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EFFECT OF SIMULATED TRANSPORTATION ON PHYSICO-CHEMICAL PROPERTIES OF BER CV. UMRAN

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ABSTRACT

The work was undertaken to evaluate the effect of simulated transportation by providing different levels of vibration and time duration on physico-chemical properties of ber fruits cv. Umran during transportation and storage under ambient storage conditions. The total soluble solids, TSS: acid ratio and organoleptic rating first increased and then decreased with increase in duration of storage. The TSS, TSS: acid ratio and ascorbic acid content decreased with increased intensity and duration of vibration. The acidity of the fruits first decreased and then increased with increase in period of storage. Based upon above parameters among various levels of simulation vibration and duration of vibration, fruits without simulation vibration were best in maintaining their physico-chemical attributes whereas the simulation vibration given to the fruits up to 50 rpm for 3 and 6 hours were found effective for maintaining their organoleptic acceptability.

INTRODUCTION

The ber (*Ziziphus mauritiana* Lamk.) known as "poor man's fruit" is an important fruit crop of semi-arid regions, belongs to the family Rhamnaceae. It occupied nearly 26.31 thousand hectares of area and contributed production of 289.41 thousand MT in India during the year 2012-13 (Tiwari *et al.*, 2013).Ber is not being marketed to any far extent places where it is not grown. This is because of the absence of proper post-harvest handling technology including transportation and storage. In particular, it has been reported that the basic mechanisms involved in the fresh fruit damage are impact and vibrations experienced by the individual items of the fruit as the vehicles traverse abrupt changes in road profiles (Jones *et al.,* 1991; Olorunda and Tung, 1995; Singh and Singh, 1992).The vibrations due to transportation are influenced by road roughness, distance, traveling speed, packaging and some characteristics of the truck such as suspension and the number of axles (Vursavus and Ozguven, 2004).

Cuts, vibrations, abrasion, compression, and impacts are the main causes of mechanical damages to produce during handling and transportation. Compression damage occurs when fruits are over loaded and usually the weight of the load is supported by the product than the container in most of the fruit handling systems. Vibration damage is prominent in vehicles fitted with steel leaf-spring-suspension systems (Vigneault *et al.*, 2009). During the transportation process the vehicles transmit vibrations and jerks that cause damage to the fruits. Therefore, during long distance transportation there is needed to standardize the speed of the vehicles so that the shelf life of the fruits can be increased. In the present studies, attempts were made to know the impact of transportation on physico-chemical properties of ber by providing simulated transportation at different frequency levels for different time durations and on that basis the frequency of vibrations were standardized.

MATERIALS AND METHODS

The experiment was carried out in the post-harvest technology laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar. Laboratory vibration tester powered with 3HP electric motor was used to provide simulation vibration with required time as per treatments. The frequency and time of which were adjusted by the frequency and time adjusting knobs respectively, as per requirement. The ber fruits of cultivar Umran were selected after harvesting and packed in nylon netted bags. Approx. 4kg fruits were packed in each of the nylon netted bags and were subjected to simulation vibration at three levels *i.e.* 50,100 and 200 rpm for 3 and 6 hour durations. The physico-chemical parameters were recorded at alternate days up to 8th day of storage after simulation vibration and fruits were stored at ambient temperature (26 ± 3°C). A control (without any simulated vibration *i.e.* 0 rpm) was also taken for comparing with simulated vibration treated fruits. The seven treatments were replicated four times following the complete randomized design (CRD) and data recorded analyzed accordingly.

The TSS of the representative fruit juice was determined by using hand refractometer. The titratable acidity and ascorbic acid content was determined as per the method given by AOAC (1990). Organoleptic test of fruits was made by using nine points hedonic rating test by a panel of five judges on the basis of colour, flavour, texture and taste.

