Wine Packaging for Market in Containers Other than Glass

Stefano Buiatti,*,† Emilio Celotti,† Roberto Ferrarini,‡ and Roberto Zironi†

Department of Food Science, University of Udine, Udine, Italy, and Department of Agricultural and Environmental Biotechnology, University of Ancona, Ancona, Italy

In this study, the preservation of red and white wine in containers other than glass (PET, wine boxes, multilayer cartons) has been compared to that of the same wines in glass bottles. Preservation has been estimated up to 24 months, i.e., beyond the limits required by the Italian law, which are 12 months in the case of cartons and 9 months in the case of PET containers and wine boxes. Analytical parameters measuring preservation state, such as amount of oxygen dissolved, absorbance at 420 and 520 nm, tonality, total phenols, volatile acidity, and sulfur dioxide have been considered. The results have confirmed that the alternative containers are efficient for preserving both red and white wines, even for longer periods than those required by law. In particular, multilayer cartons proved to be particularly efficient since this material is less gas-permeable.

Keywords: *Wine; packaging; alternative containers; preservation*

INTRODUCTION

The use of containers other than glass ones for packaging wine has become common in Italy, as in many other European countries. In Italy, after various years of provisional authorizations, in 1991 a departmental order (Ministerial Decree 16/12/1991) finally allowed wine packaging in containers other than glass. The materials which can be used in Italy are multilayer carton formed of cellulose cardboard, aluminum, and low-density polyethylene, PET (polyethylene terephthalate); multilayer plastic bag-shaped containers with a capacity of over 5 L in polyethylene and polyester inside a cardboard box or other stiff material (bag in box or wine boxes).

These containers can only be used for table wine (EEC Regulation No. 822/87), excluding those wines with name of origin. Moreover, sparkling wines and carbonated sparkling wines (EEC Regulation No. 822/87) can be sold in PET containers and in internally varnished aluminum cans.

With regard to materials used, it is interesting to note that no common legislation exists in the various member countries of the European Community. This has led to an extremely variable situation in the different countries; for example, poly(vinyl chloride) (PVC) bottles cannot be used in Italy for wine packaging. They are instead common in France where about 20% of table wines are packaged using this plastic material (Dalpasso, 1991).

As mentioned above regarding the preservation of the product, the expiration date must not exceed 12 months from the date of packaging in the case of wines in cartons, 9 months in the case of wines packaged in PET, in bags in box (or wine boxes), and in cans.

In light of these considerations, an inquiry has been carried out which aimed at evaluating the preservation in time of wine packaged in containers other than glass. The evaluation was also made after a considerable length of time from the packaging date (24 months) to check the efficiency of the alternative materials used.

* Corresponding author.
† University of Udine.
‡ University of Ancona.

Table 1. Analytical Methods Utilized

determination	method
alcohol content % vol	*Official Gazette of EEC* (1990)
pH 20 °C	*Official Gazette of EEC* (1990)
titratable acidity g/L	*Official Gazette of EEC* (1990)
sulfur dioxide mg/L	*Official Gazette of EEC* (1990)
dissolved oxygen mg/L	Klemensen and Nissen (1986)
volatile acidity g/L	*Official Gazette of EEC* (1990)
total phenols mg/L	Singleton and Rossi (1965)
absorbance at 420 nm 20°C	*Official Gazette of EEC* (1990)
absorbance at 520 nm 20 °C	*Official Gazette of EEC* (1990)
tonality (abs 420 nm/ abs 520 nm) 20 °C	*Official Gazette of EEC* (1990)

MATERIALS AND METHODS

The control analysis was carried out on white and red table wines packaged in PET containers (thickness 800−1000 μm), bags in box (or wine boxes), cartons, and in glass bottles with crown cap closures used as control.

The multilayer plastic bag used in the bags in box consists of an outer and an inner barrier film. The outer barrier is formed of three layers: polyethylene (PE) (thickness 40−50 μm), poly(ethylene terephthalate) (PET) metallized with aluminum (12 μm), and PE (40−50 μm). The inner film, in contact with wine, is formed of only one layer of low-density PE (50 μm).

The multilayer carton is formed of six layers; from outer to inner layer these are PE (10−15 μm), cardboard (300−400 μm), PE (20−30 μm), aluminum (6−7 μm), and PE (30−40 μm), which is in contact with wine.

Three wine-producing firms were taken into consideration, and production requirements dictated that the number of replicates (wines) differed between type of container so that the experimental design was as follows.

Firm A: 2 white wines and 2 red wines packaged both in PET and in glass containers;

Firm B: 5 white wines and 5 red wines packaged both in bags in box (or wine boxes) and in glass containers;

Firm C: 4 white wines and 5 red wines packaged both in carton and in glass containers.

The analytical parameters recorded over the two-year period are shown in Table 1.

The analyses were carried out at regular intervals: at the moment of packaging (time 0) and after 6, 12, and 24 months. The main compositive characteristics of white and red wines before packaging are shown in Table 2.

All analyses were performed in duplicate. The samples was stored at room temperature and in the dark.

