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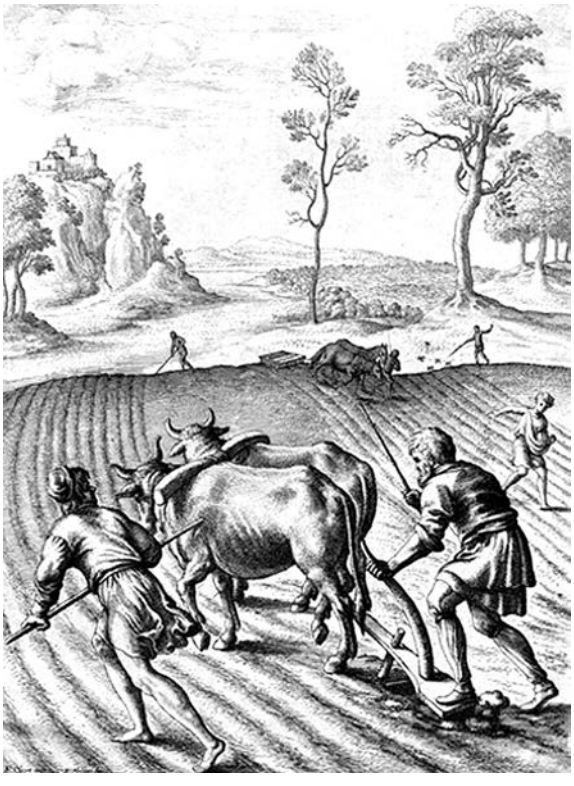

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Technical and Economical Evaluation of Traditional vs. Advanced Handling of Grapes in Jordan

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Abstract: The aim of present study was to compare the effect of the traditional postharvest practices vs. modern technology in handling of grapes. Superior seedless grapes were subject to storage treatments at 0, 10 and 22°C in two groups, advance vs. traditional handling for 10 days. Marketability of grapes was evaluated from technical and economical aspects. Technical evaluation was based on some quality parameters such as Total Soluble Solids (TSS), shattering, weight loss, decay incidence and shelf life. Economical evaluation was based on the crop enterprise budgets to estimate the profitability. Results revealed that TSS was not affected by treatments, rather by delayed harvest time, while all other parameters were substantially affected by temperature management and advance handling. Additionally, an increase in the farmer's net profit and the benefit-cost ratio by 9.3%. and from 5.62 to 6.05, respectively. Thus, the use of proper postharvest handling including sorting and temperature management is highly recommended for the export produce.

Key words: *Vitis vinifera* L., shattering, shelf life, weight loss, profit

INTRODUCTION

Jordan is an exporter of fresh fruits and vegetables to the Region and Europe. As a member of the World Trade Organization (WTO), Jordan, as well as many developing countries, is faced with a challenge to comply with the international standards. Often, the produce is rejected for failure to meet market standards mainly at the European markets, while still being considered edible. In such a case, the rejections lead to losses of the entire shipments of otherwise wholly edible produce. Postharvest losses in Jordan have been reported to reach as high as 23.0% in peppers and 21.9 in squashes (El Assi, 2002) and 18.0% in eggplants and 19.4% in tomatoes (El Assi, 2004). Even though, no other reports are available for other fresh fruits and vegetables, but substantial amount of postharvest losses is believed to stem from the improper handling of fresh produce that is practiced widely in the less developed systems.

Early seedless grapes can be harvested as early as May, when the market potential in West Europe is highly demanding. All impedances to proper postharvest handling techniques can be overcome by applying simple practices such as temperature management, sorting and careful handling. As such, high quality grapes meeting the international standards can be exported with no difficulties.

The objective of the current study was to compare the effect of the traditional postharvest practices vs. the modern technology in the handling of grapes and estimate the economic impact accordingly.

MATERIALS AND METHODS

Plant materials: Superior seedless grapes grown in the open field were obtained from three commercial farms located in the Jordan Valley in the year 2002. Grapes were collected from five harvests, from each farm, with a 3 day interval between harvests. Harvest frequency was designated as: 1st Harvest (1st H) to the 5th Harvest (5th H). Fruits then were either kept as packed by the farmers (Group I- Traditional handling), or sorted, trimmed and packed by the working team (Group II- Advance handling). Grape boxes, from both groups, were divided into three main treatments: held continuously at room temperature 22±2°C for the duration of the experiment; held at 0°C for 10 days, removed and then held at room temperature; or held at 10°C for 10 days, removed and then held at room temperature. The total number of boxes (weighed 4 kg each) obtained was 180 boxes (12 boxes*3 farms*5 harvests). Samples were transported on the same day of harvest to the storage rooms at the Fresh Fruit Company in Juwaideh, Amman, where testing of the studied parameters were performed.

