

IMPACT OF DIFFERENT PACKAGING TECHNOLOGIES ON POST-HARVEST LOSSES OF STONE FRUITS IN SWAT PAKISTAN

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ABSTRACT:- Soft texture of stone fruits makes them prone to post-harvest losses. Effect of different packaging materials on the texture of fruits also varies for their post-harvest losses. The present study was conducted to evaluate the effect of wooden and cardboard box technologies on post-harvest losses of plum through its marketing channel. Primary data was collected through pre tested questionnaires by proportionate random sampling procedure. Quantitative losses were estimated through percentage method while partial losses were estimated at the wholesale and retail level by price differential method. Multiple regression analysis was employed to find relation between post-harvest losses and different factors at three different stages. Findings of the study revealed the channel of cardboard box technology accounted for post-harvest losses of 10.49% while at farm level, losses were 2.90%, at wholesale level 1.45% and retail level the losses were 6.14%. On the other hand post-harvest losses were 14.24% in wooden box channel; in which 6.10% occurred at farm level, 1.43% at the wholesale level and 6.71% at the retail level. Cardboard box technology has reduced post-harvest losses of plum by 27%. Post-harvest losses were moderate and positively correlated at farm level, weakly and positive related at whole sale level and weak and negatively correlated at retail level. Pre-harvest management, careful handling and harvesting in proper maturity can help in reducing post-harvest losses.

Key Words: Plum, Packaging Technology, Price Differential, Cardboard, Wooden Box; Pakistan.

INTRODUCTION

Pakistan has rich topographic and climatic endowments and variations in soil where, large range of horticultural crops is grown. Horticulture sector can provide opportunities to increase income alleviate hunger, poverty and reduce socio-economic problems (Alam and Mujtaba, 2002). Total annual production of fruits and vegetables is 12 mt in Pakistan wherein, fruits

production is about 5.71 mt. Important fruits being produced in Pakistan are citrus, mango, dates, guava, banana, peach, plum, pear, apple, apricot, grapes, persimmon. In term of production, citrus fruit is leading followed by mango, dates and guava (GoP, 2008). Some of these fruits are specific to certain regions. Plum (*Prunus domestica*) is an important stone fruit after peach in terms of area and production. Different varieties of plum (Fazle

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mananai, Faramusa, Beauty and Late mananai) are grown in different climatic conditions. Pakistan ranked 17th with annual production of 67000 tons for plum in the world. Most of the fruit is consumed at the domestic level whereas; a slight share is exported to the neighboring countries like India, Bangladesh, Sri Lanka and Gulf countries. It is rich in iron, vitamin A, vitamin C, fibers and consumed in fresh, dry, canned, and preserved into jams and jellies (Gunnes, 2003). Its soft texture makes it prone to post-harvest losses at different stages of marketing (Muhammad, 2012). Technically post-harvest losses refer to the measurable quantitative and qualitative loss such as change in the availability, edibility, wholesomeness and quality of a produce from harvest to consumption (Troger et al., 2007). Literature revealed enhancement of post-harvest losses by 14-30% in perishable commodities due to inappropriate packaging during shipment (Saeed et al., 2010). In tamarind plastic bags cause 25% more damages as compared to paperboard packaging (Jarimopas et al., 2009). Costa et al. (2010) found that cardboard carton cause more injuries to banana as compared to plastic and torito cardboard boxes. Buyukbay et al. (2011) estimated post-harvest losses of 25% and 30% for beans and tomato respectively, due to inappropriate packaging. Hence, use of appropriate packaging material can help in protecting the produce from mechanical injury, contamination and reducing post-harvest losses during marketing process (Marsh, 2001; Kader and Rolle, 2004).

Traditionally fruits are packed in

wooden crates in Pakistan whose rough surfaces cause injuries. Poor road and transport enhance these injuries in the process of marketing. To avoid these injuries unripe fruits are plucked and chemicals are used for ripening. Literature revealed that chemical ripening is hazardous for health. Cardboard carton has been introduced to reduce the mechanical injuries and provide suitable cushioning to the produce. The present study has been conducted to find out the impact of different packaging boxes on post-harvest losses of plum and help the stakeholders to decide packaging technology for reducing post-harvest losses.

