Table Grapes Transport Simulation Study by Bardas (Vitis vinifera L.) Cultivar Grown in Karaman Turkey

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Abstract: Table grapes is a second industry in viticulture in Turkey and have been grown in primarily Mediterranean region a popular fruit for local consumption and export to many European and Asian countries as a fresh dessert and for this reason this product has to be transport so long distances for marketing. This simulated export transit experiment with Bardas (*Vitis vinifera L.*) local table grape cultivar grown in Karaman province was conducted in lab condition Selcuk University Faculty of Agriculture. To produce main knowledge, and to improve the application of resources used to produce, pack, transport, and merchandise Turkish table grapes by increasing efficiency, controlling cost and managing risk throughout the supply chain. In order to develop optimized methods of reducing table grape damage transport stimulatory as vibration stimulator have been used to measure the shocks and vibrations in market bins during 30 min and 60 min transport stimulation. During road transport simulation at 25°C in wooden boxes damages of clusters and berries were measured by laboratory trials to stimulate the events in a controlled and repeatable manner. 3 bins full of fruits were placed onto a vibration table, and during the stimulation three-load profile sensor were placed inside each of bins. While the number of separated berry was determined as a 31.33 in 30 min, the number was 83.10 in vibration period of 60 min. Starting with the beginning the numbers separate resistance of berry, resistance to cracking of berry and elasticity modulus is continuously lowering in 30-60 min vibration periods. The berry separate resistance from cluster were changing between 4.46 N to 1.73 N, and berry cracking resistance were measured between 31.59 N to 26.01 N, and berry elasticity modulus were obtained as between 1423 kPa to 1076.7 kPa. Natural frequency of berry was calculated as on 109.332 Hz that was obtained in of 1.42 m box height.

Introduction

Table grapes (*Vitis vinifera L.*) are physiologically speaking, a relatively durable fruit. They have a low respiration rate and can therefore live a long time after harvest. However, they are extremely susceptible to decay, can be injured easily, and lose water readily. If any of these deterioration factors is not well controlled, the potentially long post harvest life will be drastically shortened (Nelson, 1985; Bollen *et al.*, 1994; Burton *et al.*, 1989; Campbell *et al.*, 1986; Maindonald & Finsh, 1986; Hinsch *et al.*, 1993).

Many of horticultural products are in consumer hands within 2 day of harvest in another part of the world. Transportation and packaging is the key to this success. Under the best circumstances the quality of table grapes can only be maintained, not improved, during transportation. During transportation, storage and marketing table grapes may be exposed to rough handling during loading and unloading, compression from the overhead weight of other containers of products, impact and vibration during transportation.

Grapes are not ripening after harvest. Transits and storage life is 1-6 months. Packaging is by fiberboard, polystyrene foam, or wood lugs, or perforated film liners and 100 – 110 N some with sulfur dioxide pads. Transportation is by highways, and piggyback trailers, van containers or break-bulk vessels. Loading is unitized on pallets with corner. Proper packaging of table grapes is essential to maintaining product quality during transportation and marketing (Olorunda & Tung, 1985; McGregor, 1989; Kaynaş *et al*., 1989).

In Turkey, current produce container standardization is not, but many of markets prefer to outside dimension of a 420 x 310 x 150 mm wooden containers that have 60-80 N grapes for table grape transportation.

Pang *et al*. (1995) in their investigation observed solve natural handling conditions for transportation and used his observation to replicate the same situation in laboratory simulations.

Mechanical damage on agricultural products changes depending on physical and biological structure of the products and type of the force applied. First damage on the products appears during harvest and transportation. This damage usually occurs as a result of colliding of products with the others or vibrations of the transportation system, and causes severe deformation, such as breakage, separation and bruise. According to the estimates, approximately 25% of the agricultural products harvested in Turkey is spoilt and wasted away between the producer and consumer (Dokuzoğuz, 1997).

