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# Effects of package and storage conditions on the keeping quality of Perlette grapes

by

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## Einfluß der Verpackungs- und Lagerungsbedingungen auf die Haltbarkeit von Perlette-Trauben

Zusammenfassung: Um die Verluste zwischen Ernte und Verkauf von Perlette-Trauben zu verringern, wurde jeweils 1/4 eines $SO_2$-Spenders („Dual Release" $SO_2$ generator) in die 2 kg Trauben fassenden Polyäthylenbeutel gelegt; die Verpackungsbeutel waren mit Perforationen versehen, die 0,56; 0,84; 1,12; 1,40 und 1,68 % der Folienfläche ausmachten. Die gefüllten Beutel wurden bei 5, 15, 25, 30 und 35 °C (Freilandtemperatur) in belüftete 2-kg-Kartons aus Wellpappe verpackt und 60 d lang kühlgelagert (0—3 °C). Bei der Verkostung wurden die Trauben mit einer Verpackungstemperatur von 35 °C und 1,12%iger Perforation der Verpackungsbeutel am besten beurteilt. Die niedrigste Verpackungstemperatur (5 °C) und der niedrigste Perforationsgrad (0,56 %) verringerten beide den physiologischen Gewichtsverlust (PLW) und das Abfallen der Beeren am stärksten. PLW nahm mit der Dauer der Lagerung zu. Bis zu einer Lagerungsdauer von 40 d in zu 0,56 %, 0,85 % und 1,12 % perforierten Beuteln trat keine Beerenfäulnis auf; diese war jedoch auch bei erhöhter Perforation noch zu vernachlässigen. Die höchsten Mostgewichte wurden bei Verpackungstemperaturen von 30 oder 35 °C nach 40tägiger Lagerung festgestellt; danach nahm das Mostgewicht ab. Die höchsten Säurewerte wurden bei Verpackungstemperaturen von 25 und 35 °C nach einer Lagerungsdauer von 40 d, bei 15 und 30 °C nach 60 d ermittelt. Demzufolge können Perlette-Trauben durch beigepackte $SO_2$-Spender in Folienbeuteln, die zu 1,12 % perforiert sind und Verpacken bei 35 °C bis zu 40 d erfolgreich gelagert werden.

Key words: table grape, India, bunch, storage, cold, temperature, polyethylene, ventilation, sulphur, keeping quality, sensory rating, weight, berry shatter, berry rot, must quality.

## Introduction

In India, grape occupies an area of 13,000 ha with annual production of 0.2 million t (ANONYMOUS 1986). Table grape cultivar Perlette takes up 90 % of the area under grapes. A very short harvesting period (June) and the predominance of Perlette which ripens simultaneously in different zones of Northern India (25—33 °N) cause frequent market surpluses. The situation becomes aggravated if rains during harvest time force growers to dispose their produce immediately at lower prices. Grapes cannot withstand high temperature (40—44 °C) and low humidity (40—60 %) prevailing at the time of harvesting. As there are limited possibilities of refrigerated transport, grape marketing is centralized in big cities around the production centres. For all these reasons, there is a pressing need to increase the shelf life of cv. Perlette under refrigerated conditions so that fruit can be marketed for longer periods.

Traditionally wooden crates and bamboo baskets have been used for packaging grapes, but for many reasons growers are switching to other packages. The use of corrugated fibre board cartons is gradually increasing (ANONYMOUS 1985). Plastic liners have not yet been commercially adopted due to high degree of losses since facilities for pre-cooling of grapes are grossly lacking in India. Suitable decay control system and packaging need to be tested for this purpose.

This paper embodies the effect of various packaging temperatures and simultaneously placing of sulphur dioxide generators in polyliners having various degree of perforation on the storage life of grapes.

## Materials and methods

Investigations were carried out in the Department of Horticulture of the Punjab Agricultural University, Ludhiana during 1986.

### Packaging

The grapes were packed in corrugated fibre board cartons of 2 kg capacity (25 × 20 × 10 cm) prepared from five ply Kraft paper. Either 20 × 10 cm side had two vents of 1.5 cm diameter. Perforated polyethylene bags (100 gauge thickness, 45 × 30 cm in size) were used for wrapping. The bags were having five treatments of perforation intensity viz. 0.56, 0.84, 1.12, 1.40 and 1.68 %, by making randomly distributed holes of 5 mm diameter.

