Development of Corrugated Fiber Board Cartons for Long Distance Transport of Tomato in India

Girja Sharan
S. Srivastav
Kishor P. Rawale
Umang Dave

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Girja Sharan
Centre for Management in Agriculture
Indian Institute of Management
Ahmedabad, India, 380 015
gsharan@iimahd.ernet.in

S. Srivastav
Department of Food Processing Technology
A. D. Patel Institute of Technology
New V V Nagar, Anand, India, 388121
shivmurtis@gmail.com

Kishor P. Rawale
Assistant Manager
Jain Irrigation Systems Ltd.
(Agriculture & Food Division)
Sirsoli Road, Jalgaon, India, 425001
kishor27@yahoo.com

Umang Dave
Assistant General Manager
Core Emballage Limited
Core House, Off C. G. Road
Ahmedabad, India, 380 006

Abstract

Tomato growers of Gujarat , north-west India , traditionally send produce to wholesale market in Ahmedabad city for auction. Growing areas lie about 250-300 km from the city. Growers were constrained to sell there even if the prices were not attractive which the case usually as season advanced was. Lack of sturdy packaging deterred them from sending produce to more distant markets such as Bombay (600 km) , Delhi (900 km) or Bangalore (2000) . Peti, the box used presently, made of strips of wood nailed together does not protect the produce adequately. Although, there are many large packaging firms in the region producing boxes for various consumer products, problem of tomato growers was not recognized. Their view was that tomato being a low-value commodity, growers will not buy better packaging. Being mostly small, growers were not organized enough to raise funds to sponsor research at public R&D institutions in the area. That task was therefore taken up. Boxes that protected the produce better on long journey and were affordable were designed and introduced successfully in the region. This paper describes the development.

Index Terms –Cartons for tomato, fruit damages in transit, packaging for shipment.

INTRODUCTION

Gujarat, a province in north-west India, produces about 700,000 ton of tomato each season. Growers are mostly small farmers. Crop is planted in August; picking starts in November and continues till March. Growers pack the produce at farmstead and then send via trucks to the wholesale market in Ahmedabad city for auction. Growing areas lie in 200 km radius around the city. As picking starts only a small quantity of produce arrives for auction. Arrivals peak towards the end of December and then a gradual decline sets in. Growers realize better price in the beginning. But by the middle of the season prices decline considerably. In some seasons, the decline is so steep that growers are unable to recover even the cost of packaging and transport. Small growers numbering thousands are impacted severely. This problem was noticed in the season of 1998, when growers were forced to suspend picking mid season because of slump in prices. Media highlighted the problem. Perceiving an opportunity for service engineering, we visited and interviewed growers to find out what would help in such a situation in future. They indicated that when prices are low in Ahmedabad, higher prices actually prevail in adjoining provinces where during that time there is no local crop. But the deterrent was lack of sturdy packaging which could transport the produce safely to distant markets- Bombay (500 km), Jaipur (700 km), Delhi (900 km), and Bangalore (2000 km). Their conventional packaging -"peti"-box made of strips of wood nailed together, they felt would not protect the produce adequately in transit.

The information gathered from growers led us first to quantify the damages incurred in transit with tomato packed in petis. A random sample of petis arriving at Ahmedabad auction market was studied (Siripurapu, et al, 1998). Sample petis were emptied out, each fruit inspected visually for mechanical damages. Petis that had traveled 120 km had 3 – 4.5 % (600 to 900 gm in 20 kg) fruit with serious damages - bursts, bruises, fresh skin cracks. Those with 270 km travel had greater damage 5.5 to 7 %. Mechanical damages tend to grow non-linearly with transit distance. Thus the view of the growers about likely losses on longer journey was well –founded. It became apparent that a better packaging would be needed to enable growers to send produce safely over longer distances.