RESULTS AND DISCUSSION

Total soluble solids (%)

The TSS content of the fruits decreased significantly with increased intensity of vibration (Table 1.1). It was observed maximum (13.60 %) in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (13.31 %) and minimum TSS (12.97 %) was recorded in the fruits simulated at vibration of 200 rpm. TSS content of the fruits decreased after transportation. Similar results were reported by Lal and Fageria (2004) and Yadav *et al*. (2005).With increased duration of vibration, there was significant decrease in TSS content of the fruits. Maximum (13.32 %) TSS content was observed in the fruits exposed to simulation vibration for 3 hours, while minimum TSS (13.25 %) was observed in fruits given simulation vibration for 6 hours. The data depicted in the Table 1.2 indicated that the TSS content first increased and then decreased. The increase in TSS during storage might be due to conversion of reserved starch and other polysaccharides to soluble form of sugar (Gohlani and Bisen). It was also observed in ber by Bhardwaj *et.al.,* 1999 and Lal *et al*., 2002. Further decrease in TSS might be due to fermentation of sugars during storage of fruits. It could be attributed to the utilization of TSS in respiration (Bhaviskar *et al.,* 1995 and Wasker *et al.,* 1999). Maximum TSS content (13.66 %) was observed on the 4th day of storage while, it was minimum (12.77 %) on 8th day of storage. The interaction given in the Table 1.4 indicated that the maximum TSS content (14.05 %) was observed in the fruits without simulation

Table 1.1: Effect of simulation transportation (duration of vibration and simulation vibration) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationPeriod(Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	13.60	13.34	13.27	13.07	13.32
6	13.60	13.29	13.25	12.86	13.25
Mean	13.60	13.31	13.26	12.97	

C.D at 5 % H=0.05 S= 0.07 H x S= 0.10

Table 1.2: Effect of simulation transportation (duration of vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationPeriod(Hours)	Days of storage					Mean
	0	2	4	6	8	
3	13.20	13.56	13.66	13.26	12.90	13.32
6	13.20	13.71	13.65	13.04	12.64	13.25
Mean	13.20	13.64	13.66	13.16	12.77	

C.D at 5 % H= 0.05 D= 0.08 H x D= 0.11

Table 1.3: Effect of simulation transportation (simulation vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

SimulationVibration (rpm)	Days of storage					Mean
	0	2	4	6	8	
0	13.20	13.38	13.70	14.05	13.68	13.60
50	13.20	13.60	13.80	13.20	12.75	13.31
100	13.20	13.68	13.94	12.96	12.53	13.26
200	13.20	13.90	13.19	12.41	12.13	12.97
Mean	13.20	13.64	13.66	13.16	12.77	

C.D at 5 % S= 0.07 D= 0.08 S x D= 0.16

Table 1.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on total soluble solids (%) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
Days	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	13.20	13.20	13.20	13.20	13.20	13.20	13.20	13.20
2	13.38	13.53	13.60	13.75	13.38	13.68	13.75	14.04
4	13.70	13.75	13.85	13.35	13.70	13.85	14.03	13.03
6	14.05	13.35	13.05	12.63	14.05	13.05	12.88	12.20
8	13.68	12.85	12.65	12.43	13.68	12.65	12.40	11.83

C.D at 5 % H=0.05 S= 0.07 D= 0.08 H x S x D = 0.23

Table 2.1: Effect of simulation transportation (duration of vibration and simulation vibration) on acidity (%) of ber cv. Umran during storage at ambient temperature.

Simulation Period (Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	0.20	0.19	0.19	0.20	0.19
6	0.20	0.21	0.22	0.22	0.21
Mean	0.20	0.20	0.20	0.21	

C.D at 5 % H = NS S = NS H x S = NS

Table 2.2: Effect of simulation transportation (duration of vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Simulationperiod	Days of storage					Mean
	0	2	4	6	8	
3	0.24	0.20	0.17	0.16	0.20	0.19
6	0.24	0.22	0.19	0.19	0.22	0.21
Mean	0.24	0.21	0.18	0.17	0.21	