Transportation of vegetables and fruits should be rearranged to avoid any loss in quality and to provide more economical and productive conditions. Transportation type is chosen depending on the biological decay rate, rigidness and maturity of the product, on the carrier type, distance and purpose of the product usage. Other factors influencing this are physical characteristics, basic dimensions (geometrical measures, weight, density, pouring and shaking density), static- dynamic press resistance elasticity, vibration, behavior and also biological characteristics and product's content, carriage style and type of container (Moser 1984). Static-dynamic press resistance and form changing characteristics of the product determine the allowable pouring and filling amount, fall height and vibration limit during the transportation of the product.

Allowable static resistance (cell blowout biological resistance limit) is calculated by force deformation diagrams and dynamic resistance by crashing experiments for applications, allowable press resistance limit is the point of biological crashing. But some safety distance should be allocated. The resonance frequency, f_R of the product is closely related to the speed and shock absorber of the transportation vehicle and to the filling depth of the container. In order to prevent the crushing, resonance frequency should not be the same with vehicles generated from outside factory frequency. Resonance frequency is inversely proportional to the pouring dept and the densityρ, λ of the container frequency acceleration affecting fruits carried in low depth containers is doubled especially in upper and middle levels when compared to deep containers (Moser 1984; Pang *et al*., 1995).

The purpose of this study is to investigate factors on concerning the damage in table grape during transportation period in a simulated transportation environment in terms of separation resistance of berry from pedicel, number of separated berry, resistance to cracking of berry and elasticity modulus.

Materials and Methods

Materials

In this study, table grape cv Bardas (*Vitis vinifera* L.) were used since it is an important product in Konya and Karaman, Province of Turkey. The description of cv. Bardas is as follow. This is a local variety. It accounts for about 20 percent of the table grape production in Göksu Valley in Turkey. Sex of flower is hermaphrodite. The cluster is large in size and compact in density. The very large and uniform berries are somewhat ovoid and elongated in shape dark red to reddish black in color with advanced maturity, particular flavor is none, and are seeded. Berry must yield is very high sugar and total acid content of must is medium. Harvest season extends from mid September through October. Because the berry is thick skinned and crisp, and stem attachment is hard clusters resist damage well during post harvest handling. The cluster of this variety is shown *Fig 1.*

Fig 1. Table grape cv. Bardas (*Vitis vinifera* L.)

Methods

Chemical Properties

The titration acidity of the fruits was analysis established with titration method by using 2,6 - dichlorophenal indophenol solution. Soluble solids of the fruits were determined by Atago hand refractometer (Kara, 1992; Anonymous 1997). The initial moisture content of the berry was determined by using standard method (USDA, 1970).

Technological Properties

To determine the sizes and projected areas of berry, 10% samples were randomly taken and their linear dimensions were measured, *i.e.* length (*L*), width (*W*) and projected area (*P*). Projected area of a fruit was determined using a digital camera (Kodak DC 240) and Sigma Scan Pro5 program (Trooien & Heermann, 1992). Also, linear dimensions were established by using a digital vernier caliper with sensitivity of 0.01 mm. Several investigators (Deshpande *et al*., 1993; Gubta & Das, 1997; Demir & Özcan, 2001) have measured these dimensions for other grains and seeds in a similar manner to determine size and shape properties.

The geometric mean diameter *Dg* of the berry was calculated by using the following formula (Sreenarayanan *et al*., 1985):

(1) $Dg = (LW^2)^{1/3} \quad (W=T)$

The berry volume *V* was calculated by using the following formula and its berry or true density P_k, Pycnometer and toluene displacement method. Toluene (C_7H_8) was used rather than water because it is absorbed by fruits to a lesser extent. Also, its surface tension is low, so that it fills even shallow dips in a berry and its dissolution power is low (Sahay & Singh, 1994).