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Measurements: Measurements were taken at 0 day, after 10 days holding at the corresponding temperature for each treatment, after removal from storage and holding for 3 days at 22°C for the 0 and 10°C treatments and after 6 days holding at 22°C upon removal from storage for the 0°C treatment. Initial values at 0 days were all 0 except for the total soluble solids.

Total soluble solids (TSS): Three to six berries were taken from the middle area of the clusters (Nelson, 1985), squeezed and the TSS was measured using the Refractometer (Abbe-Refractometer Nr. 301, Japan, BREMER LABORHANDEL GMBH).

Shattering: Abscised berries from the clusters in each box were collected, weighed and their percentage was calculated from the total weight of the box.

Weight loss: Ten clusters from each box were tagged and weighed periodically using an automatic balance (Model "NCI-30" Kemeralti Cad. 69. Karakoy. Istanbul).

Decay: Decayed berries were collected, weighed and their percentage was calculated from the total weight of the box.

Shelf life: Determination was based on the parameters tested above to the point where the grapes no longer could be marketable.

Economical analysis: Crop enterprise budgets are used in economic analysis to estimate the profitability of agricultural products. In this research a crop enterprise budget for seedless grapes produced in the Jordan Valley was constructed using collected data from farmers specialized in this type of production. The budget shows the total revenue from selling the produce at the local market evaluated at the farm gate price. It shows also the different types of costs involved in the production process. The costs are classified into variable and fixed costs. The variable costs are those cost items that vary with the variation of the production level while the fixed costs do not change with the variation in production. The crop budget shows the costs of the different items involved in the production process for a unit of one hectare during the production season of 2005/2006.

Different economic indicators are used in this study including: 1) gross margins per hectare; 2) net returns and 3) benefit cost ratio. Gross margin per is estimated by deducting the total variable costs from the total revenues. The net returns represent the net profit per hectare that is estimated by deducting the total costs from total revenues. The benefit cost ratio is obtained by dividing the total revenues by the total costs per one hectare of grapes.

The three economic indicators were used in this paper to evaluate in economic terms the impact of shifting from traditional handling to advanced handling. The analysis is based on the impact of the weight loss of grapes following testing at room temperature (RT), 0 and 10°C for group I (traditional handling) and group II (advance handling).

STATISTICAL ANALYSIS

Data obtained from each of the studied parameters were analyzed separately using Analyses of Variance (ANOVA) by the Statistical Analysis Systems computer package (SAS institute, 2003) with main effects and interaction evaluated at $p = 0.05$. Treatment means were separated by Least Significant Difference methods at the 0.05 level.

RESULTS AND DISCUSSION

Technical results

Total soluble solids (TSS): Very slight variation in the TTS percentages were observed among treatments within each harvest, with the exception of the 1st harvest (Table 1). However, a steady increase in the TSS values among harvests with time progression, with significant differences among values, was observed (Table 1). Even though, the time period between the first and the last harvest was only 15 days, however; the fruits were able to accumulate 2.1% more of TSS (the difference between the highest 17.2% and the lowest 15.1%), which practically improve the optimum eating quality. No significant differences were detected between group I and II treatments (Table 1). These results agree with the physiological behavior of the grapes as a non-climacteric fruit that typically will not ripen off the tree and no compositional changes, contributing to better eating quality, would be expected after harvest. Hence, grapes are among this category of fruits that should be harvested when posses the prerequisites of optimum eating quality.

