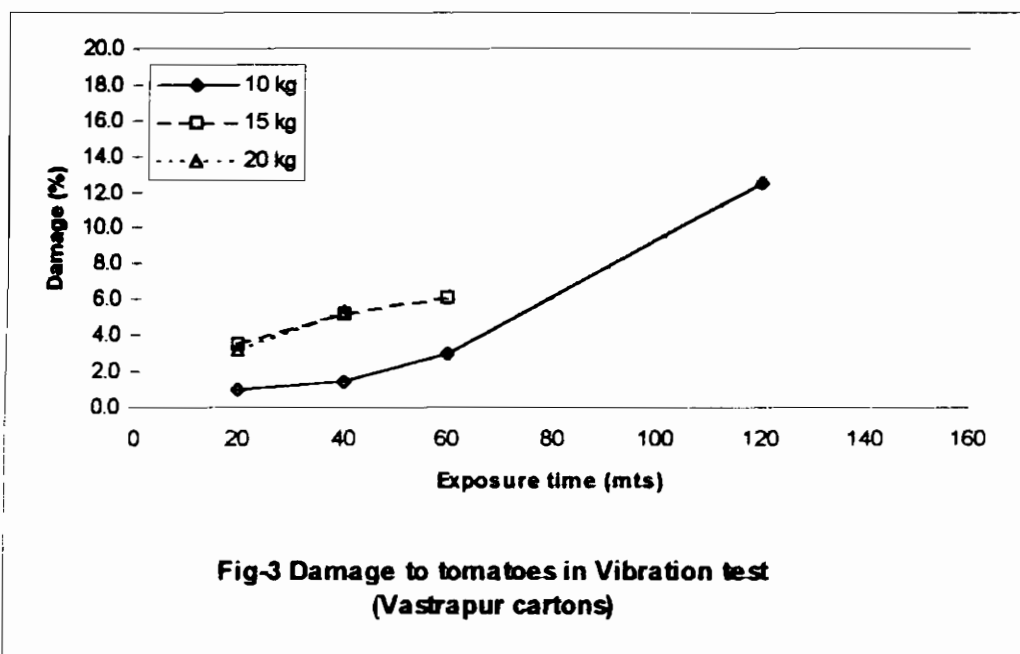
**Tray : Damage is mean of 3 replications and rounded off**  
**Carton-15 : Damage is mean of 3 replications and rounded off**  
**Carton-20 : Damage is mean of 3 replications and rounded off**



<b>Table 4</b>				
<b>Damage to Tomato due to Vibration</b>				
	<i>Exposure time (min)</i>			
	20	40	60	120
Tray	1.0 %	1.5 %	3.0 %	12.5 %
Carton-15	3.6 %	5.3 %	6.2 %	-
Carton-20	3.2 %	5.4 %	-	-

**Frequency of vibration :  $300 \pm 2$  cycles/min**

**Note : Damage is mean of 2 replications and rounded off. When tests were terminated Carton-20 had high amount of damage, about 16 %**



<b>Table 5</b>				
<b>Comparative Performance of Conventional Wood Carton and Newly Developed Vastrapur (CFB) Cartons</b>				
<i>Tests</i>	<i>Wood Carton (20 kg capacity)</i>	<i>Vastrapur (CFB) Cartons</i>		
		<i>Tray (10 kg capacity)</i>	<i>Carton-15 (15 kg capacity)</i>	<i>Carton-20 (20 kg capacity)</i>
<b>1) Compression test</b>				
(a) Stacking strength	>>350 kg	350 kg	256 kg	334 kg
(b) Deformation when loaded upto stacking strength	8 mm	10 mm	5.7 mm	6.6 mm
(c) Compressive strength	43 kg/mm	36 kg/mm	35 kg/mm	42 kg/mm
<b>2) Vibration test</b>				
Damage to tomato after				
(a) 20 minutes	7.0 %	1.0 %	3.6 %	3.2 %
(b) 40 minutes	10.5 %	1.5 %	5.3 %	5.4 %
(c) 60 minutes	13.5 %	3.0 %	6.2 %	-
(d) 120 minutes	-	12.5 %	-	-
<b>3) Drop test</b>				
(i) Straight fall (20 cm) Damage to tomato				
(a) With 6 drops	4.0 %	1.0 %	2.1 %	2.6 %
(b) With 12 drops	6.0 %	2.2 %	2.8 %	3.3 %
(c) With 15 drops	-	3.0 %	3.2 %	4.0 %
(ii) Angular fall (25° tilt)				
(a) 10 drops	4.0 %	-	-	-
(b) 15 drops	-	2.7 %	2.9 %	2.3 %
<b>Date : Jan-Feb, 1999</b>		<b>Place : Core Emballage Ltd, Ahmedabad</b>		
<b>Material : CFB</b>				
<b>Tomatoes Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)</b>				

