# Quality characteristics of Sultanina table grapes stored in a pilot plant scale

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## Quality characteristics of Sultanina table grapes stored in a pilot plant scale.

**Abstract** — **Introduction**. Sultanina (Thompson seedless) berry's characteristic evolution was studied during the storage period in specified conditions. **Materials and methods**. Grapes were harvested at the beginning of October, then they were placed in paper boxes containing 5 kg of fruit each after packing either in plastic bags, or in paper bags, or without bag. The stored grapes, kept at –1 to 0 °C and 95% relative humidity, received a first sulfur dioxide ($SO_2$) fumigation as soon as the first storage day, then another fumigation was applied every 10 days. A water tower was used for defumigation of the storage room, in order to avoid $SO_2$ injury and residues in grapes. Grape weight loss was controlled and their acidity, pH, soluble solid and $SO_2$ content were determined. A selected taste panel was used for sensorial evaluation. **Results and discussion**. The storage time significantly affected only the weight loss of grapes, while the packaging type used influenced both changes in acidity and weight loss. The pH values and soluble solid content remained unchanged. Decay was reduced considerably, the stem remained green, the berries were turgid, the $SO_2$ injury and residues were insignificant and the appearance and taste of the grapes were excellent. **Conclusion**. Sultanina grapes can be stored at least for 60 days, from their harvest in October up to Christmas time, with $SO_2$ fumigation and a water tower system for the defumigation of the storage room, with no effect on the fruit quality characteristics and no sulfur dioxide residue. (© Elsevier, Paris)

**Greece / *Vitis vinefera* / storage / fumigation / sulphur dioxide / quality / fruit**

## Qualité du raisin Sultanine stocké en conditions expérimentales.

**Résumé** — **Introduction**. L'évolution de grappes de raisin de Sultanine (variété Thompson sans graines) a été étudiée en conditions spécifiques de stockage. **Matériel et méthodes**. Des grappes récoltées début octobre ont été placées en boîtes de papier, à raison de 5 kg de fruits par boîte, soit directement, soit après avoir été mises en sachets plastique ou sachets de papier. Les grappes, conservées à une température de –1 à 0 °C et 95 % d'humidité relative, ont reçu une première fumigation de dioxyde de sulfure ($SO_2$) dès le premier jour de stockage ; celle-ci a été renouvelée tous les 10 d. Après traitement, l'enceinte de stockage a été défumigée par vapeur d'eau afin d'éviter les dommages dus au $SO_2$ et ses résidus. Le poids des grappes, ainsi que leur acidité, pH, extrait sec et teneur en $SO_2$ ont été suivis. Un panel de personnes a été constitué pour évaluer l'apparence et le goût du raisin après conservation. **Résultats et discussion**. Seule la diminution du poids des grappes a été influencée par le temps de stockage, alors que le type d'emballage a eu des répercussions à la fois sur l'acidité et sur la perte de poids. Le pH et la teneur en extrait sec n'ont pas bougé. Le pourrissement des baies a été fortement réduit, leur tige est restée verte, les baies turgescentes, les résidus de $SO_2$ ont été insignifiants et l'apparence et le goût du raisin sont restés excellents. **Conclusion**. Les grappes de Sultanine peuvent être stockées au moins 60 d – donc de leur récolte en octobre à Noël – après fumigation au $SO_2$ et défumigation de l'enceinte de stockage par vapeur d'eau, sans présenter de résidus et en conservant la qualité des fruits. (© Elsevier, Paris)

**Grèce / *Vitis vinefera* / stockage / fumigation / dioxyde de soufre /qualité / fruit**

## 1. introduction

Soultanina table grapes (*Vitis vinifera* L.) is a significant crop of Greece; the major part of the annual production, about 0.1 Mt, is exported, particularly toward the United Kingdom [1].