### Storage treatments

The grapes were harvested between 6 and 7 a.m. when packaging temperature was 35 °C. Quarter size of 'Dual Release' sulphur dioxide generator paper (supplied by M/s. UVAS Quality Packaging, USA) was enclosed in each of the polyliners. The $SO_2$ generator was placed on top of grapes with a thin paper sheet between the fruit and the generator. Polyethylene bags containing grapes and the $SO_2$ generator were folded, stapled, placed in the corrugated fibre board cartons, closed with gum tape and shifted within 3 h to cold storage. In the remaining treatments, the $SO_2$ generators were placed in the perforated polyliners when the grape bunches attained 30, 25, 15 and 5 °C temperature in the cold storage (0—3 °C temperature and 85—90 % RH) which took 1, 2.5, 6 and 10.5 h, respectively.

### Quality analysis

Physico-chemical changes were recorded after 20, 40 and 60 d of cold storage. Organoleptic evaluation was done using a 9-point 'hedonic' scale as follows: 9, extremely desirable; 8, very much desirable; 7, moderately desirable; 6, slightly desirable; 5, neither desirable nor undesirable; 4, slightly undesirable; 3, moderately undesirable; 2, very much undesirable and 1, extremely undesirable.

After 20, 40 and 60 d of cold storage, the grapes in each pack were weighed and per cent loss in weight was calculated. The per cent berry shatter was determined by weighing the shattered berries of a pack. The per cent berry rot was noted after observing each decay during subsequent intervals. To find out the fungi involved in berry rot, isolates were made and the cultures examined for fungi present. Total soluble solids of the freshly extracted grape juice were determined by use of a hand refractometer (Erma, Japan), correcting the readings to 20 °C (A.O.A.C. 1980). The total titratable acidity of the juice was estimated by titrating with 0.1 N NaOH using phenolphtalein as an indicator and expressed as mg of tartaric acid per 100 ml of juice (A.O.A.C. 1980). Total sugars were determined by Fehling's solution with methylene blue as indicator. The post cold storage life of grapes under ambient conditions was recorded till being marketable.

### Statistical design and analysis

One corrugated fibre board carton served as a treatment unit and each treatment was replicated four times. The experimental data were analysed with a factorial design. Regression analysis included correlations between the explanatory variables like packaging temperature, intensity of perforation and storage interval with the dependent variables such as organoleptic rating, physiological loss in weight, berry shatter, berry rot, total soluble solids, total titratable acidity and total sugars. Variation explained by the independent variables of the regression equations was also worked out.

## Results and discussion

### 1. Organoleptic rating

The interaction between packaging temperature and perforation was found to be significant. The overall acceptability score was highest (8.58) at 35 °C packaging temperature and 1.12 % perforation (Fig. 1 a). This was perhaps due to the increased absorption of $SO_2$ at higher temperature. Other effective treatments having same mean score value (8.42) were 25 and 30 °C packaging temperature with 1.12 % perforation in the polyliner. However, the interactions between packaging temperature and storage interval and between perforation and storage interval were non-significant (Fig. 1 b, c). The regression coefficient for packaging temperature and intensity of perforation was non-significant and explained as little as 6.24 % variation in the organoleptic rating. Packaging temperature and storage interval (Table, regression no. 1.2) and intensity of perforation and storage interval (1.3) explained about 94 and 81 % of the total variation. An increase of the storage interval by 1 d resulted in a decline of about 0.04 % in the organoleptic rating (Table).

### 2. Physiological loss in weight

The interaction between packaging temperature and per cent perforation was found to be statistically significant (Fig. 2 a). The lowest physiological loss in weight (0.60 %) was obtained at 5 °C with 0.56 % perforation, whereas the highest loss in weight (1.98 %) was recorded at 35 °C with 1.68 % perforation in the polyliner.