Abscission (shattering): The highest percentages of abscised berries were found at RT treatment as compared to 0 and 10°C treatments (Table 2). Yet, shattering was higher at 10 that at 0°C treatments (Table 2). The higher the temperature the higher the percentage of shattering with significant differences among the treatments. Shattering also increase with delayed harvest suggesting that berries might have been at an advanced stage of

Table 1: Total Soluble Solids (TSS) percentages [1,2,3]of grapes following testing at 0, 10°C and Room Temperature (RT), for group I (traditional handling) and group II (advance handling)

	Harvest				
	1st H	2nd H	3rd H	4th H	5th H
Treatments	TSS (%)				
Group I					
0°C	15.1k[4]	15.5ijk	16.0efg	16.8abc	16.7bcd
10°C	15.5ijk	16.2efg	16.8abc	16.9ab	17.2a
RT	15.2jk	15.7hi	16.0fgh	16.3def	16.6bcde
Group II					
0°C	15.5ijk	16.0fgh	16.2efg	16.4cdef	16.6bcde
10°C	15.2jk	15.6hij	16.0fgh	16.4cdef	16.7bcd
RT	15.2jk	15.8ghi	16.3def	16.5a	16.6bcde

[1,2] Means are the average of six separate samples (six boxes). [3]Higher values represent more TSS content. [4]Values followed by the same letter are not significantly different at the 0.05 level by the LSD method

Table 2: Abscission (Shattering) percentages[1,2,3] of grape berries following testing at 0, 10°C and Room Temperature (RT), for group I(traditional handling) and group II (advance handling)

	Harvest				
	1st H	2nd H	3rd H	4th H	5th H
Treatments	Abscission (%)				
Group I					
0°C	10.8lm[4]	10.2mn	11.5kl	15.3g	13.9h
10°C	16.4f	12.8i	15.2g	17.6e	12.4ig
RT	18.4d	18.5d	25.2a	19.9cd	16.7e
Group II					
0°C	9.3o	9.7no	14.7g	11.7jk	12.2ijk
10°C	16.6f	15.2g	15.3g	15.2g	17.4e
RT	17.4e	23.3b	25.8a	20.9c	16.9ef

[1,2]Means are the average of six separate samples (six boxes). [3]Higher values represent more shattering percentages. [4]Values followed by the same letter are not significantly different at the 0.05 level by the LSD method

maturity rendering them to be very prone to shattering regardless of any other factors involved. Moreover, an overall lower shattering percentage observed in Group II as compared to Group I (Table 2). These results are in agreement with previous reports indicating that shattering is caused by some factors such as moisture stress during the growing season, high temperature at harvest time and delay in cooling (Harvey *et al*., 1986), advance maturity, rough handling during field packing and exposure to high levels of ethylene (Crisosto *et al*., 2002). Additionally, Crisosto *et al*. (2002) suggested that berries of seedless cultivars, are less well attached to the cap stem than seeded cultivars.

Weight loss: Weight loss is due mainly to water loss from the berries. It is very well known that the cuticle is closely bound to the epidermal layer and relatively impermeable ands highly resistant to movement of water or water vapor. However, water can be lost readily through the pedicel and cluster stems resulting in their drying, browning and berry shatter. Significant differences were observed among the weight loss values of all treatments

Table 3: Weight loss percentages[1,2,3] of grapes following testing at 0, 10°C and Room Temperature (RT), for group I(traditional handling) and group II (advance handling)

	Harvest				
	1st H	2nd H	3rd H	4th H	5th H
Treatment	Weight loss (%)				
Group I					
0°C	1.7i[4]	1.8i	1.6i	1.8i	1.6i
10°C	3.6h	4.3ef	4.6e	4.8de	5.4d
RT	9.2bc	9.8ab	10.3a	8.9c	9.8ab
Group II					
0°C	1.4i	1.5i	1.8i	1.6i	1.8i
10°C	4.3efg	4.3efg	3.6gh	3.9fg	4.5e
RT	9.9a	10.2a	9.0c	10.0a	9.8a

[1,2]Means are the average of six separate samples (six boxes). [3] Higher values represent firmer berries. [4]Values followed by the same letter are not significantly different at the 0.05 level by the LSD method

in all harvests (Table 3). Weight loss percentages were the highest in grapes held at Room Temperature (RT) followed by those held at 10°C and the lowest were those kept at 0°C, with significant differences among the values (Table 3). Temperature rather than harvest time was of influence on berries, since no steady pattern was recorded among the harvests. These results are confirmed with the finding of Crisosto and Mitchell (2002) indicating that water loss range of 0.5 to 2.1% with an 8 h delay of cooling after harvest and that the magnitude of losses was directly related to temperature, length of exposure to high temperatures (Crisosto and Mitchell, 2002).