Sulfur dioxide ($SO_2$) is widely used as a chemical preservative in numerous foods and beverages (dry fruits, dehydrated vegetables, jams, juices, sausages, grapes, wines, soft drinks, etc.). Apart from its efficiency to inhibit the growth of microorganisms (bacteria, yeasts, moulds), it can also delay adverse chemical reactions [2, 3]. The sulfur dioxide in foodstuffs is determined by several rapid techniques [4–6], while the addition of sulfur dioxide to food is controlled by many regulations, European Economic Community directives etc. [7–13].

The effectiveness of sulfur dioxide in slowing the decay of fresh grapes in storage is well known since 1925 [14–15] demonstrated that both initial and subsequent sulfur dioxide treatments affected decay and injury. Increased concentrations of sulfur dioxide gave a better control of decay, but caused more injury to fruit, while best control with minimum injury was obtained with a 7-day interval.

Paulin [16] used polyethylene bags to stabilize the emission of sulfur dioxide from a metabisulfide solution, while Gentry and Nelson [17] used $NaHSO_3$ (sodium bisulfite) in a two-stage generator of $SO_2$ within unvented containers. Gueifat-Reich and Safran [18] reported that the method of depressing $K_2S_2O_7$ (potassium metabisulfite) in paper cups and bowls at the bottom of the packing box is convenient, inexpensive and effective for short-term storage of 3 weeks. However, in some cases, $SO_2$ may be released suddently, particularly from the slow-release stage of the generator, as a result of the increased vapor pressure of the water causing accelerated breakdown of the remaining $NaHSO_3$. The gas can cause excessive bleaching of the grapes and increase $SO_2$ residues [19].

The sulfur dioxide fumigation was also believed to prevent the original colour and conditions of stems for several months, whereas the stems of untreated grapes soon turn brown or black and better stem condition reduces berry shatter in the box [20]. These changes nowadays are due to the loss of water in grapes, during the storage period [21].

The purpose of this study was to investigate the quality characteristics of Sultanina grapes, stored with $SO_2$ fumigation by the help of a water tower for defumigation, from the grapes stored up to Christmas time.

## 2. materials and methods

The study was conducted at the Agricultural University of Athens, in a pilot plant scale. The grapes used were Sultanina (Thompson) seedless variety (*Vitis vinifera* L.), grown at Assos Corinthias, Greece.

Grapes were harvested at the beginning of October with an average soluble solid content of 18.8 and 19.2% w/w in 1994–1995 and 1995–1996, respectively. The day of harvest, grapes were transported to Athens by vehicle with cooling facilities. The day after harvest, the grapes were packed in paper boxes with four wooden corner bags (200 boxes), containing 5 kg of fruit each. In these paper boxes, the grapes were placed either in plastic bags, each containing 0.5 kg of fruit, or in paper bags, each containing 1.5 kg of fruit, or without bag. Then they were kept in cold storage (–1 to 0 °C and 95% relative humidity). A first fumigation was applied at the same day of storage, using 50 g (600 ppm) $SO_2$ for 20 min (0.05 g $SO_2 \cdot kg^{-1}$ of grapes) with fumigation system converting the liquid form of $SO_2$ into gas, and, every 10 d, an other fumigation was applied with the

same dosage of $SO_2$. The $SO_2$ dose was calculated by the formula described by Ashrae [21].

The cooling room, of about 31 $m^3$, was equipped with the following basic units:

– an air cooling system (R-22 refrigerant);

– a water atomizer (Crystal R-800 type);

– a thermostat to control the temperature;

– a fumigation system ($SO_2$ in a liquid form, measured in g and converted into gas);

– a water tower which was operated with an air flow rate of 1 200 $L \cdot h^{-1}$ and water at 120 $L \cdot h^{-1}$, manufactured by Fruit Control, Milan, Italy. This water tower was used for defumigation of the storage room, in order to avoid $SO_2$ injury and residues of sulfur dioxide in grapes. During the fumigation period, the water tower system was kept closed and it was functioning again, after finishing the fumigation of the storage room.