Optimum and uniform release of $SO_2$ from the $SO_2$ generator at low packaging temperature might have controlled the metabolic processes (Nabiev and Velieva 1985) consistent with reduction in respiration and prevention of moisture loss (Winkler *et al.* 1974). Reduced weight loss in less perforated polyliners may be linked to high relative humidity, modified atmosphere (low $O_2$ and high $CO_2$) inside the polyliners (Hall *et al.* 1975) and permissible exchange of gasses (Siddappa *et al.* 1954) which reduced both water loss (Rao 1973) and respiration of the berries (Rao 1969). Maintenance of optimum concentration of $SO_2$ in the polyliner might have reduced ethylene production (Singh and Weaver 1982) and respiration rate (Pentzer *et al.* 1933) since polyethylene coated containers were found to be more effective than Kraft paper containers in maintaining $SO_2$ and water vapours (Nelson and Ahmedullah 1972).

The interaction between packaging temperature and storage interval was worked out to be significant (Fig. 2 b). Minimum loss in weight (0.42 and 1.00 %) occurred at 5 °C after 20 d and 40 d of storage, respectively. The weight loss after 60 d of storage at different temperatures (except 35 °C) was statistically non-significant. The interaction between per cent perforation and storage interval was also significant (Fig. 2 c). Minimum losses in weight of 0.09, 0.55 and 1.58 % with 0.56 % perforation and maximum losses of 0.91, 1.91 and 2.74 % with 1.68 % perforation were recorded after 20, 40 and 60 d of storage, respectively.

Relationship of packaging temperature (PT), intensity of perforation (IP) and storage interval (SI) with organoleptic rating, physiological loss in weight (PLW), berry shatter, berry rot, total soluble solids (TSS), total titratable acidity (TTA) and total sugars

Statistische Beziehungen zwischen Verpackungstemperatur (PT), Dichte der Perforationen (IP) und Lagerungsdauer (SI) einerseits und sensorischer Bewertung, physiologischem Gewichtsverlust (PLW), Abfallen der Beeren, Beerenfäulnis, Mostgewicht (TSS), titrierbarer Gesamtsäure (TTA) und Gesamtzucker andererseits

| Regression no. | Intercept | PT | IP | SI | $R^2$ |
|---|---|---|---|---|---|
| 1. Dependent variable : Organoleptic rating | | | | | |
| 1.1 | 7.7918 | 0.0074 | −0.1300 | — | 0.0624 |
| | | (0.0074) | (0.2021) | | |
| 1.2 | 9.3871 | 0.0075 | — | −0.0435** | 0.9411 |
| | | (0.0047) | | (0.0031) | |
| 1.3 | 9.7000 | — | −0.1309 | −0.0435** | 0.8085 |
| | | | (0.2527) | (0.0061) | |
| 2. Dependent variable : Physiological loss in weight | | | | | |
| 2.1 | − 0.0655 | 0.0086** | 1.0114** | — | 0.9923 |
| | | (0.0007) | (0.0195) | | |
| 2.2 | − 0.5665 | 0.0092** | — | 0.0406** | 0.9082 |
| | | (0.0019) | | (0.0012) | |
| 2.3 | − 1.4780 | — | 0.9940** | 0.0406** | 0.0933 |
| | | | (0.0728) | (0.0017) | |
| 3. Dependent variable : Berry shatter | | | | | |
| 3.1 | 0.6683 | 0.0015** | 0.4871** | — | 0.9835 |
| | | (0.00028) | (0.0076) | | |
| 3.2 | − 0.6796 | 0.0014 | — | 0.0474** | 0.9086 |
| | | (0.0007) | | (0.0005) | |
| 3.3 | − 0.0119 | — | 0.4893** | 0.0474** | 0.9968 |
| | | | (0.0330) | (0.0008) | |
| 4. Dependent variable : Berry rot | | | | | |
| 4.1 | 0.1147 | −0.0013 | 0.1357* | — | 0.2415 |
| | | (0.0019) | (0.0530) | | |
| 4.2 | − 0.3750 | −0.0001 | — | 0.0149** | 0.8217 |
| | | (0.0030) | | (0.0020) | |
| 4.3 | − 0.4547 | — | 0.0678 | 0.0149** | 0.8002 |
| | | | (0.0891) | (0.0021) | |
| 5. Dependent variable : Total soluble solids | | | | | |
| 5.1 | 0.0018 | 0.0041** | 0.3014** | — | 0.9670 |
| | | (0.0004) | (0.0126) | | |
| 5.2 | 0.0018 | 0.0041 | — | 0.0046 | 0.1614 |
| | | (0.0053) | | (0.0035) | |
| 5.3 | 0.0018 | — | 0.3000 | 0.0045 | 0.3362 |
| | | | (0.1435) | (0.0034) | |