The next step was to search for a better box in the market. There are a number of box makers in the region – some large ones. Interaction indicated that some of them were aware of the packaging problems of tomato growers but had no plans to address it. They said they did not have the experience of designing containers for materials that need special care and are perishable. They also apprehended that tomato being a low value produce, growers may not spend more for better packaging. That triggered the start of the initiative reported here. Two boxes made of corrugated fiber board (CFB) were developed keeping in view the physiological and rheological properties of tomato and the economic conditions of the growers. One box was launched in the Gujarat market in the season of 1999-2000, just over a year after the problem was identified. The second box was modified slightly in response to needs of growers of a different region (Himachal) who too were in search of a better packaging. It was named Himachal Carton and launched in 2001 in that region. This paper describes the development which passed through the following stages.

1. Survey of packaging currently used, engineering evaluation of the most important one to identify its merits and demerits.

2. Setting specifications for new packaging in consultation with the stakeholders-growers, transporters, handlers and traders.
3. Design prototype, laboratory tests and field trial
4. Introduction in the market.

Engineering Evaluation of Peti

A survey revealed that growers used an assortment of boxes to pack tomato which included used CFB boxes that previously packed cold drink bottles, medicine, cosmetics, biscuits, household appliances. These were purchased from scrap dealers. Flutes of these single-journey boxes get flattened on first use, compressive strength is lowered and these tend to bulge easily. Usage only signified that growers were in need of a better packaging. More common mode of packaging was the peti-a box of 42x30x28 cm, holding 20 kg produce. Peti was selected for study and evaluation (Figure 1).

MATERIALS AND METHODS

Generally these are stacked in columns of 4 to 6 in the truck. Thus, the bottom peti would have a load of about 125 kg. On occasions there could be some extra such as person sitting atop. Petis are exposed to shocks while being loaded and unloaded. From farm gate to the retail stores there could be up to ten lift-drops. More sever shocks are encountered in transit when vehicle moves on rough roads with potholes and speed breakers. Shocks induced from road surface are transmitted to the produce via wheel-suspension-packaging box link. A good box should preserve its structural integrity and protect the produce through all these. Three type of tests were accordingly carried out-Box Compression Test (BCT), Drop Test and Vibration Test–to evaluate the peti.

In BCT empty petis were placed between platens of the machine (Unique Enterprises, Pune, India). As the upper platen moved down, deformation and load were displayed on the read-out panel. Loading rate was 11.8 mm/minute. Deformation was noted at intervals of 25 kg. Six replications were made. Drop tests involved subjecting petis filled with 20 kg tomato to a sequence of drops. Two types of test were done-straight drop from height of 20 cm, second, one edge of the box bottom remained on platform, opposite edge lifted to angle of 25 degree and dropped. Structural damages to petis and to produce were noted. Vibration tests were done on a machine supplied by the same manufacturer. It had pre-set frequency (3 Hz) and pre-set amplitude (15-mm horizontal and 6 mm vertical). The manufacturer indicated that one hour on the machine represented 1000 km of road travel. Three identical tomato-filled boxes were placed side by side on the platform of a vibrator. Machine was turned on. One box was removed after every 20 minutes. At the end of the test, damages to the boxes and produce were noted.

Tests were conducted in July 1998. A set of newly made petis was procured for tests. The outer dimension of the sample petis was 42x30x28 cm, tare weight between 2.4 to 2.6 kg. Petis were stored for 72 hours in a room with temperature at 23°C and RH 50 percent. Tests were carried out in the laboratory of Core Emballage Limited, Ahmedabad, and a large box maker of India. This was not a growing season in Gujarat; therefore tomatoes were purchased from the wholesale market, each day in the morning. Fruits used for tests were carefully selected-free from cracks and skin discontinuities. Tomatoes were also sorted for size uniformity with a template with various sizes of opening. Fruits of 50–55 mm along major axis were selected for tests.