Carton-15 and Carton-20 are designed for only about 1000 km travel. Hence, these were tested only for one hour exposure time. Carton-15 did retain its structural integrity. But Carton-20 failed both times--first after 35 minutes and next after 55 minutes. Carton-20 thus, will require some modification on the aspect. At the end of one hour, the damage to produce in Carton-15 was 6.2%, nearly twice as much as in the Tray after equal exposure.

When tests were terminated, Carton-20 had much higher damage, about 16%.

### **Comparison of Vastrapur Cartons with Wood Carton**

**Table 5** gives the comparison between currently used wood carton and newly developed Vastrapur cartons. Wood carton has much higher stacking strength and the Vastrapur cartons. The Tray and Carton-20 have stacking strength of slightly greater than 300 kg. Carton-15 is slightly weaker.

The Tray is superior to the wood carton in transport. It is better suited for long distance transport, as shown by much lower damage to produce. Carton-15 and Carton-20 also perform better than wood carton in transport. Result of drop test also indicates that the damage to produce due to handling abuse is less in Vastrapur cartons than the wood carton.

### **Conclusion**

The Tray (10 kg) appears promising for long distance transport. Carton-15 requires improvement in stacking strength. Carton-20 requires improvement in ability to withstand vibratory shocks. All three are, however, promising and after due modification, need to be put through field trial. During the field trial, views of the growers will also need to be obtained on comparative costs.

**Appendix Table-A1  
Compression Test (Tray)**

<i>Load (kg)</i>	<i>Deformation (mm)</i>					
	C1	C2	C3	C4	C5	C6
25	0	0	0	0	0	0
50	0.9	1.3	0.6	1.2	0.7	0.7
75	2	2	1.5	2.4	1.6	2.1
100	2.8	3.2	2.9	3.7	2.9	3.2
125	3.9	4	3.6	4.2	3.6	4
150	4.7	5	4.2	4.9	4.3	4.8
175	4.9	5.4	4.7	5.3	5	5.2
200	5.6	6	5.1	5.8	5.4	5.7
225	6	6	5.8	6.2	5.9	6.2
250	6.7	6.2	6.1	6.8	6.3	6.8
275	7.2	7.2	6.4	7.6	6.6	8
300	7.8	8.7	7.8	8.9	8.7	9.1
325	8.9	10	8.9	9.3	9.1	9.5
350	9.2	10.6	9.1	9.5	9.2	9.7

**Damage to tray**

- C1 - (Tare -360g) Both smaller side walls and one bottom edge damaged.  
 C2 - (Tare -351g) Both longer side walls bulged, both the top and one bottom edge damaged.  
 C3 - (Tare -356.5g) Both longer side walls bulged, both the top and one bottom edge damaged.  
 C4 - (Tare -353.5g) Both longer side walls bulged.  
 C5 - (Tare -353.5g) Both longer side walls bulged, both the top edges damaged.  
 C6 - (Tare -353.5g) Both longer side walls bulged.

In all cases bulge reversed, when load removed.

**Date : January 21, 1999**

**Place: Core Emballage Ltd, Ahmedabad**

**Material : CFB Tray of 10 kg capacity**

<b>Appendix Table-A2 Compression Test (Carton-15)</b>						
<b>Load (kg)</b>	<b>Deformation (mm)</b>					
	<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>	<b>C6</b>
25	0	0	0	0	0	0
50	0	0	0	0	0	0
75	1.3	2.2	2.5	1.8	1.8	1.7
100	2.5	3.8	3.8	2.9	2.5	2.8
125	3.3	4.3	4.5	3.4	3.2	4.0
150	3.6	4.7	4.9	3.7	3.4	4.4
175	4.0	5.1	5.8	4.0	3.7	4.8
200	4.4	5.8	6.4	4.7	4.0	5.1
225	4.8	6.7	7.1	5.2	4.3	5.3
250	5.3	TT	TT	6.9	4.8	TT
275	6.5			TT	5.2	
300	TT				6.1	
325					TT	
350						

**TT : Test Terminated**

**Damage to the carton**

C1- (Tare -515 g) one longer side wall bulged, failure at 276 kg, deformation 7.4 mm.