(continued)

(Table continued)

| Regression no. | Intercept | PT | IP | SI | $R^2$ |
|---|---|---|---|---|---|
| 6. Dependent variable : Total titratable acidity | | | | | |
| 6.1 | 0.6520 | 0.0004** | −0.0321** | — | 0.9574 |
| | | (0.00005) | (0.0015) | | |
| 6.2 | 0.4527 | 0.0004* | — | 0.0019** | 0.9626 |
| | | (0.0001) | | (0.0001) | |
| 6.3 | 57.9331 | — | −0.0238** | 0.0019** | 0.9670 |
| | | | (0.0042) | (0.0001) | |
| 7. Dependent variable : Sugars | | | | | |
| 7.1 | 0.0016 | 0.0034** | 0.2914** | — | 0.9034 |
| | | (0.0007) | (0.0213) | | |
| 7.2 | 0.0017 | 0.0036 | — | 0.0004 | 0.0995 |
| | | (0.0029) | | (0.0019) | |
| 7.3 | 0.0016 | — | 0.2851** | 0.0011 | 0.5788 |
| | | | (0.0740) | (0.0016) | |

Figures in parentheses are the respective standard errors of the regression coefficients.
* significant at 5 % level. ** significant at 1 % level.

Different combinations of packaging temperature, percentage of perforation and storage interval as independent variables explained nearly the total variation present in the dependent variable PLW (Table). The results indicate that an increase of 1 °C in packaging temperature, 1 % increase in the perforation and 1 d increase in the storage period increased the PLW by about 0.01, 1 and 0.04 %, respectively, when keeping the other factors constant.

### 3. Berry shatter

The interaction between packaging temperature and perforation was non-significant (Fig. 3 a). However, minimum berry shatter (0.96 %) was recorded at 5 °C with polyliner having 0.56 % perforation. The interaction between packaging temperature and storage interval was also non-significant (Fig. 3 b) but between perforation and storage interval revealed to be significant (Fig. 3 c). Minimum berry shatter (0.04, 0.97, 1.94 %) was recorded with lowest perforation (0.56 %), while it was maximum (0.62, 1.41, 2.57 %) with highest perforation (1.68 %) after 20, 40 and 60 d of storage period.

Different combinations of packaging temperature, intensity of perforation and storage interval, when two variables were taken at a time, explained nearly all the variations present in the dependent variable, berry shatter (Table, regression nos. 3.1—3.3). An increase of 1 °C in packaging temperature, 1 % in the intensity of perforation and of 1 d in storage interval increased the berry shatter by about 0.001, 0.48 and 0.047 %, respectively (Table).

### 4. Berry rot

Most of the fungi responsible for berry rot during storage were already present on the surface of healthy berries. Yeast, *Alternaria tenuis* and *Aspergillus luchenensis* were abundantly, *Aspergillus niger* was fairly, while *Cephelosporium roseogrisium* and *Curvularia lunata* were rarely present. A similar pattern of occurrence of these fungi was recorded after 40 and 60 d of storage. Yeasts were the first to appear in the culture, followed by *A. tenuis* and *A. luchenensis*. *Botrytis cinerea* was not detected at the time of packing but appeared after 60 d of storage. *Trichoderma lignorum*, *Helminthosporium* spp., *Mucor*, *Penicillium* and *C. lunata* were recorded very rarely as the causal agents of rotting during storage. Though *C. roseogrisium* was present on healthy berries, it was only once recorded after 60 d of storage. After a considerable period of storage, *A. luchenensis* and *Penicillium* (developed *de novo*) overgrew the rest of the fungi.