MATERIALS AND METHOD

The study carried out in 2012 was based on primary data, collected by using structured questionnaires for different categories of respondents in four tehsils (Barikot, Babozi, Charbagh and Khwazakhela) of Swat district in Khyber Pakhtunkhwa. In total, 110 contractors, 34 growers, 40 wholesalers and 70 retailers were included in the sample on the basis of 95% confidence level with 10% confidence interval. Among the tehsils, sample was distributed proportionally on the basis of population. After selecting the sample size from different tehsils, respondents were selected randomly. The respondents were divided in to two groups (cardboard carton and wooden crate) on the basis of packaging materials. Total sample size was 254 respondents of different categories. Simple averages, multiple regression and correlation analysis was carried out to estimate post-harvest losses of

plum in different stages, role of different factors and effect of packaging technology. STATA 12 and MS Excel were used for the analysis of data.

Estimation of Post-Harvest Losses

These losses were estimated by percentage and averages method for both types of packaging materials at each level (Gangwar et al., 2007; Murthey et al., 2007 and Khan et al., 2008). Two types of post-harvest losses (quantitative and qualitative) were estimated. Quantitative losses were the thrown away plum while qualitative losses were calculated through the decrease in value of the plum deteriorated and were sold in lower grades. Quantitative losses were determined at all the levels while the qualitative losses were calculated for the wholesale and retail levels. Monetary value of the post harvest losses was calculated by the multiplication of price and quantity lost to work out qualitative losses (Shahzad et al., 2013).

Quantitative post-harvest losses were determined as:

$$\text{Percentage Loss} = \frac{Q_1}{Q_t} \times 100$$

where,

Q_1 = Quantitative loss;

Q_t = Net quantity + discarded quantity (gross quantity)

Value of the post-harvest losses in monetary terms was as follows:

$$M_L = \sum P_i Q_i - \sum P_j Q_j$$

where,

M_L = Monetary value of total losses

P_i = Price of i^{th} purchased grade

Q_i = Quantity of i^{th} purchased grade

P_j = Price of j^{th} sold grade

Q_j = Quantity of j^{th} sold grade

Value of quantitative losses (VQ_L) was estimated by the following equation:

$$VQ_L = \sum P_i Q_i$$

where,

P_i = Price of i^{th} grade,

Q_i = Quantity of i^{th} grade

Partial losses (P_L) which arose due to grade deterioration were estimated as:

$$P_L = M_L - VQ_L$$

Total post-harvest losses are the sum of losses at each level after adjustment for the losses at previous levels;

$$T_L = L_{G/C} + L_W + L_R$$

where,

T_L = Total losses

$L_{G/C}$ = Losses at grower/contractor level

L_W = Losses at wholesale level

L_R = Losses at retail level

RESULTS AND DISCUSSION

Respondents' Characteristics and Practices

Two types of packaging materials (cardboard carton and wooden crate) were used for the packing of plum. Respondent using cardboard box aged 41, 39, 34 years on the average for farm, wholesale and retail levels, respectively, whereas respondents of the same levels in wooden box channel aged 39, 46 and 33 years old. In terms of education and experience respondents of wooden box channel exhibited relatively high level for farm and whole sale levels. Wholesalers and retailers in the cardboard box channel had lower margins whereas in the wooden box channel farm level respondents

Table 1. Packaging-wise characteristics of respondents

Characteristics	Farm Level		Wholesale Level		Retail Level	
	Cardboard carton	Wooden crate	Cardboard carton	Wooden crate	Cardboard carton	Wooden crate
Age (years)	41.0	39.0	39.0	46.0	34.0	33.0
Education (years)	8.5	8.6	5.8	5.9	4.5	4.1
Experience (years)	15.0	15.8	14.1	17.4	12.6	11.3
Average Price (Rs.)	58.0	40.0	66.7	53.0	70.0	58.0
Total Quantity (kg)	54534.0	40340.0	10755.0	11535.0	90.0	56.0
Quantity lost (kg)	1594.0	2554.0	202.1	357.5	4.5	5.8

Source: Field Survey, 2012

received lower prices. Magnitudes of quantitative losses were 1594, 202.12 and 4.5 kg for the farm, wholesale and retail level respondents in the cardboard box channel for total quantity of 54534, 10755 and 90 kg, respectively (Table 1).