C2- (Tare -520 g) no damage, failure at 228 kg, deformation 8.7 mm.

C3- (Tare -518.5 g) longer side wall bulged, failure at 234 kg, deformation 9.3 mm.

C4- (Tare -520.5 g) no damage, failure at 250 kg, deformation 6.2 mm.

C5- (Tare -513.5 g) no damage, failure at 301 kg, deformation 7.3 mm.

C6- (Tare -515 g) no damage, failure at 246 kg, deformation 5.5 mm.

In all cases bulge reversed when load removed.

**Date : February 8, 1999**                      **Place : Core Emballage Ltd, Ahmedabad**

**Material : CFB Carton of 15 kg capacity**

<b>Appendix Table-A3 Compression Test (Carton-20)</b>					
<b>Load (kg)</b>	<b>Deformation (mm)</b>				
	<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>
25	0	0	0	0	0
50	0	0	0	0	0
75	0.1	2.4	0.7	1.3	0.5
100	2.0	3.6	1.3	2.5	1.2
125	2.7	4.6	1.8	3.2	1.9
150	3.1	5.1	2.5	3.9	2.3
175	3.4	5.3	2.9	4.0	3.0
200	3.7	5.8	4.0	4.7	3.4
225	4.0	6.4	4.7	5.2	4.1
250	4.2	6.9	5.6	5.7	4.8
275	4.7	7.3	6.0	6.3	5.4
300	5.1	8.0	6.5	6.8	5.9
325	5.6	TT	7.1	7.2	6.3
350	7.5		TT	TT	TT

**TT : Test Terminated**

**Damage to the carton**

C1- (Tare -638 g) one longer side wall bulged, failure at 363 kg, deformation 19.8 mm.

C2- (Tare -646 g) lower ends bulged, failure at 318 kg, deformation 21.9 mm.

C3- (Tare -631 g) longer side wall bulged, failure at 340 kg, deformation 18.9 mm.

C4- (Tare -634 g) longer side walls bulged, failure at 312 kg, deformation 17.0 mm.

C5- (Tare -634 g) longer side walls bulged, failure at 335 kg, deformation 22.4 mm.

In all cases bulge reversed when load removed.

**Date : February 1, 1999** **Place : Core Emballage Ltd, Ahmedabad**

**Material : CFB Carton of 20 kg capacity**



**Appendix Table-A4  
Drop Test (Tray)**

<b>Straight fall (20 cm height)</b>					
<i>S.No</i>	<i>Net weight of tomato (kg)</i>	<i>No of drops</i>	<i>Weight of damaged tomatoes (g)</i>	<i>Damage observed</i>	
				<i>Tray</i>	<i>Tomatoes</i>
1	10	6	100	no damage	skin break
2	10	6	90	no damage	"
3	10	6	95	no damage	"
4	10	12	200	locks opened	punctures, skin breaks and cuts
5	10	12	250	"	"
6	10	12	200	"	"
7	10	15	250	"	seriously damaged
8	10	15	300	"	"
9	10	15	350	"	"
<b>Angular fall (25° tilt)</b>					
1	10	15	250	one smaller side wall bulged, juice seeped into bottom	bottom tomatoes damaged
2	10	15	300	"	"
3	10	15	250	"	"
<b>Date : February 16, 1999</b>			<b>Place : Core Emballage Ltd, Ahmedabad</b>		
<b>Material : CFB Tray of 10 kg capacity</b>					
<b>Tomatoes Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)</b>					

**Appendix Table-A5  
Drop Test (Carton-15)**

<b>Straight fall (20 cm height)</b>					
<b>S.No</b>	<b>No of drops</b>	<b>Net wt. of tomato (kg)</b>	<b>Amount of damaged tomatoes (g)</b>	<b>Damage observed</b>	
				<b>Carton</b>	<b>Tomatoes</b>
1	6	15	300	no damage	bottom tomatoes became soft
2	6	15	350	"	"
3	6	15	300	"	"
4	12	15	400	"	skinbreaks, cuts and burst observed
5	12	15	400	"	"
6	12	15	450	"	"
7	15	15	450	"	seriously damaged
8	15	15	500	"	"
9	15	15	500	"	"
<b>Angular fall (25° tilt)</b>					
1	15	15	400	no damage	bottom tomatoes damaged
2	15	15	450	"	"
3	15	15	450	"	"
<b>Date : February 16, 1999</b>			<b>Place : Core Emballage Ltd, Ahmedabad</b>		
<b>Material : CFB Carton of 15 kg capacity</b>					
<b>Tomato Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)</b>					