Test results were published earlier elsewhere (Sharan et al, 1999a, 1999b, Sharan and Srivastav, 2000). Some key results are given here. Deformation of petis increased (Figure 2) almost linearly with load. It did not exceed 6 mm under a load of 250 kg. Fresh produce carrying boxes are required not to deform more than 10 mm when stacked in columns in truck (Technical Association of the Pulp and Paper Industry, 1993). Peti met that requirement. Up to five straight drops did not cause significant damage to peti or to produce. After the fifth drop, (Table I) nails of corner joints loosened causing the box to deform diagonally. Fruits that burst or developed skin discontinuity were 4 % after six straight drops, 7% after twelve. Angular drops are nearly equally severe. Peti was not strong enough to withstand long enough sequence of drops normally expected in handling. A significant proportion of the produce especially near the bottom will suffer damages. Vibration test simulates road travel. The acceleration to which the boxes under test are subject to is given (Technical Association of the Pulp and Paper Industry, 1993) by equation (1). Given the frequency and amplitudes in this particular machine, the acceleration to which the boxes were subjected to worked out to 0. 6 g units.

$$G = \frac{D f^2}{250} \qquad (1)$$

Where

G = Number of g units

D = Displacement, mm

f = Frequency, Hz

FIGURE 1 PETIS BEING ASSEMBLED

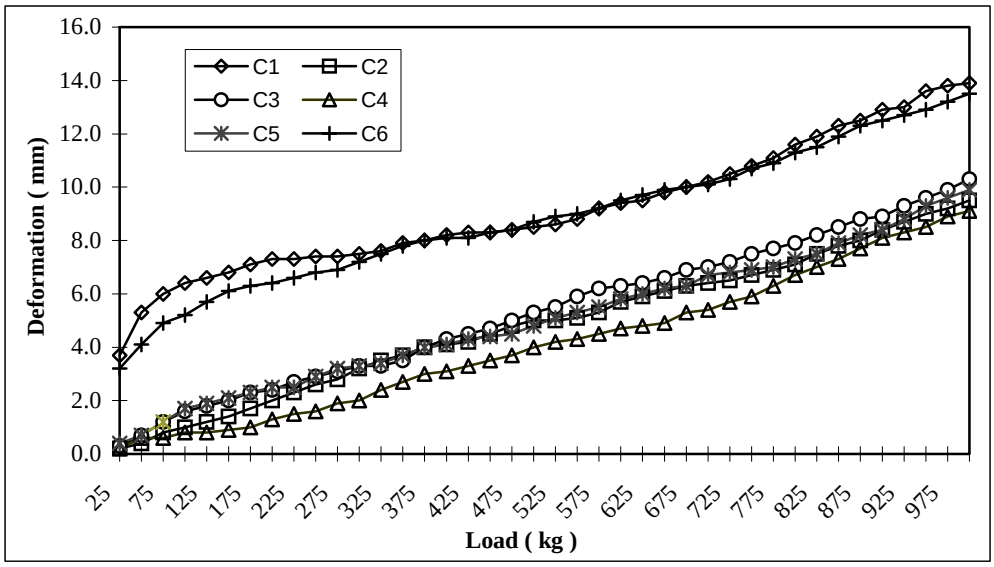

FIGURE 2
FORCE DEFORMATION CURVE OF PETI

TABLE I
DAMAGE TO PETI AND PRODUCE IN DROP TESTS

Weight of peti filled with tomato (kg)	Drops type and number	Damage to peti	Damage to tomato
20	6 (straight)	Nails loosened , cracks on some slats diagonal elongation 0.9 – 1.4 cm	Fruits in the lower part bust , burst fruit in three replications 734 gm (4% of total)
20	12 (straight)	Nails loosened , cracks on some slats diagonal elongation 0.4 – 0.9 cm	Fruits in the lower part bust , burst fruit 1280 gm (7% of total)
20	10 (angular)	One side of the cartoon was totally damaged, nails come out diagonal elongation 1.4 cm	Fruits in the lower part bust , burst fruit 850 gm (4.6 % of total)

TABLE II
DAMAGES TO PRODUCE AND PETI IN VIBRATION

Exposure time (min)	Proportion of produce damaged (%)	Diagonal Elongation of peti (cm)
20	7.0	0.3
40	10.5	0.4 – 0.6
60	13.5	1 – 1.5

Values mean of two replications

Results of vibration are given in Table II. Vibrations loosen the corner joints much the same way as in the course of drops. Amount of damaged produce increases with duration of exposure to vibration. It was concluded that peti was strong in compression but not strong enough to withstand shocks encountered in handling and transit. Its corner joints loosen causing diagonal deformation. Fruits in the lower part are damaged. An alternative that could transport the produce safely over longer distance was considered desirable.