The 200 paper boxes with the grapes were piled in the cooling room up to about 1.70 m. For the quality characteristic determination, four sampling positions of each packing type were defined: two samplings next to the air cooling system – one on the top of the box pile and the other next to the floor – and two other samplings were carried out on the opposite side of the air cooling system, at similar places as previously described. So, twelve (3 × 4) treatments were finally created corresponding to three packing types and four storage positions tested.

To control the weight loss, five boxes per packaging type were marked. The samples were removed from the storage room at periodic intervals of 10, 20, 30, 40, 50 and 60 d and evaluated within 2 h for visual appearance, *Penicillium*, *Cladosporium* or *Botrytis* decay, and some physicochemical properties.

Soluble solid content was determined with an optical Abber refractometer with an automatic temperature compensation. Acidity was determined volumetrically and the results were expressed as percentage of tartaric acid. The day after fumigation, the grape $SO_2$ content was determined colorimetrically with a Perking Elmer type spectrophotometer, involving the bleaching of rosaniline by $SO_2$ [22]. A selected and trained taste panel of 25 people from the university personnel was also used for sensorial evaluation and $SO_2$ odour in grapes. All measurements were carried out on grape juice, which was obtained by squeezing the grape berries.

The data were subjected to an analysis of variance by using the Genstant programme [23]. The comparison of means was made by using the Least Significant Difference (LSD) test at $P \leq 0.05$.

## 3. results

### 3.1. grape quality characteristics

The storage time in many cases did not significantly affect the acidity of grapes, in contrast to grape packaging types used, which significantly influenced the acidity change during the cold storage of Sultanina grapes (*table I*).

The grape pH values were not significantly affected either by the storage time or by the packaging type used (*table II*).

The grape soluble solid content remained unchanged during the cold storage and it was independent from the packaging type used (*table III*).

By increasing the storage time, the grape weight loss was significantly increased, particularly when paper boxes were used as packaging type (*table IV*).

### 3.2. grape general appearance

The macroscopic examination of grapes indicated that there was no decay due to *Botrytis cinerea* and other fungus,

at any time of the cold storage, while stems and berries were in an excellent condition. The sulfur dioxide injury was negligible and stored grape appearance and taste were reported to be very good.

### 3.3. sulfur dioxide residues

All measurements on grape juice showed that there were no sulfur dioxide residues in grapes, whatever the cold storage time. The grape packaging position in the storage room, related to the cooling system, did not significantly affect the results.

## 4. discussion

The storage temperatures and relative humidity, from –1 to 0 °C and above 95%, used in this study were slightly different from the recommended values, which are –1 °C and 90 to 95%, respectively [21].

**Table I.**
Changes in acidity (as tartaric acid %) of Soultanina grapes packed in plastic bags, paper bags and paper boxes, during cold storage with $SO_2$ fumigation and a water tower system, in a pilot plant scale (value means of 1994–1995 and 1995–1996 data).

| Storage time (days) | Grape packaging type | | |
|---|---|---|---|
| | Plastic bags | Paper bags | Paper boxes |
| 10 | 0.693 | 0.670 | 0.623 |
| 20 | 0.705 | 0.671 | 0.615 |
| 30 | 0.724 | 0.670 | 0.630 |
| 40 | 0.634 | 0.660 | 0.618 |
| 50 | 0.693 | 0.640 | 0.659 |
| 60 | 0.699 | 0.660 | 0.641 |

$LSD_{0.05}$ = 0.03, 0.04 and 0.06 to compare packaging type, time and packaging × time means, respectively.

**Table II.**
Changes in pH values of Soultanina grapes packed in plastic bags, paper bags and paper boxes, during cold storage with $SO_2$ fumigation and a water tower system, in a pilot plant scale (value means of 1994–1995 and 1995–1996 data).

| Storage time (days) | Grape packaging type | | |
|---|---|---|---|
| | Plastic bags | Paper bags | Paper boxes |
| 10 | 3.40 | 3.33 | 3.35 |
| 20 | 3.32 | 3.38 | 3.39 |
| 30 | 3.38 | 3.63 | 3.64 |
| 40 | 3.39 | 3.55 | 3.43 |
| 50 | 3.43 | 3.50 | 3.66 |
| 60 | 3.41 | 3.50 | 3.70 |

$LSD_{0.05}$ = 0.18, 0.24 and 0.42 to compare packaging type, time and packaging × time means, respectively.