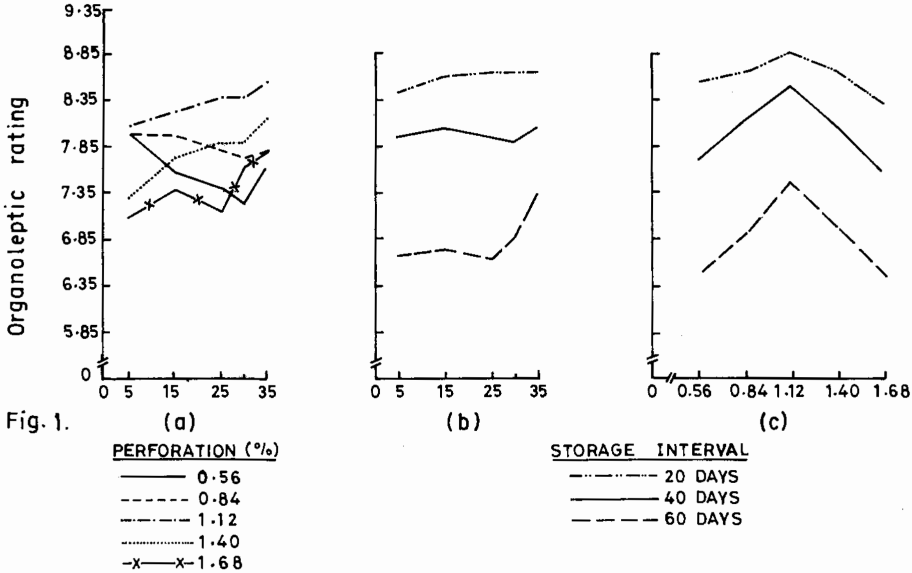



Fig. 1.

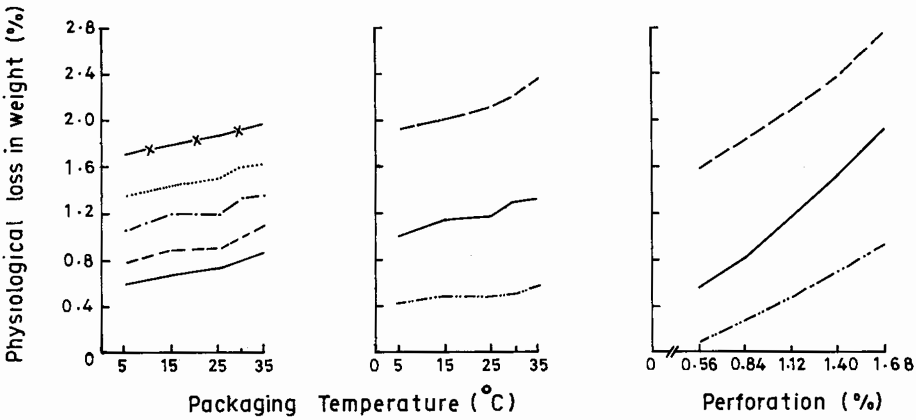



Fig. 2.

Figs. 1 and 2: Effects of interactions between (a) packaging temperature and perforation, (b) packaging temperature and storage interval, and (c) perforation and storage interval on organoleptic rating and physiological loss in weight of Perlette grapes during cold storage.

Einfluß der Interaktionen zwischen a) Verpackungstemperatur und Perforation, b) Verpackungstemperatur und Lagerungsdauer, c) Perforation und Lagerungsdauer auf die sensorische Beurteilung und den physiologischen Gewichtsverlust kühlgelagerter Perlette-Trauben.

Conclusively *Alternaria*, *Aspergillus* and *Penicillium* along with yeasts were the major rot causing fungi.