Water loss resulted in softening and shriveling and by the time such phenomenon occurred, the stems of the cluster have already dried out and the grapes were unmarketable. Such results were also reported by Nelson (1979) who stated that after dehydration of stems, they shrink and become brown and berries become flaccid.

Decay: Lower values of decay incidence were obtained for Group II as compared to those from Group I, with significant differences (Table 4). Furthermore, lower temperatures substantially reduced decay incidence in both groups as compared to RT treatment (Table 4). Among other diseases gray mold caused by *Botrytis cinerea* (Kokkalos, 1986) was the major one occurred resulting in rapid deterioration of grapes. Sorting and temperature management were the key factors in reducing or aggravating the decay incidence. These findings were in agreement with earlier report by Ballinger and McClure (1983) stating that decay incidence of fruits stored at 0°C for a week increased 20-fold when removed and held at 20°C for 72 h.

Sorting for decayed berries was shown to be beneficial in reducing the decay incidence as observed in the Group II. This is a preliminary postharvest step in preventing the spread of diseases at later stages.

Table 4: Decay percentages[1, 2,3] of grapes following testing at 0, 10°C and Room Temperature (RT), for group I (traditional handling) and group II (advance handling)

	Harvest				
	1st H	2nd H	3rd H	4th H	5th H
Treatments	Decay (%)				
Group I					
0°C	2.6ghi[4]	2.0ghi	3.0g	3.1g	2.8gh
10°C	10.3ef	10.4ef	11.1def	11.8df	12.0d
RT	17.9ab	17.6b	19.2a	18.4ab	18.5ab
Group II					
0°C	1.3hi	1.2i	2.0ghi	1.8ghi	2.1ghi
10°C	10.0f	10.0f	11.7de	11.6de	12.0d
RT	14.9c	14.8c	15.4c	15.3c	16.1c

[1,2]Means are the average of six separate samples (six boxes). [3]Higher values represent more decayed fruits. [4]Values followed by the same letter are not significantly different at the 0.05 level by the LSD method

Grapes are very tender and delicate fruits that are subject to pathogenic attack if not fumigated regularly with sulfur dioxide. Treatment with sulfur dioxide is a very common practice used in transport and storage of grapes against the Gray Mold disease caused by *Botrytis cinerea*. The absence of this treatment, even for 10 days, will result in developing of the disease. Furthermore, low temperature will not prevent the development of this disease. In present experiment, this disease resulted in high percentages of decayed fruits noticed mainly at 10°C and RT and in Group I.

Shelf life: The effect of temperature was very well pronounced on the shelf life of grapes, whereas, harvest time had no effect (Table 5). Additionally, Group II (advanced handling) had longer shelf life compared to those of Group I (traditional handling), specially at lower temperatures (Table 5). Grapes from Group II held at 0 and 10°C lasted for an average of 2.7 and 1.6 days longer than those from Group I held at the same temperatures, respectively. Significant differences exist among the values for grapes from both groups held at lower temperatures (Table 5). Grapes from both groups held at room temperature lasted an average of 10.4 days only (Table 5).

In conclusion, proper temperature management and sorting exerted a profound effect on grapes by increasing shelf life, reducing decay incidence, shattering (Table 6 and 7) and weight loss. Delaying harvest time was a secondary factor affect the studied parameters.

Economical results: The results show that there is a significant difference among the weight loss values of all treatments in all harvests. The highest economic profits are obtained from grapes held at 0°C while the lowest are obtained from grapes kept at room temperature (RT) (Table 8). The total net returns (profits) per hectare amounted to 12,555 Jordanian Dinar (1.0 JOD = 1.4 US$) for each ton of grapes kept at 0°C and 11,484 JOD per ton kept at room temperature. This implies that the proposed treatment has increased the farmer's net profit by 9.3%.

The benefit-cost ratio has also increased from 5.62 to 6.05. This implies that shifting from traditional to advanced handling of grapes is economically effective and profitable.