C.D at 5 % H = NS D = 0.01 H x D = NS

Table 2.3:Effect of simulation transportation (simulation vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Simulationvibration	Days of storage					Mean
	0	2	4	6	8	
0	0.24	0.22	0.19	0.15	0.17	0.20
50	0.24	0.22	0.19	0.15	0.20	0.20
100	0.24	0.21	0.18	0.17	0.22	0.20
200	0.24	0.19	0.16	0.22	0.25	0.21
Mean	0.24	0.21	0.18	0.17	0.21	

C.D at 5 % S = NS D = 0.01 S x D = NS

Table 2.4:Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on acidity (%) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2	0.22	0.21	0.20	0.18	0.22	0.23	0.22	0.21
4	0.19	0.18	0.17	0.15	0.19	0.20	0.19	0.17
6	0.15	0.14	0.13	0.20	0.15	0.16	0.21	0.23
8	0.17	0.19	0.21	0.24	0.17	0.21	0.23	0.27

C.D at 5 % H = NS S = NS D = 0.01 H x S x D = NS

Table 3.1: Effect of simulation transportation (duration of vibration and simulation vibration) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm)				Mean
	0	50	100	200	
3	72.50	72.67	73.78	66.92	71.47
6	72.51	65.44	61.77	59.54	64.81
Mean	72.50	69.05	67.78	63.23	

Table 3.2: Effect of simulation transportation (duration of vibration and days of storage) on TSS: acid ratioof ber cv. Umran during storage at ambient temperature

SimulationPeriod	Days of storage					Mean
(Hours)	0	2	4	6	8	
3	55.00	67.48	80.62	88.91	65.33	71.47
6	55.00	62.95	73.67	73.13	59.32	64.81
Mean	55.00	65.22	77.14	81.02	62.32	

Table 3.3: Effect of simulation transportation (simulation vibration and days of storage) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Simulation Vibration (rpm)	Days of storage 0	2	4	6	8	Mean
0	55.00	60.31	73.50	93.87	79.85	72.50
50	55.00	63.13	73.83	88.71	64.58	69.05
100	55.00	65.37	78.05	83.93	56.54	67.78
200	55.00	72.05	83.20	57.56	48.32	63.23
Mean	55.00	65.22	77.14	81.02	62.32	

Table 3.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on TSS: acid ratio of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
2	60.31	66.00	68.09	75.52	60.31	60.27	62.65	68.58
4	73.50	78.89	80.88	89.21	73.50	68.77	75.22	77.19
6	93.87	93.94	105.38	62.44	93.87	83.48	62.47	52.69
8	79.85	69.51	59.55	52.41	79.85	59.66	53.53	44.24

Table 4.1: Effect of simulation transportation (duration of vibration and simulation vibration) on ascorbic acid content (mg/100 g) of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm) 0	50	100	200	Mean
3	69.28	68.52	67.19	64.72	67.43
6	69.28	67.29	65.41	61.38	65.84
Mean	69.28	67.90	66.30	63.05	

C.D at 5 % H = 0.31 S = 0.44 H x S = 0.62

Table 4.2: Effect of simulation transportation (duration of vibration and days of storage) on ascorbic acid content (mg/100 g) of ber cv. Umran during storage at ambient temperature

SimulationPeriod (Hours)	Days of storage 0	2	4	6	8	Mean
3	76.63	72.85	67.09	63.14	57.41	67.43
6	75.15	72.05	65.90	60.64	55.45	65.84
Mean	75.89	72.45	66.50	61.89	56.43	

C.D at 5 % H = 0.31 D = 0.49 H x D = 0.69

Table 4.3: Effect of simulation transportation (simulation vibration and days of storage) on ascorbic acid content (mg/100g) of ber cv. Umran during storage at ambient temperature

SimulationVibration (rpm)	Days of storage 0	2	4	6	8	Mean
0	79.23	72.58	69.08	65.40	60.09	69.28
50	77.46	73.17	68.00	62.32	58.57	67.90
100	75.09	72.02	66.84	62.13	55.43	66.30
200	71.78	72.02	62.06	57.71	51.65	63.05
Mean	75.89	72.45	66.50	61.89	56.43	

C.D at 5 % S = 0.44 D = 0.49 S x D = 0.98

vibration while minimum TSS (11.83 %) was observed on the 8th day in the fruits simulated at vibration of 200 rpm for 6 hours.