The interactions between packaging temperature and perforation and temperature and storage interval were non-significant (Fig. 4 a, b), while that of perforation and storage interval was found to be significant (Fig. 4 c). Polyliners showed, irrespective of the varying percentage of perforation, no decay up to 40 d of storage with 0.56, 0.84 and 1.12 % perforation, while negligible berry rot of 0.08 and 0.20 % was obtained with 1.40

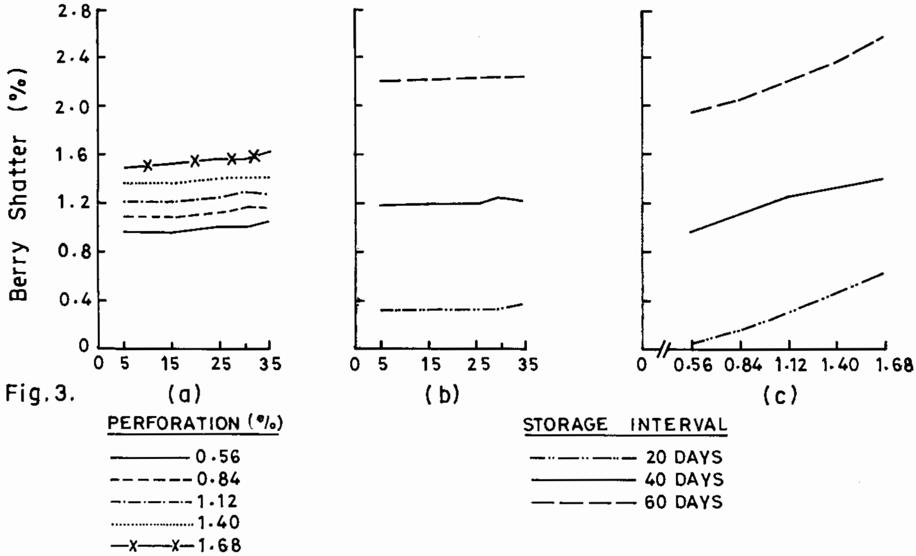



Fig. 3.

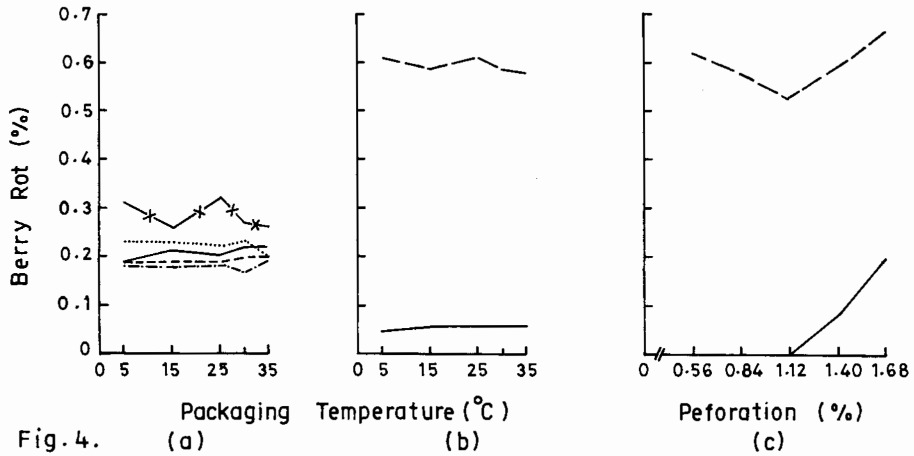


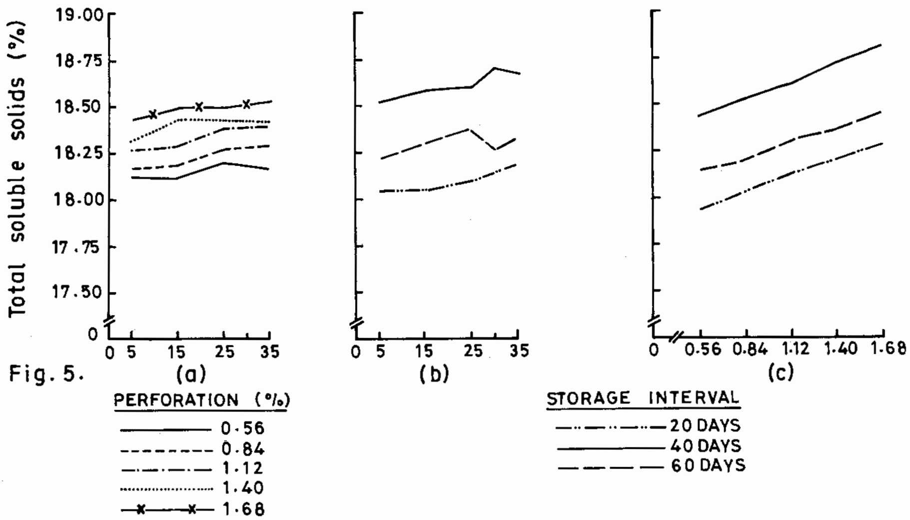

Fig. 4.