Specifications of New Packaging Box

Desired features of new boxes were developed by consultation with users and transporters.

(a) *Stacking strength* -250 kg- so that these could be stacked to height of up to 2 m common in Indian trucks.
(b) *Withstand handling abuse*-retain structural integrity through a sequence of at least 15 straight and angular drops.

(c) *Withstand road-induced shock* - protect produce and its own structural integrity over a 2000 km road journey.
(d) *Ventilation* -8 holes of 20 mm diameter.
(e) *Capacity* - 20 to 25 kg tomato.
(f) *Material and Environmental Factor* -material used should not create disposal problem.
(g) *Cost* -about Rs.15 per piece comparable to that of the peti.
(h) *Ease of Handling -p*rovision of grip for handling.
(i) *Produce Identification -g*raphics printable

Two different boxes VC-20, VC-15 were designed with specifications given in table III.

TABLE III
SPECIFICATIONS

Specifications	*VC-20*	*VC-15*
Capacity (kg)	20	15
Material of construction	CFB, 5 ply	CFB, 5 ply
Internal dimensions (mm)	430 x 205 x 390	363 x 192 x 373
Style of box	RSC 0201	RSC 0201
Direction of flutes	Vertical	Vertical
Type of flutes	B/C	B/C
Grammage of plies (g/m^2)	150	150
Bursting strength ($kg.cm^2$)	11±1	11±1
Cobb value (g/m^2)	140 gsm	140 gsm
Type of adhesive	Starch based	Starch based
Number of pieces per box	1	1
Joints	Glued	Glued
Number of ventilation holes	8	8
Diameter and position of holes	24.5 mm, long wall	24.5 mm, long wall

Laboratory and field trial
Fifty pieces of each were fabricated and tested in manner described above. All cartons used in the test were pre-conditioned for 72 hours, in a room where relative humidity of 50 per cent and temperature of 23°C was maintained (Sharan, et al, 1999b). Tomatoes (trade name Rashmi) were commercial hybrids. BCT tests (Table IV) confirmed that both boxes were capable of withstanding 250 kg load with less than 6 mm deformation. As expected, the damage increases with increase in the number of drops (Table V). There was no damage to the boxes during the drops, both straight and angular. Vibration tests revealed that damage to produce increases with exposure time (Table VI). Box VC -15 retained its structural integrity. But VC-20 failed after 35-55 mt. Table VII gives a summary of attributes of wood and newly developed boxes.

TABLE IV
BCT TEST DATA

Load (kg)	Deformation (mm)	
	VC-15	*VC-20*
25	0	0
50	0	0
75	1.9	1
100	3.1	2.1
125	3.8	2.8
150	4.1	3.4
175	4.6	3.7
200	5.1	4.3
225	5.6	4.9
250	5.7	5.4
275	Failure	5.9
300		6.5
325		6.6
350		Failure

VC-15 : Values up to 225 kg are mean of 6, and 250 kg value of 4 replications
VC-20 : Values up to 300 kg are mean of 5, and 320 kg value of 4 replications

TABLE V
DAMAGE TO PRODUCE IN DROP TEST

Cartons	Straight Drop (20 cm)			Angular Drop (25^0)
	6 nos.	*12 nos.*	*15 nos.*	15
VC-15	2.1 %	2.8 %	3.2 %	2.9 %
VC-20	2.6 %	3.3 %	4.0 %	2.3 %

Damage values mean of 3 replications

TABLE VI
DAMAGE TO PRODUCE IN VIBRATION TEST

Cartons	Exposure time (min)			
	20	*40*	*60*	*120*
VC-15	3.6 %	5.3 %	6.2 %	-
VC-20	3.2 %	5.4 %	-	-

Damage is mean of 2 replications and rounded off.