Acidity (%)

The acidity content of the ber fruits in cv. Umran did not differed significantly with increased intensity of vibration and duration of vibration (Table 2.1). The acidity content of the fruits first decreased and then increased (Table 2.2). The decrease in acidity might be due increased rate of respiration (Kapse *et al.*, 1977) or could be due to conversion of acids into salts and sugars by invertase enzyme (Hawker, 1968). The increase in acidity might be due to water loss from the fruits during storage (Hifney and Abdel, 1977). Acidity of the fruits first decreased up to 6th day and then it increased up to 8th day of storage. Minimum acidity (0.17%) was recorded in the fruits on 6th day which is at par with the 4th day of storage, while it was maximum (0.24%) on zero day. The acidity

Table 4.4: Effect of simulation transportation (duration of vibration, simulation vibration and days of storage) on ascorbic acid content (mg/ 100 g) of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	79.23	78.14	76.05	73.11	79.23	76.77	74.13	70.46
2	72.58	73.35	72.65	72.83	72.58	73.00	71.40	71.22
4	69.08	68.71	67.18	63.38	69.08	67.29	66.50	60.75
6	65.40	62.77	63.58	60.82	65.40	61.88	60.68	54.61
8	60.09	59.61	56.51	53.46	60.09	57.52	54.35	49.84

C.D at 5 % H=0.31 S= 0.44 D= 0.49 H x S x D = NS

Table 5.1: Effect of simulation transportation (duration of vibration and simulation vibration) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Simulation Period (Hours)	Simulation vibration (rpm) 0	50	100	200	Mean
3	7.2	6.9	6.0	5.1	6.3
6	7.2	6.6	5.4	4.5	5.9
Mean	7.2	6.8	5.7	4.8	

Table 5.2: Effect of simulation transportation (duration of vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

SimulationPeriod (Hours)	Days of storage 0	2	4	6	8	Mean
3	7.4	7.8	6.8	5.5	3.8	6.3
6	7.4	7.7	6.4	5.0	3.0	5.9
Mean	7.4	7.8	6.6	5.2	3.4	

Table 5.3: Effect of simulation transportation (simulation vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Simulation Vibration (rpm)	Days of storage 0	2	4	6	8	Mean
0	7.4	8.1	8.5	6.8	5.0	7.2
50	7.4	7.8	8.1	6.3	4.2	6.8
100	7.4	7.7	5.6	4.8	2.8	5.7
200	7.4	7.6	4.3	3.0	1.6	4.8
Mean	7.4	7.8	6.6	5.2	3.4	

Table 5.4: Effect of simulation transportation (vibration and days of storage) on organoleptic quality of ber cv. Umran during storage at ambient temperature

Days of storage	Simulation period and vibration							
	3 Hours				6 Hours			
	0 rpm	50rpm	100rpm	200rpm	0 rpm	50rpm	100rpm	200rpm
0	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
2	8.1	7.9	7.8	7.7	8.1	7.7	7.6	7.5
4	8.5	8.2	6.0	4.5	8.5	8.0	5.2	4.0
6	6.8	6.5	5.2	3.6	6.8	6.1	4.5	2.4
8	5.0	4.5	3.5	2.2	5.0	3.8	2.1	1.1

decreased after transportation of the fruits. This decline in acidity after transportation and during storage might be due to rapid utilization of organic acids in the energy production and alcoholic fermentation. The results are in close agreement with Bisen *et al.* (2014).The interaction of duration of vibration, simulation vibration intensity and days of storage was found non-significant (Table 2.4).