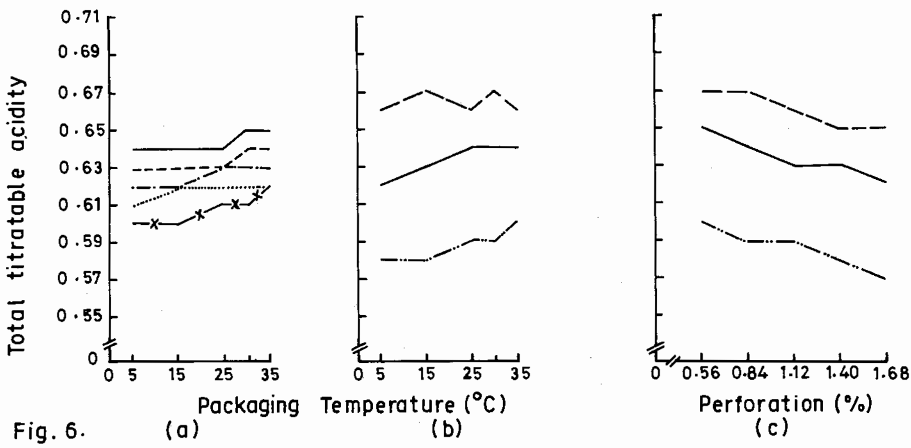
Figs. 3 and 4: Effects of interactions between (a) packaging temperature and perforation, (b) packaging temperature and storage interval, and (c) perforation and storage interval on berry shatter and berry rot of Perlette grapes during cold storage.

Einfluß der Interaktionen zwischen a) Verpackungstemperatur und Perforation, b) Verpackungsand 1.68 % perforation, respectively, which differed significantly from each other. After 60 d, minimum (0.53 %) and maximum (0.66 %) berry rot was recorded with 1.12 and 1.68 % perforation, respectively. The difference between both treatments was significant.

With prolongation of the storage period the $SO_2$ generators were probably exhausted and thus the berry rot was higher in later sampling. Reduction in total soluble solids after 40 d of storage (Fig. 5) indicated completion of post-ripening, over-ripening and entrance of berries into senescence which led to increased berry rot as a result of decreased resistance to decay causing organisms (BURG *et al.* 1964).

Interpreting only the significant regression coefficients from nos. 4.1—4.3 (Table),




Figs. 5 and 6: Effects of interactions between (a) packaging temperature and perforation (b) packaging temperature and storage interval, and (c) perforation and storage interval on total soluble solids and titratable acidity of Perlette grapes during cold storage.

Einfluß der Interaktionen zwischen a) Verpackungstemperatur und Perforation, b) Verpackungstemperatur und Lagerungsdauer, c) Perforation und Lagerungsdauer auf das Mostgewicht und die titrierbare Säure kühlgelagerter Perlette-Trauben.

it was observed that 1 % increase in the intensity of perforation and an increase of 1 d in the storage period, keeping other variables constant, resulted in an increase of 0.136 and 0.015 % in berry rot.

## 5. Total soluble solids

The interaction between packaging temperature and perforation was non-significant (Fig. 5 a). However, a significant relationship was found between packaging temperature and storage interval (Fig. 5 b). The highest total soluble solids (18.70 %) were recorded after 40 d of storage at 30 °C, which was equal with 35 °C, but significantly superior to values at lower temperatures. The interaction between perforation and storage interval was non-significant (Fig. 5 c). However, the highest total soluble solids (18.80 %) were recorded with 1.68 % perforation after 40 d of storage.