Farm Level Post-Harvest Losses

Two types of farm respondents perform harvesting operations i.e., growers (harvesting their orchards by themselves) and contractors (who takes contract of the orchard on a pre determined price). Weather and pre-harvest management play an important role in the adoption of packaging technology. Growers applying cardboard carton as packaging material faced losses of 2.58 % against the 6.28 % of wooden crate packaging material (Table 2). Post-harvest losses were 2.96% and 6.03 % in cardboard and wooden box, respectively, for contractors. Reasons of the difference in losses were the timely management of orchards by cardboard carton adopters. Adopters of cardboard carton harvested their orchards at proper maturity and faced low level of losses. Growers marketing at their own were in better position to harvest

at proper time whereas; contractors faced management problems while dealing in multiple orchards. On the whole reasons of post-harvest losses at the farm level were striking down due to placing of ladders in improper manner, climbing method of the pickers on ladder, long pedicle of plum, over maturity, shaking in the baskets while carrying the plum from trees to packing place, heaping of the fruit on the tarpaulin without any cushioning and hasty packing. The over ripe fruits are more prone to injuries and losses (Paull et al., 1997). Absence of contractors from orchards at harvest time due to marketing is another reason of higher losses. Most of the farmers harvesting and marketing at their own applied proper pre harvest measures, having positive effect on the quality of fruit and reduction of losses

Table 2. Farm level post-harvest losses

Packaging	Physical losses (%)		Overall farm level losses (%)
	Farmers	Contractors	
Cardboard carton	2.58	2.96	2.90
Wooden crate	6.28	6.03	6.10
Overall	4.85	5.40	5.12

Source: Field Survey, 2012

(Kader and Rolle, 2004).

Determinants of Farm Level Post-Harvest Losses

To quantify the role of different factors multiple regression model was employed at the farm level. Coefficient of determination (R^2) value of the model was 0.55 indicated that the explanatory variables; education and experience of the grower/contractor, ownership (dummy), labor skill, maturity of the plum, heaping (dummy), packaging (cardboard carton), storage (dummy), Barikot (dummy), Charbagh (dummy) and Khwazakhela (dummy) explained 55% of the variation in the percentage losses at the farm level (Table 3). Determinants with negative signs had inverse relation with the post-harvest losses. Experience played a significant role and increase of one percentage point in the mean level of experience will cause a decline in the farm level post-harvest losses by 0.14% at 5% level of significance. Increase of 1% in skilled labor and cardboard carton packaging have highly significant role in the reduction of post-harvest losses by 0.38% and 0.40% with t-values of 4.75% and 4.86%, respectively. Storage, Barikot and Khwazakhela are dummies play insignificant role in the reduction of post-harvest losses at the farm level. The factors enhancing the magnitude of post harvest losses are the ownership (contractor), maturity (ripeness) of the plum and Charbagh (tehsil dummy). Maturity of the plum increases the post-harvest losses by 0.14% at 10% level of significance. More ripe fruits are susceptible to injuries whereas contractors had to manage many orchards and could not take proper care of the orchards due

to overload. In Chabagh tehsil, plum are harvested late and monsoon rains caused huge ruptures in fruits.

Post Harvest Losses at the Wholesale Level

At the wholesale level post-harvest losses were calculated to be 1.49% in physical terms in cardboard carton whereas, in wooden crates the loss was 1.53%. Monetary losses (loss in the value of fruits due to physical waste and price deterioration) were 2.11% and 1.52% wherein shares of partial (qualitative) losses were 0.79% and 0.32% for the above packaging boxes, respectively (Table 4). After adjustment for the losses of farm