(2) $V=\pi W^2L^2/6(2L-W)$

According to Mohsenin (1986); Sreenarayanan *et al*., 1985), the degree of sphericity (*Ø*) can be expressed as follows;

(3) $Ø = (LW^2)^{1/3} / L = Dg/L$

(4)

The surface area *S* of the fruit was calculated by using the following formula (McCabe *et al*., 1986);

(5) $S = (\pi WL^2) / (2L-W) = \pi Dg^2$

The containers used in this study are of 420 x 310 x 150 mm size. These have four pieces horizontal wooden bar and bottom four pieces leveled wooden bar and four pieces flat wooden vertically, fixed nails. This is shown *Fig. 2*. Paperbound cartons were used as cushion materials, in order to reduce the damage on the bunch in transit. Paperbound cartons were placed at the bottom and side at the containers. The grape bunches were lined up in one layer in containers. Bunches contact with one another. According to the observation, 60-80 N bunches were placed in the containers.

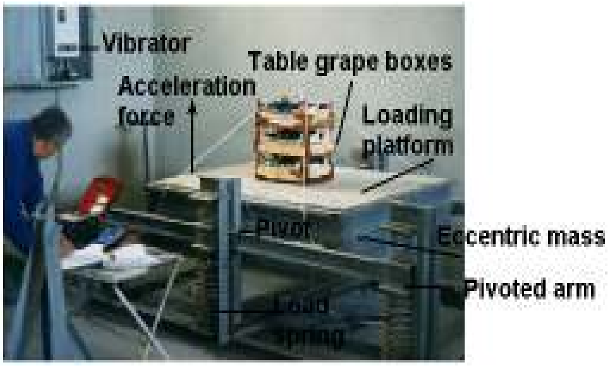

Fig. 2. Experiment device for simulates table grapes transport in laboratory

During the transportation in truck and trailer the frequency is between 7.5 and 11.5 Hz and the acceleration *g'* value is between 0.8 and 13 ms^{-2}. It's amplitude *A* is 0.6 and 6 mm (Aydin, 1993; Witney 1996).

An important application of dynamic test is the determination of the vibration properties of table grape cultivars, in order to assess, their sensitivity to damage during transit. The table grape cultivars are generally transporting in containers on board motor vehicle. f_R during transport the resonance frequency of the road or vehicle, then the acceleration of the grape berries will increase considerably owing to resonance and it will be damaged by impact. The natural frequency f_n of table grapes in a container may be calculated approximately from the equation:

(6) $f_n = [1/4\lambda]\sqrt{E_g/\rho}$

Computation using Eqn. (6) were found to correspond well with those of table grapes in bins vibration at resonance on a laboratory condition *Fig. 3*. Observation of berries were measured at average of 100 berries taken from the 1/3 medium scope of bunches.

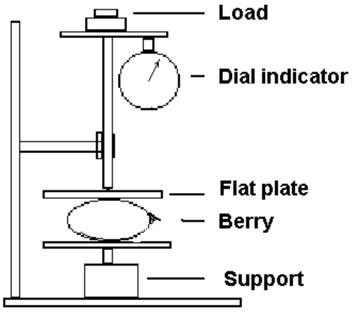

Fig. 3. Test equipment used in compression test

The vibration simulation container used in this study, like the vibration container was projected California University (Öğüt *et.al., 1999*; O'Birien & Guillou, 1969). On this box, vibration was formed at every cycle using unbalanced weights. Changing the number of weights enables setting of maximum acceleration and expansion plate caused by natural frequency f_n of the spiral system and the container. The vibration container is activated by a 0,55 kW electrical engine with a 2800 min^{-1} rotation and cos φ=0,827 and rotation of the box is set by an electronic vibrator. In treatments, the resonance frequency was adjusted as or 11.5 Hz. This frequency was obtained in 690 min^{-1} of simulation platform. The movement flow diagram in the vibration simulation container is given in *Fig 2*. Motor's rotation is measured as min^{-1} using an electrical dynamo coupled directly with motor' once and working linearly and measuring instrument's monitor. Damage on the product was determined after 30-60 minutes of vibrating the container at the set frequency.

The vibration box had worked for 30 min and 60 min, which are equal to transportation of track with 540 km and 1080 km respectively in Turkish highways. The value of vibration were measured and recorded on magnetic tape. In order to determine the elasticity of berry, a plate test was used (Zohadie 1982). The test equipment is shown in *Fig. 4*.