TSS: acid ratio

The TSS to acid ratio decreased with increase intensity of vibration (Table 3.1). Maximum TSS: acid ratio (72.50) was recorded in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (69.05). The ratio was observed minimum (63.23) in the fruits simulated at vibration of 200 rpm. It also decreased with increased duration of vibration. Maximum ratio (71.47) was found in the fruits given simulation vibration for 3 hours, while the minimum ratio (64.81) was found in the fruits rendered to simulation vibration for 6 hour. The TSS: acid ratio increased then it decreased (Table 3.2). Initial increase in TSS: acid ratio might be due to the fact that there was continuous increase in TSS and decrease in acidity of the fruits which resulted in increased TSS-acid ratio. At later stages decline in TSS: acid ratio might be due to continuous decrease in TSS and increase in acidity of the fruits. Similar findings were reported by Kaur *et. al.* (2013) in pear. It increased up to 6th day of storage and there after it decreased. The maximum TSS: acid ratio (81.02) was recorded in the fruits on 6th day of storage, while it was minimum (55.00) on zero day of storage. The interaction given in the Table 3.4 indicated that the maximum TSS: acid ratio (105.38) was observed in the fruits that simulated at 100 rpm for 3 hours on 6th day, whereas minimum ratio (44.24) was found in the fruits that were given simulation at vibration of 200 rpm for 6 hours on 8th day of storage.

Ascorbic acid content (mg/100 g)

The data given in the Table 4.1 indicated that there was significant decrease in ascorbic acid content of the fruits with increased intensity of vibration. Maximum of ascorbic acid content (69.28 mg/100g) was observed in the fruits without simulation vibration followed by the fruits simulated at vibration of 50 rpm (67.90 mg/100g). The minimum ascorbic acid content (63.05 mg/100g) was observed in fruits simulated at vibration of 200 rpm. With increase in the duration of vibration there was decrease in ascorbic acid content of the fruits. Maximum ascorbic acid (67.43 mg/100g) was retained in the fruits given simulation vibration for 3 hours. It was found minimum (65.84 mg/100g) in the fruits employed simulation vibration for 6 hours. Further, there was significant decrease in the ascorbic acid content with storage (Table.4.2). This could be due to the oxidation and irreversible conversion of ascorbic acid to dehydro-ascorbic acid in the presence of enzyme ascorbinase. Similar results were also found by Yadav *et al.* (2005) in ber and Das and Dash (1967) in mosambi fruits. The maximum ascorbic acid content retention (75.89 mg/100g) was observed on the zero day followed by 2nd day (72.45 mg/100g) and minimum (56.43 mg/100g) was observed on the 8th day. The interaction (Table 4.4) of duration of vibration, simulation vibration and days of storage showed no significant effect on the ascorbic acid content of the fruits.

Organoleptic rating

Organoleptic rating differed with increased period of storage. The rating decreased with increased intensity of vibration (Table 5.1). Maximum oraganoleptic rating (7.2) was attained by the fruits without simulation followed by the fruits simulated at 50 rpm (6.8). The fruits simulated at vibration of 200 rpm were rated minimum (4.8). Organoleptic rating also decreased with increased duration of vibration. Maximum rating (6.3) was observed in the fruits which were given simulation vibration for 3 hours while minimum rating (5.9) was observed in the fruits given simulation vibration for 6 hours. The data indicated in the Table 5.2 indicated that the organoleptic rating first increased then decreased with increased period of storage. The initial increase in organoleptic rating may be due to ripening of the fruits from green mature stage to optimum state, improvement in texture, TSS, TSS: acid ratio and total sugars. At later stages, reduction in organoleptic rating could be attributed to over ripening, loss of texture and decrease in biochemical attributes like TSS and total sugars. The results are in close agreement with Yadav *et al.* (2005) in ber. Organoleptic rating was maximum (7.8) on 2nd day and it was minimum on 8th day of storage (3.4). The interaction given in the Table 5.4 indicated that the maximum organoleptic rating (8.5) was observed on 4th day in the fruits without simulation while minimum rating (1.1) was noted on the 8th day in the fruits simulated at vibration of 200 rpm for 6 hours

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