The acidity values obtained during the cold storage of Sultanina grapes followed a stable fluctuation regarding to the storage time, with a slight increased value at 30 d. The grape packaging types used significantly affected the results, giving higher values with plastic bags and lower values with paper boxes. These results are situated within the normal rates and are in agreement with reports of Winkler et al. [24]. The results were expressed as tartaric acid because in fully ripe grape berries, the concentration of tartaric acid is higher than that of malic acid [25].

The pH value means of grape juice ranged between 3.39 and 3.53, according to the grape packaging type used. Those values are in agreement with those reported by Pesis and Marinansky [26]. Little change occurred in the pH of the grapes during storage, depending also on the packaging type used.

The soluble solid content value means obtained, from 19.8 to 20.9%, according

**Table III.**
Changes in soluble solids content (%) of Soultanina grapes packed in plastic bags, paper bags and paper boxes, during cold storage with $SO_2$ fumigation and a water tower system, in a pilot plant scale (value means of 1994–1995 and 1995–1996 data).

| Storage time (days) | Grape packaging type | | |
|---|---|---|---|
| | Plastic bags | Paper bags | Paper boxes |
| 10 | 19.7 | 19.9 | 20.2 |
| 20 | 18.7 | 20.3 | 19.2 |
| 30 | 19.7 | 21.0 | 20.4 |
| 40 | 20.0 | 21.4 | 21.0 |
| 50 | 20.4 | 21.3 | 20.4 |
| 60 | 20.1 | 21.2 | 20.6 |

$LSD_{0.05}$ = 1.10, 1.55 and 2.69 to compare packaging type, time and packaging × time means, respectively.

**Table IV.**
Weight loss (%) of Soultanina grapes packed in plastic bags, paper bags and paper boxes, during cold storage with $SO_2$ fumigation and a water tower system, in a pilot plant scale (value means of 1994–1995 and 1995–1996 data).

| Storage time (days) | Grape packaging type | | |
|---|---|---|---|
| | Plastic bags | Paper bags | Paper boxes |
| 10 | 0.83 | 0.83 | 0.97 |
| 20 | 1.51 | 1.61 | 1.80 |
| 30 | 2.49 | 2.55 | 2.94 |
| 40 | 3.89 | 4.04 | 4.16 |
| 50 | 4.35 | 4.55 | 4.75 |
| 60 | 4.65 | 4.75 | 5.30 |

$LSD_{0.05}$ = 0.08, 0.11 and 0.19 to compare packaging type, time and packaging × time means, respectively.

to the grape packaging type used, are considered high [26]. However, those high values did not affect the general appearance of grapes. The degree Brix (juice soluble solid percent) is often called the sugar percentage and is affected by other compounds, although usually to a small extent. Degree Brix and the Brix/acid ratio are specified for all varieties, whether coloured or white, and are used to determine the maturity rate.

The greatest change that takes place in grapes during the storage was the loss of water. This is in general agreement with Ashrae [21]. After 10 days of storage, Sultanina grapes lost almost 1% of their weight, while, after 60 days of storage, the average weight loss was of 4.7, 4.8 and 5.3% for grapes packed in plastic bags, paper bags and paper boxes, respectively. Nelson [27] noticed that water loss was aggravated by microscopic injuries coupled with killing of epidermal cells by sulfur dioxide, while there were at least three symptoms of water loss from grapes: the first symptom to appear is a shriveled stem that usually becomes brittle and breaks easily when handled; the second symptom is the stem browning; the third symptom is the berry shrinkage. This author also determined that a loss of about 1 to 2% of the grape weight indicates the first noticeable effects which are drying and browning of stems and pedices, while a grape weight loss of 3 to 5% corresponds to fruit turgidity loss and fruit softening [21]. Nevertheless, in the case of Sultanina grapes, although the water loss reached almost 5.3%, such previous described symptoms were not noticed during the whole storage period.