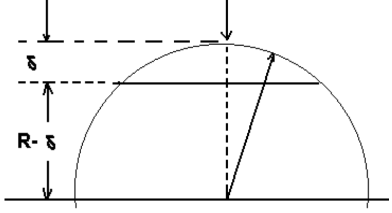

Fig. 4. Deformation of berry during compression

The calculation of elasticity modulus is based on the following assumptions: 1) The berries are long elliptic in shaped very small expansion in the longitudinal plane occurred with compression in vertical plane, and 2) Each side of the berry in contact with the flat plates has and equal deflection (O'Brien *et al.*, 1965).

According to following expression, the modulus of elasticity was calculated following equation:

(7) $E= F/\pi\delta^2$

In order to determine damage during transport, the modulus of elasticity before the berries (which were harvested by hand) was placed on the vibration container and 30 and 60 min after than the modulus of elasticity that is subject to vibration was determined.

In this study, damage is described as a difference of elasticity modulus, separation resistance, number of separated berry and resistance to cracking before and after the test. This study was carried out tree replication. MINITAB was used for statistical analysis.

Vibration of the simulation container was measured using a HBM, SMM-31 type instrument which can measure vibration's expansion, speed and acceleration at different levels.

Results and Discussion

Physical and chemical characteristics of grape fruits are given in Table 1. Among chemical characteristics; titration acidity content was 5.1 g/l and with 17.4 °Brix soluble solids, and 83 ml/100 g fruit juice.

Berry volume	5476.05	mm^3
Berry weight	11.17 ± 2.36	g
Berry length	34.59 ± 1.81	mm
Berry width	20.61 ± 1.28	mm
Number of seeds per berry	1.92 ± 0.79	number
Cluster weight	682.65 ± 33.19	g
Number of berry per cluster	62.06 ± 4.70	number
Soluble solids	17.4	°Brix
Titration acidity	5.1	g/l
Berry juice	83	ml / 100 g
Project area	763.3	mm^2
Surface area	1594.19	mm^2
Sphericity	0.708	
Geometric mean diameter	24.49	mm
Moisture content	82.48	%
Natural frequency	109.322	Hz
Elasticity modulus	1347	kPa
Density of berry in the container	3072.196	N/m^3
Separating resistance of berry from pedicel	3.846±0.095	N
Berry density	2.137	g/cm^3
Resistance to cracking of berry	31.743±0.479	N

Table 1. Some characteristics of berry and cluster

Average berry moisture content was 82.48% (w.b.), berry length was 34.59 mm, berry width was 20.61 mm, berry weight was 11.79 g, berry volume was 5476.05 mm^3, and berry sphericity was 0.708, the geometric mean diameter was 24.49 mm, the project area 763.3 mm^2 and the surface area is 1594.19 mm^2 found (by using the method of Moser, 1984).

It's found that there was a decrease in the separate resistance of the grape in the beginning. First related to 30 min vibration period it was 44.40% and there was a decrease of 61.21% in the vibration period of 60 min. This decrease is found significant ($p<0.01$) from statistical respect and the lowest separate resistance was found at 60 min. period with 1.73 N average (Table 2). The increase in the period vibration lowered the separate resistance. Moser (1984) reports similar results.

Containers position	Beginning (N)	30 min (N)	60 min (N)
Top	4.33	2.26	1.33
Middle	4.46	2.60	1.61
Bottom	4.60	2.60	2.24
Average (LSD: 0.58)	4.46 a	2.48 b	1.73 c

Table 2. Separating resistance of berry from pedicel

Means followed by the same letter are not significantly different at the 1% level of significance

The container position and the vibration period is found statistically significant ($p<0.01$) on the number of separated berry (Table 3). The number of the separated berry was determined 82.83 at average in the top container and it decreased with 31.6% in the middle container. The number again reduced with 61.17% in the bottom container. These numbers were found at 30-60 min. vibration period. This results from the effect of high acceleration in the top container. Turczyn *et al.,* (1986) found similar conclusions. The number of the separated berry had an increase of 265.2% in 30 min. vibration period to the period of 60 min.