Table 3. Farm level determinants of percent post-harvest losses

Determinants	Coefficients	t-values
Education (years)	-0.06	-0.95
Experience (years)	-0.14**	-2.14
Ownership (dummy)	0.01	0.01
Labor skill (percentage)	-0.38***	-4.75
Maturity (percentage)	0.14*	1.93
Heaping (dummy)	0.20	0.27
Packaging (dummy)	-0.40***	-4.86
Storage (dummy)	-0.08	-1.14
Barikot (dummy)	-0.09	-0.80
Charbagh (dummy)	0.05	0.46
Khwazakhela (dummy)	-0.08	-0.88
Constant	13.09	6.06
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$F_{(11, 110)}$	= 12.45	
Prob > F	= 0.00	
R^2	= 0.55	
Adj R^2	= 0.51	

*, ** and *** = Significant at 10%, 5% and 1% level, respectively

Source: Field Survey

level, losses share of the wholesale level was 1.45% and 1.42% for cardboard and wooden box, respectively. Reason of the more shrink in the losses in wooden box was the more losses at the farm level. Proper and tight grading at the earlier stages result in lower losses at the next stages (Murthey et al., 2007). Reasons of post-harvest losses at wholesale level were poor transport, pressing the boxes while nailing, injuries due to friction with the strips, tearing of cartons, mishandling by the labors, filling of bruised and infected fruits in the box, lack of cold storage facility and the fear of remaining unsold (Adeoye et al., 2009). Reasons of the higher physical losses in wooden crates were the high weight of box and more pressure on the fruits in lower layers. Increase in number of layers in the box speeds up the deterioration process (Javed et al., 1995). High magnitude of monetary losses in cardboard carton was due to the average high price of the plum packed in cardboard carton.

Determinants of Post-harvest Losses at Whole Sale Level

The role of different factors has been quantified by employing multiple linear regression model at the wholesale level. Coefficient of

determination (R^2) value of 0.55 showed that the independent variables: education, experience, packaging (cardboard carton), cold storage (dummy), examined boxes, A, B and C grades, labor skill, maturity (ripeness) and business volume are responsible for the 55% variation in the wholesale level post-harvest losses (Table 5). Availing of cold storage facility and dealing in A grade fruit significantly shrink the extent of post-harvest losses by 0.39 and 0.38 percentage points with t-values of 2.57 and 2.06, respectively. In the factors with positive coefficients total business volume (total quantity) increases the magnitude of post-harvest losses by 1.01 percentage point at 10% significance. Factors like maturity (ripeness) of the plum and packaging (cardboard carton) enhance the magnitude of post-harvest losses insignificantly.

Post-harvest Losses at the Retail Level

Retail level is the final link between producers and consumers. Retailers faced post-harvest losses of 6.42% and 7.26% in cardboard and wooden boxes respectively. After adjustment for the losses at farm and whole sale levels losses shrank to 6.14% and 6.71%, respectively.

Table 4. Wholesale level percent post-harvest losses

Packaging Losses		Physical	Monetary	Value of physical	Value of partial
Overall	Magnitude	1.52			
	Share in TP	1.44	1.73	1.24	0.49
Cardboard Carton	Magnitude	1.49	2.11	1.32	0.79
	Share in TP	1.45			
Wooden Crate	Magnitude	1.53	1.52	1.20	0.32
	Share in TP	1.42			

TP = Total produce

Source: Field Survey, 2012

Table 5. Wholesale level determinants of percent post-harvest losses

Determinant	Coefficient	t-value
Education (years)	-0.11	-0.37
Experience (years)	-0.08	-0.05
Packaging (cardboard carton)	0.09	0.57
Cold Storage (dummy)	-0.39 ^{***}	-2.57
Examined boxes (%)	0.02	0.13
A grade purchased Qty (kg)	-0.38 ^{**}	-2.06
B grade purchased Qty (kg)	-0.55	-1.09
C grade purchased Qty (kg)	-0.10	-0.37
Ripeness	0.03	0.15
Labor skill (%)	-0.16	-1.19
Total qty (kg)	1.01 [*]	1.78
Constant	3.42	2.15