**Appendix Table-A6  
Drop Test (Carton-20)**

<b>Straight fall (20 cm height)</b>					
<b>S.No</b>	<b>No of drops</b>	<b>Net wt. of tomato (kg)</b>	<b>Amount of damaged tomatoes (g)</b>	<b>Damage observed</b>	
				<b>Carton</b>	<b>Tomatoes</b>
1	6	20	500	no damage	bottom tomatoes became soft
2	6	20	550	"	"
3	6	20	500	"	"
4	12	20	700	"	skin breaks, cuts and burst observed
5	12	20	650	"	"
6	12	20	650	"	"
7	15	20	700	"	seriously damaged
8	15	20	850	"	"
9	15	20	800	"	"
<b>Angular fall (25° tilt)</b>					
1	15	20	400	no damage	bottom tomatoes damaged
2	15	20	450	"	"
3	15	20	500	"	"
<b>Date : February 16, 1999</b>					
<b>Place : Core Emballage Ltd, Ahmedabad</b>					
<b>Material : CFB Carton of 20 kg capacity</b>					
<b>Tomato Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)</b>					

**Appendix Table-A7  
Vibration Test (Tray)**

<i>S.No</i>	<i>Net wt. of tomato (kg)</i>	<i>Exposure time (min)</i>	<i>Wt. of damaged tomato (gm)</i>	<i>Damage observed</i>	
				<i>Tray</i>	<i>Tomatoes</i>
1	10	20	100	no damage	bottom tomatoes became soft but no bursting seen.
2	10	20	100	"	"
3	10	40	200	"	bottom tomatoes became soft and burst.
4	10	40	100	"	"
5	10	60	200	small damages seen at bottom	"
6	10	60	400	"	"
7	10	120	1250	totally damaged	seriously damaged

**Frequency of vibration : 300 ± 2 cycles /min**

**Date : February 11, 1999** **Place : Core Emballage Ltd, Ahmedabad**

**Material : CFB Tray of 10 kg capacity**

**Tomatoes Procured : APMC, Jamalpur, Ahmedabad (Source :Near by villages)**

**Appendix Table-A8  
Vibration Test (Carton-15)**

<i>S.No</i>	<i>Net wt. of tomatoes (kg)</i>	<i>Exposure time (min)</i>	<i>Wt. of damaged tomatoes (g)</i>	<i>Damage to carton</i>	<i>Damage to tomatoes</i>
1	16.7	20	800	no damage	bottom tomatoes became soft but no bursting seen
2	16.2	20	400	"	"
3	15.8	40	800	"	bottom tomatoes became soft and burst
4	16.1	40	900	"	"
5	16.6	60	1200	"	seriously damaged
6	17.2	60	900	"	"

**Frequency of vibration :  $300 \pm 2$  cycles /min**

**Date : February 11, 1999**

**Place : Core Emballage Ltd, Ahmedabad**

**Material : CFB Carton of 15 kg capacity**

**Tomatoes Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)**

<b>Appendix Table-A9 Vibration Test (Carton-20)</b>			
<b>S.No</b>	<b>Net wt. of tomato (kg)</b>	<b>Exposure time (min)</b>	<b>Amount of damaged tomato at the end of test (g)</b>
1	21.3	20	500
2	22.6	20	900
3	21.8	40	1100
4	22.8	40	1300
5	21.4	60 (TT at 35 min)	3200
6	22.3	60 (TT at 55 min)	3800

**TT : Test Terminated**

**Frequency of vibration : 300 ± 2 cycles/min**

**20 min Vibration:** Bottom tomatoes became soft, burst and cuts low; no significant damage to the carton

**40 min Vibration:** Most of bottom tomatoes became soft and burst; bottom of the carton got wetted

**60 min Vibration :** both the tests had to be terminated prematurely; bottom and the walls got soaked in juice and gave away

**Date : February 11, 1999**      **Place : Core Emballage Ltd, Ahmedabad**

**Material : CFB Carton of 20 kg capacity**

**Tomato Procured : APMC, Jamalpur, Ahmedabad (Source : Near by villages)**

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