Containers position	30 min (Number)	60 min (Number)	Average (LSD: 4.70)
Top	51.00	114.66	82.83 a
Middle	24.33	89.00	56.66 b
Bottom	18.66	45.66	32.16 c
Average	31.33 a	83.10 b	

Table 3. Number of separated berry

Means followed by the same letter are not significantly different at the 1% level of significance

The numbers of the cracking resistance of the berry related to the position of the container and the vibration period is given in Table 4. The effect of the containers position and vibration period on the cracking resistance was found statistically significant ($p<0.01$). While the highest cracking resistance number was found in the bottom container with 28.81 N, the numbers were 27.67 N and 28.0 N in the middle and top containers. Statistically there was no difference between the middle and top container. While the cracking resistance number was 31.59 N averages in the beginning, the numbers were 26.01 N and 26.87 N at 30-60 min vibration periods. There has been no difference between the two vibrations periods found at statistical respect.

Containers position	Beginning (N)	30 min (N)	60 min (N)	Average (LSD=0.94)
Top	31.74	24.79	27.48	28.00 b
Middle	31.59	24.72	26.70	27.67 b
Bottom	31.47	28.53	26.43	28.81 a
Average (LSD: 0.94)	31.59 a	26.01 b	26.87 b	

Table 4. Resistance to cracking of berry

Means followed by the same letter are not significantly different at the 1% level of significance.

Although the effect of elasticity modulus on the container position was not significant, the vibration period's effect was found significant ($p<0.01$). While the elasticity modulus was 1423 kPa in the beginning the number was 1203,7 kPa and 1076,7 kPa at 30-60 min vibration period, but there has no statistical difference observed between the two vibration periods (Table 5). (O'Brien *et al.,* 1965; Fridley *et al.,* 1968; Zohadie, 1982) These investigators found similar results.

Box acceleration at top, middle and bottom were 1.90 ms^{-2}, 0.90 ms^{-2} and 0.7 ms^{-2} respectively.

Natural frequency of berry was calculated as on 109.332 Hz. This frequency was obtained in box height of 1.42 m. Aydin (1993) reported that natural frequency for the peach is varied between 7-110 Hz according to the box height.

Containers position	Beginning (kPa)	30 min (kPa)	60 min (kPa)
Top	1464	1228	1098
Middle	1381	1140	1020
Bottom	1424	1245	1112
Average (LSD: 153.7)	1423 a	1203.7 b	1076.7 b

Table 5. Elasticity modulus

Means followed by the same letter are not significantly different at the %1 level of significance

Conclusions

1. Berry separating resistance from pedicel, number of separated berry, and berry resistance to cracking, and elasticity modulus were affected significantly by the vibration time. The affection was less at the 30 min vibration than 60 min vibration. The number of separated berry and resistance of the cracking of berry are affected significantly by the position of the container.
2. The separate resistance which is 4.46 N in the beginning becomes 2.48 N in the periods of 30 min and 1.73 N averages in the periods of 60 min.
3. The number of separated berry is 31.33 in the period of 30 min average and increased to 83.10 in the period of 60 min. While this is 82.83 in the top box the number is 32.16 in the bottom box.
4. Resistance to cracking is determined 28.81 N in the bottom box as the highest number. The resistance of cracking is 31.59 N in the beginning, and changes to 26.01 N and 26.87 N in the period of 30 and 60 min vibration time respectively.
5. While the elasticity modulus is 1423 kPa in the beginning these are 1203.7 kPa and 1076.7 kPa in 30 min and 60 min periods respectively.
6. Natural frequency of berry was calculated as on 109.332 Hz. This frequency was obtained in box height of 1.42 m.
7. Table grape variety Bardas (*Vitis vinifera* L.) grown in Karaman Turkey have been found resistance to transportation.

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