F (11, 29) = 3.09

Prob > F = 0.01

R² = 0.55Adj R² = 0.37

*, ** and *** = Significant at 10%, 5% and 1% level, respectively

Source: Field Survey

Monetary and partial losses were higher in cardboard carton despite less physical losses due to higher prices for plum packed in cardboard carton (Table 6). Ratio of the physical loss value is smaller than value of physical losses in wooden crates. Malpractices of the previous levels have an important role in the

magnification of post-harvest losses magnitude at retail level. Packing over ripe and damaged fruits in box at the farm level, pressing of the box while packing, filling of more fruits in the box, poor and delayed transportation, multiple and mis-handling at wholesale level and exposing the fruits to heat and air were the causes of post-harvest losses at retail level (Murthey et al., 2007; Tafera et al., 2008). Fruits packed in small packs of carton were mostly safe from damages. These packs were purchased by retailers who had fixed shops and protection from sun and heat. On the other hand hawkers had no protection from heat and it was difficult for them to deal in small cardboard box. They dealt in fruits packed in large wooden crates due to its lower per unit price but experienced higher losses.

Determinants of Post-Harvest Losses at Retail Level

The value of the coefficient of determination was 0.68 which indicated that the determinants (education, experience, packaging, homogeneity, carbide presence, shop keeper, examined boxes, daily hours, showcasing, A grade, B grade, total quantity (business volume), Babozi, Khwazakhela and Barikot explain

Table 6. Retail level percent post-harvest losses

Packaging		Physical	Monetary	Value of physical	Value of partial
Overall	Magnitude	6.75	9.55	6.30	3.25
	Share in TP	6.31			
Cardboard Carton	Magnitude	6.42	9.65	6.12	3.53
	Share in TP	6.14			
Wooden Crate	Magnitude	7.26	9.38	6.61	2.77
	Share in TP	6.71			

TP = Total produce

Source: Field Survey, 2012

68% variation in the percentage physical losses at the retail level. Increasing the level of experience of the retailers, packaging (cardboard carton) and homogeneity (same quality of fruit in the box throughout) by 1% will result in the reduction of post-harvest losses by 0.23%, 0.28% and 0.21% at the 5%, 1% and 5% significance, respectively (Table 7). Business nature (shop keeper), examined boxes, daily hours, showcasing, A grade, B grade, Babozi (tehsil) and Khwazakhela (tehsil) also had negative coefficients but their t-values were insignificant. Increasing the presence of carbide, business volume and retailers from Barikot (tehsil) will cause the extent of retail level losses. Total business volume is significant at 5% level and increased losses by 0.18%.

Total Post-harvest Losses

Overall post-harvest loss was 12.87% wherein, 40%, 11% and 49% losses occurred at the farm, wholesale and retail level, respectively. In card board carton as packaging the extent of post-harvest losses was 10.49% shares of the different levels were 27.64%, 13.82% and 58.54% for farm, wholesale and retail levels, respectively (Table 8). In the channel of wooden crate packaging quantitative losses were 14.24% in total. Share of farm, wholesale and retail levels in the total post-harvest losses were 42.84, 10.4 and 47.12%, respectively. Thus cardboard carton accounts for 27% less losses than wooden crate.

Correlation of Post-harvest Losses and Packaging Materials

Estimation of post-harvest losses by percentage method revealed that cardboard packaging accounts for

less losses as compared to wooden crates. At the farm level losses and packaging (cardboard carton) are having moderate and negative correlation revealing that post-harvest losses are reduced with the adoption of cardboard carton where-as, maturity stage (ripeness) has weak and positive correlation with losses.

Factors like age, education and experience also have negative signs but very weak. At the whole sale level no factor was having significant effect where packaging had positive and weak correlation with post-harvest losses. Reason was the easiness to