TABLE VII
COMPARATIVE PERFORMANCE OF PETI AND CARTONS

Particulars	Peti	VC-15 (15 kg cap)	VC-20 (20 kg cap)
Compression Test			
(a) Stacking strength	>>350 kg	250 kg	325 kg
(b) Compressive strength	43 kg/mm	35 kg/mm	42 kg/mm
Vibration Test			
Damage to tomato after			
(a) 20 minutes	7.0 %	3.6 %	3.2 %
(b) 40 minutes	10.5 %	5.3 %	5.4 %
(c) 60 minutes	13.5 %	6.2 %	-
(d) 120 minutes	-	-	-
Drop Test			
Damage to tomato after			
(i) Straight fall (20 cm)			
(a) 6 drops	4.0 %	2.1%	2.6 %
(b) 12 drops	6.0 %	2.8%	3.3 %
(c) 15 drops	-	3.2%	4.0 %
(ii) Angular fall (25^0 tilt)			
(a) 10 drops	4.0 %	-	-
(b) 15 drops	-	2.9%	2.3 %

Jan-Feb, 1999 Core Emballage Ltd, Ahmedabad

After laboratory tests, a transport trial was carried out. One-half of the truck was loaded with tomato packed in petis and the other half with produce packed in VC-15 and VC-20. Overall damage in petis was found to be higher (4.6 per cent) than that on Vastrapur cartons (2.8 per cent) (Sharan et al, 1999b, Sharan and Srivastav, 2000). The boxes appeared to be satisfactory in performance and an improvement over the petis.

The box (VC-20) was introduced in the Gujarat region in the season of 1999- 2000. About a year after the launch of cartons in Gujarat region, we were approached by the International Development Enterprises (IDE, India), an NGO working with small tomato growers in the hills in Himachal. There too the growers used similar peti. But the Himachal government had just then passed a law banning felling trees to make the petis. Pine trees were mostly used. IDE perceived that an alternative would need to be developed urgently. IDE team visited us to see the box, took a sample to show to the growers in Solan area and selected VC-15 for trial. They also invited us to visit their growers to receive feedback and to determine if any special features were needed. We visited the area and had discussions with the growers. The post harvest practices were

documented. Almost all aspects were similar here except one-which the harvest season here got some rains and therefore the cartons will need protection. A positive aspect was that the tomato here was off-season and attracted much better prices making it easier to spend some more for packaging.

Kits consisted of sets of wood strips cut to measure. Suppliers delivered the kits at a convenient pick-up point on the road side near the farms. Growers needed only to use hammer and nails to assemble the peti from the kits. It took about four minutes to assemble one. Peti had provision for aeration, and smooth inner finish, though nails some times protruded. Tare weight of freshly made peti was 2.7 kg. Petis were usually available for Rs.18-20 per piece. Growers indicated that they liked the VC-15 box. But before finalizing the choice they required that a transport trial be organized from their area to Delhi. Two thousand five hundred boxes were manufactured and taken to Solan. They set the aims of trial as follows. Overall damage to the produce was 1.5% in VC, nearly half of that in the (2.1 %) in the petis (Sharan and Rawale, 2001). Growers who witnessed the trial also suggested modifications relating to the capacity of the box, placement of ventilation holes, side grip, moisture resistance and competitiveness in pricing. The modifications were carried out and the new box-Himachal Carton -was made available in the market in Delhi (FIGURE 3, 4) and Shimla area.

FIGURE 3
HIMACHAL CARTONS AT ROADHEAD FOR TRANSPORT

FIGURE 4
HIMACHAL CARTONS AT DELHI AUCTION MARKET

CONCLUSION

The wood box traditionally used by commercial growers to transport tomato to auction market in Gujarat province (India) was a poor packaging. It has sufficient compressive strength for four- tier stacking usual on trucks , but could not withstand long sequences of lift-drops in handling and the dynamic shocks encountered in transit over rough roads. That constrained the growers to sell produce in Ahmedabad and deterred them from sending it to more distant markets to realize better prices. Growers community consists of thousands of small farmers who could not engage R&D institutions to solve their packaging problem. The local box makers too ignored the problem apprehending that the growers will not be willing to pay for better packaging. The task of developing a safer and affordable packaging was recognized as important and was carried out in partnership with a large box- maker. Two boxes were developed, tested in laboratory and in road journey. Manufacturing and marketing arrangements were worked out with private firms and cartons introduced in the regional markets. New boxes have gradually gained acceptance are in increasing use.

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