Table 5: Shelf life [1,2,3] of grapes following holding at 0, 10°C and room temperature (RT), for group I (traditional handling) and group II (advance handling)

	Harvest				
	1st H	2nd H	3rd H	4th H	5th H
Treatments	Days				
Group I					
0°C	18cd	17d	18cd	18cd	17d
10°C	14ef	13fg	13fg	13fg	12gh
RT	11hi	11hi	10i	10i	10i
Group II					
0°C	21a	20ab	19bc	21a	20ab
10°C	15e	15e	14ef	15e	14ef
RT	11hi	10i	10i	11hi	10i

[1,2]Means are the average of three separate samples (three boxes). [3]Higher values represent longer shelf life. [4]Values followed by the same letter are not significantly different at the 0.05 level by the LSD method

Table 6: Abscission (Shattering), weight loss and decay of grapes following holding at 0°C and 10°C for 10 days, removal and holding at 22°C for 3 days for group I (traditional handling) and group II (advance handling)

Treatments	Abscission (%)	Weight loss (%)	Decay (%)
Group I			
0°C	16.6b[1,2]	6.4c[1]	9.3c[1]
10°C	21.1a[3]	9.3a[3]	16.4a[3]
Group II			
0°C	14.3c	7.4bc	7.4d
10°C	19.4a	8.5ab	14.4b

[1]Means are the average of five harvests (15 boxes). [2]Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method. [3]Means are the average of four harvests (12 boxes)

Table 7: Abscission (Shattering), weight loss and decay of grapes following holding at 0°C for 10 days, removal and holding at 22°C for 6 days for group I (traditional handling) and group II (advance handling)

Treatments	Abscission (%)	Weight loss (%)	Decay (%)
Group I			
0°C	18.4b[1,2]	8.3b[1,2]	16.3a[1,2]
Group II			
0°C	19.2a	9.3c	13.4b

[1]Means are the average of 15 boxes. [2]Values within columns followed by the same letter are not significantly different at the 0.05 level by the LSD method

Table 8: Economic implications of weight loss of grapes following testing at 0°C, 10°C and room temperature (RT)

	Room temperature				10°C for 10 days			0°C for 10 days		
Characters	Unit definition	Unit	Price JD Unit	Total JD	Unit	Price JD Unit	Total JD	Unit	Price JD Unit	Total JD
Crop produce (output)	kg	29120.0	0.5	13967.9	30400.0	0.5	14581.9	31360.0	0.5	15042
Water requirements	m^3	12680.0	0.0	139.5	12680.0	0.0	139.5	12680.0	0.0	139
Manure-Fertilizer	Ton	15.0	25.0	375.0	15.0	25.0	375.0	15.0	25.0	375
Total chemical fertilizer	kg			478.0			478.0			478
- N	kg	500.0	0.5	240.0	500.0	0.5	240.0	500.0	0.5	240
- P_2O_5	kg	100.0	0.8	77.0	100.0	0.8	77.0	100.0	0.8	77
- K_2O	kg	230.0	0.7	161.0	230.0	0.7	161.0	230.0	0.7	161
Pesticides	Hect	1.0	235.0	235.0	1.0	235.0	235.0	1.0	235.0	235
Costs of machinery	JD			129.7			129.7			130
- Land preparation	h	20.0	5.0	100.0	20.0	5.0	100.0	20.0	5.0	100
- Husbandry	h	3.3	9.0	29.7	3.3	9.0	29.7	3.3	9.0	30
Labor requirements:	JD	82.0		410.0	82.0		414.0	82.0		414
- For land preparation	man h^{-1}		0.5	0.0		0.5	0.0		0.5	0
- Sowing/planting	man h^{-1}		0.5	0.0		0.5	0.0		0.5	0
- Husbandry (Weeding and irrigation)	man h^{-1}	520.0	0.5	260.0	520.0	0.5	260.0	520.0	0.5	260
- Pruning	man h^{-1}	100.0	0.5	50.0	100.0	0.5	50.0	100.0	0.5	50
- Harvesting and post harvest handling	man h^{-1}	200.0	0.5	100.0	208.0	0.5	104.0	208.0	0.5	104
Total variable costs	JD			1767.2			1771.2			1771
Gross margin	JD			12200.7			12810.7			13271
Fixed Costs:				450.0			450.0			450
- Land rent	Hect	320.0	1.0	320.0	320.0	1.0	320.0	320.0	1.0	320
- Investment cost	Hect	1.0	130.0	130.0	1.0	130.0	130.0	1.0	130.0	130
- Interest on working capital	JD	2217.18	0.12	266.06	2221.18	0.12	266.54	2221.18	0.12	267
Total fixed costs	JD			716.06			716.54			717
Total cost	JD			2483.24			2487.72			2488
Net returns	JD			11484.65			12094.15			12555
Benefit-cost ratio (BCR)	%			5.62			5.86			6.05

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