Table 7. Retail level determinants of percent post-harvest losses

Determinants	Coefficients	t-values
Education	0.07	0.92
Experience	-0.23**	-2.27
Packaging (dummy)	-0.28***	-3.04
Homogeneity (dummy)	-0.21**	-2.29
Carbide (dummy)	0.12	1.54
Business Nature (dummy)	-0.01	-0.12
Examined boxes (%)	-0.14	-1.57
Daily hours	-0.11	-1.36
Showcasing (dummy)	-0.04	-0.38
A grade (kg)	-0.09	-1.04
B grade (kg)	-0.13	-1.50
Total Qty (kg)	0.18**	1.97
Babozi (dummy)	-0.07	-0.58
Khwazakhela (dummy)	-0.08	-0.84
Barikot (dummy)	0.09	0.88
Constant	13.73	5.78

$$F_{(14, 55)} = 8.00$$

$$\text{Prob} > F = 0.00$$

$$R^2 = 0.68$$

$$\text{Adj } R^2 = 0.60$$

*, ** and *** = Significant at 10%, 5% and 1% level, respectively

Source: Field Survey

IMPACT OF DIFFERENT PACKAGING TECHNOLOGIES

Table 8. Overall quantitative percent post-harvest losses

Packaging / Losses		Farm	Wholesale	Retail	Total
Overall	Magnitude	5.12	1.52	6.75	13.39
	Share in TP	5.12	1.44	6.31	12.87
	Share in TL	40.00	11.00	49.00	100.00
Cardboard carton	Magnitude	2.90	1.49	6.42	10.81
	Share in TP	2.90	1.45	6.14	10.49
	Share in TL	27.64	13.82	58.54	100.00
Wooden crate	Magnitude	6.10	1.53	7.26	14.89
	Share in TP	6.10	1.43	6.71	14.24
	Share in TL	42.84	10.04	47.12	100.00

TP = Total produce

TL = Total post harvest losses

Source: Field Survey, 2012

Table 9. Correlation analysis of losses with different factors at different stages

Farm Level	Losses	Packaging	Age	Education	Experience	Maturity
Losses	1					
Packaging	-0.5716	1				
Age	-0.0508	0.0783	1			
Education	-0.0924	-0.0129	-0.2248	1		
Experience	-0.1126	-0.0417	0.5946	-0.1064	1	
Maturity	0.3880	-0.2423	-0.029	-0.0215	0.008	1
Wholesale Level	Losses	Age	Education	Experience	Packaging	
Losses	1					
Age	0.0002	1				
Education	-0.0562	-0.372	1			
Experience	-0.1328	0.4336	-0.1755	1		
Packaging	0.2876	-0.3142	-0.0047	-0.1852	1	
Retail Level	Losses	Education	Experience	Packaging	Age	
Losses	1					
Education	-0.1187	1				
Experience	-0.0412	-0.1199	1			
Packaging	-0.2849	0.0494	0.104	1		
Age	0.0471	-0.2795	0.5616	0.0546	1	

identify the box with pressed and damaged fruits in cardboard carton as the juice squeezed penetrate through cardboard box. Similarly at retail level age, education, experience and packaging (cardboard carton) were negatively correlated (Table 9). Packaging was strongly and negatively correlated to post-harvest losses whereas, other factors have negligible effect as their magnitudes were in the lowest ranges.

CONCLUSION AND RECOMMENDATIONS

•This study was conducted to evaluate wooden box and cardboard carton packaging technologies for post-harvest losses of plum. Using percentage method post harvest losses were estimated to be 12.87% on the overall basis in the marketing channel of plum. Cardboard box channel accounts for 10.49% whereas, wooden box channel accounted for 14.24% of the total produce. Post-harvest losses and cardboard carton were moderate and negatively correlated at the farm level and weak and negatively correlated at the retail level, whereas positive and weakly correlated at the whole sale level. Share of farm, wholesale and retail levels were 27.64%, 13.82% and 58.54%, respectively, in the cardboard box channel while, the share of these levels were 42.84%, 10.04% and 47.12% in wooden box. It can be concluded that post-harvest losses are 26.34% less in cardboard box than wooden crate. The recommendation of present study are as follows:

- Apply the recommended nutrients in sufficient quantities in pre-harvest management stage.
- Provide the cold storage facility

in the area.

- Harvest the plum before over ripening.
- Harvest and pack the plum with care to avoid bruises.
- Sort out the damaged fruit at the time of packing.
- Decrease size of the box in wooden packaging.
- Smoothen surface of wooden box.
- Avoid pressing of box and nailing in proper manner.
- Cardboard should be strengthened for stacking.
- Cardboard box should be modified for cold storage atmosphere.
- Search new markets for plum.

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