Macroscopic examination of grape, during the whole preservation period, showed that there was no decay due to *Botrytis cinerea*, which is the most common cause of loss in grape storage, or to other microorganisms. Blue mold rot (*Penicillium*), *Cladosporium* rot and *Phizopus* rot are also responsible for decay in grape storage [28]. If, as often happens, a *Botrytis* infected berry is not detected and is packed, the fungus will continue to grow in the berry. The fungus cannot be eradicated with sulfur dioxide, even at severe dosage levels [29]. However, if stored fruit is retreated with the $SO_2$ proper dosage every 7 to 10 days, the infection can be contained within the berry. Stems of Sultanina grapes were maintained in a fresh green condition, while injury of $SO_2$ was inconspicuous and did not influence the marketable quality of the grapes.

The sulfur dioxide residues in Soultanina grapes during the cold storage were non-existent and this is in agreement with the permitted maximum levels in food [10–13]). In foods with acid pH (pH < 4.0), sulfur dioxide can be volatilized and lost from sulfited foods [3]. Nevertheless, in many foods, an amount of the added sulfite remains in the finished product as free in organic sulfite. For the majority of the population, there is no evidence that the sulfiting agents represent any hazard at current levels of use [30], which for $SO_2$ in grapes comes up to < 10 ppm, however consumers prefer foods completely free from pesticide residues or food preservatives.

## 5. conclusion

The results of this study indicate that Sultanina grapes can be stored at least for 60 d, from their harvest in October up to Christmas time, with $SO_2$ fumigation and a water tower system for the defumigation of the storage room, with no effect on the fruit quality characteristics and no sulfur dioxide residue. The very good quality characteristics and the lack of $SO_2$ residues in grapes should make the combination atractive to consumers. In order to get excellent results, only grapes of high quality should by used for such a storage.

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## Calidad de la uva Sultanina almacenada en condiciones experimentales.

**Resumen — Introducción**. Se ha estudiado la evolución de racimos de uva Sultanina (variedad Thompson sin pepitas) en unas condiciones específicas de almacenamiento. **Material y métodos**. Se colocaron unos racimos recolectados a principios de octubre en unas cajas de papel, a razón de 5 kg de frutos por caja; anteriormente, éstos se habían introducido en bolsitas de plástico, en saquitos de papel o colocados directamente en las cajas. Los racimos, conservados a una temperatura entre –1 y 0 °C y 95 % de humedad relativa, se fumigaron con dióxido sulfúrico ($SO_2$) desde el primer día de almacenado, la fumigación se renovó cada diez días. Tras el tratamiento, se limpió el recinto de almacenamiento con vapor de agua para evitar los daños debidos al $SO_2$ y a sus residuos. Se efectuó un seguimiento del peso de los racimos, su acidez, pH, extracto seco y contenido en $SO_2$. Se constituyó un panel de personas para evaluar el aspecto y el sabor de la uva tras su conservación. **Resultados y discusión**. El tiempo de almacenamiento sólo influyó en la disminución del peso de los racimos, mientras que el tipo de embalaje repercutió a la vez en la acidez y en la pérdida de peso. El pH y el contenido en extracto seco no variaron. Se redujo de forma importante la podredumbre de los frutos, su talló se conservó verde, los frutos turgentes, los residuos de $SO_2$ fueron insignificantes y tanto el sabor como el aspecto de las uvas siguieron siendo excelentes. **Conclusión**. Los racimos de Sultanina se pueden almacenar al menos 60 d, (o sea: desde su recolección en octubre hasta el periodo de Navidad) tras fumigación con $SO_2$ y limpieza del recinto de almacenamiento con vapor de agua, sin que presenten residuos y conservando la calidad de los frutos. (© Elsevier, Paris)

**Grecia / *Vitis vinefera* / almacenamiento / fumigación / dioxido de azufre / calidad / fruto**