Perusal of regressions no 5.1—5.3 (Table) indicates that only 5.1 gave a significant regression coefficient, with respect to the independent variables packaging temperature and intensity of perforation and exhibited more than 86 % of the total variation in the dependent variable, TSS. It was observed that TSS increased by 0.004 and 0.301 % when packaging temperature was increased by 1 °C and intensity of perforation by 1 %, respectively.

## 6. Total titratable acidity

There was no significant interaction between packaging temperature and perforation (Fig. 6 a), while the interaction of packaging temperature and storage interval was found to be significant (Fig. 6 b). Minimum acidity (0.58 %) was recorded at 5 and 15 °C after 20 d of storage. The minimum acidity (0.62 %) after 40 d of storage at 5 °C differed significantly from the values at higher temperatures. The highest acidity (0.64 %) after 40 d was obtained at 25 and 35 °C. The highest acidity (0.67 %) after 60 d was, however, observed at 15 and 30 °C. The interaction between perforation and storage intervals did not prove to be significant (Fig. 6 c).

Regression analysis (no. 6.1—6.3, Table) showed that packaging temperature, intensity of perforation and storage interval, when two factors taken at a time, explained about 96 % of the total variation present in the dependent variable TTA. An increase of 1 °C in the packaging temperature and a 1 d increase in the storage period enhanced the TTA by 0.0004 and 0.002 %. An increase of 1 % in the intensity of perforation, however, led to a decline of 0.03 % in the TTA.

## 7. Total sugars

The interactions between packaging temperature and perforation, packaging temperature and storage interval and perforation and storage interval were non-significant (data not presented).

Regression no. 7.1 (Table) wherein packaging temperature and intensity of perforation were taken as independent variables showed the best results as compared to other combinations of the independent variables. These two independent factors explained about 90 % of the total variation in the dependent variable sugars. The sugars increased by 0.003 and 0.291 % when packaging temperature was increased by 1 °C and intensity of perforation by 1 %, keeping the other factors constant.

## 8. Post cold storage life of grapes

The grapes removed from the cold storage after 20 d showed best appearance for 2 d at ambient conditions. The bunches were commercially unacceptable on the 3rd day as berries turned brown. After 40 d of cold storage, the grapes showed acceptable appearance only for 1 d. However, after 60 d of storage, the bunches maintained moderate appearance and remained acceptable only up to 10 h, thereafter berries turned brown.

## Conclusions

Perlette grapes can be stored up to 40 d by enclosing in quarter size 'Dual Release' $SO_2$ generator in the polyliners having 1.12 % perforation and packing in 2 kg vented corrugated fibre board cartons at 35 °C. This combination was proved convenient and economical, because in such packs the $SO_2$ generators were placed straightway at the time of packaging in the collection yard/shed. Whereas at other temperatures, the packs were first shifted to the cold storage and were taken out after meeting the required temperatures for enclosing the $SO_2$ generators. All such cartons were thus re-packed, which involved higher labour costs. The reduction of losses recorded under other temperatures did not compensate the labour costs incurred on re-packing.

## Summary

To reduce post harvest losses of Perlette grapes, quarter size 'Dual Release' $SO_2$ generators were enclosed in polyethylene bags (containing 2 kg grapes) having 0.56, 0.84, 1.12, 1.40 and 1.68 % perforation. These bags were packed in 2 kg vented corrugated fibre board cartons at 5, 15, 25, 30, and 35 °C (field temperature) and were kept for 60 d in the cold storage. The highest organoleptic score was observed at 35 °C packaging temperature and 1.12 % perforation in the polyliner. Both, lowest packaging temperature (5 °C) and lowest perforation in the polyliner (0.56 %) minimized the physiological loss in weight (PLW) and berry shatter. PLW increased with prolonged storage period. There was no berry rot up to 40 d of storage with 0.56, 0.84 and 1.12 % perforation which, however, was negligible with higher percentage of perforation. The highest values of total soluble solids were retained at 30 or 35 °C after 40 d of storage, thereafter TSS declined. However, highest acidity was recorded at 25 and 35 °C after 40 d and at 15 and 30 °C after 60 d of storage. Thus in cold storage, Perlette grapes can be successfully stored up to 40 d by enclosing quarter size 'Dual Release' $SO_2$ generators in the polyliners having 1.12 % perforation and packing at 35 °C.

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