The container−wine interaction over time was evaluated by calculating the regression equation for each parameter and

S0021-8561(96)00826-6 CCC: $14.00

Table 2. Main Analytical Parameters (Mean Values) of Red and White Wines before Packaging

wine	alcohol content (% vol)	pH (20 °C)	titratable acidity (g/L)	volatile acidity (g/L)	tonality	absorbance (520 nm)	total phenols (mg/L)	total SO_2 (mg/L)
white								
firm A	11.3	3.2	5.6	0.22			250	114
firm B	11.1	3.2	5.7	0.18			268	103
firm C	11.0	3.3	5.8	0.12			245	102
red								
firm A	11.5	3.4	5.6	0.24	0.88	1.420	1220	100
firm B	11.8	3.4	5.5	0.27	0.92	1.650	1175	85
firm C	11.2	3.5	5.8	0.25	0.84	1.965	1372	92

Table 3. Red Wines Packaged in Glass and in the Alternative Containers over the 0−24 Month Period[a]

	slope	intercept	R^2
total phenols			
glass	−8.6219	1092	0.0577
carton	−9.6400	1194	0.0592
glass	−8.9095	1258	0.5134
PET	−6.6667	1291	0.4054
glass	0.3733	1355	0.0001
wine boxes	1.0095	1353	0.0010
dissolved oxygen			
glass	−0.0082	0.31	0.0759
carton	−0.0055	0.37	0.0438
glass	−0.0002	0.15	0.0010
PET	−0.0112	0.41	0.1026
glass	0.0007	0.11	0.0327
wine boxes	0.0133	0.44	0.0186
tonality			
glass	0.0117	0.81	0.3199
carton	0.0119	0.78	0.4044
glass	0.0098	0.72	0.6246
PET	0.0095	0.74	0.6242
glass	0.0062	0.71	0.3922
wine boxes	0.0078	0.70	0.4519
absorbance at 520 nm			
glass	−0.0044	1.177	0.0050
carton	−0.0009	1.373	0.0002
glass	−0.0073	1.564	0.0306
PET	0.0255	1.601	0.3488
glass	−0.0068	1.842	0.0057
wine boxes	−0.0006	2.119	0.00003
absorbance at 420 nm			
glass	0.0071	0.903	0.0228
carton	0.0126	1.026	0.0440
glass	0.0203	0.999	0.2021
wine boxes	0.0386	1.017	0.4465
volatile acidity			
glass	0.0089	0.18	0.6072
carton	0.0068	0.19	0.5713
glass	0.0084	0.19	0.8994
PET	0.0067	0.20	0.8421
glass	0.0016	0.10	0.3497
wine boxes	0.0018	0.12	0.3122
free SO_2			
glass	−0.2686	12.9	0.2051
carton	−0.3619	14.0	0.3454
glass	−0.2595	9.6	0.9052
PET	−0.3690	9.5	0.7670

[a] Values of regression equations at which no significant differences between slope (Student's *t* test) were found.

each container in the four periods of time considered. A parallelism test was performed on the angular coefficients from the equations obtained, using a Student's *t* test, in order to identify any statistically differences between the trends (slopes) represented by the regression equation. SPSS/W (SPSS Inc., 1989, release 6.0) was used for statistic analysis.

DISCUSSION

The regressions calculated for total polyphenols are shown in Tables 3 and 4; the result of the parallelism test (*t*) indicated that for this parameter, in both red and white wines, there were no significant differences between the wines packaged in PET, in bag in box, or in carton and the same wines kept in glass bottles; in fact, the regression lines were parallel according to the statistical test.

Table 4. White Wines Packaged in Glass and in the Alternative Containers over the 0−24 Month Period[a]

	slope	intercept	R^2
total phenols			
glass	−2.4155	269	0.3702
carton	−3.1798	290	0.3510
glass	−3.2524	319	0.2418
PET	−4.9738	320	0.4387
glass	−0.7010	227	0.0112
wine boxes	−0.7162	228	0.0098
dissolved oxygen			
glass	−0.0278	0.66	0.1438
carton	−0.0188	0.65	0.0728
glass	−0.0471	0.95	0.2367
PET	0.0036	0.62	0.0410
absorbance at 420 nm			
glass	0.0012	0.062	0.3482
carton	0.0016	0.049	0.5231
volatile acidity			
glass	0.0084	0.16	0.3411
carton	0.0074	0.16	0.3809
glass	0.0033	0.18	0.2316
PET	0.0047	0.16	0.6533
glass	0.0027	0.10	0.3992
wine boxes	0.0019	0.09	0.1623
free SO_2			
glass	−0.3619	20.3	0.0934
carton	−0.4750	24.3	0.1469
glass	−0.2857	13.5	0.6122
PET	−0.4333	10.8	0.8861
glass	−0.2524	19.6	0.3966
wine boxes	−0.4400	19.7	0.6005

[a] Values of regression equations at which no significant differences between slope (Student's *t* test) were found.

With regard to dissolved oxygen there was a difference in the behavior of two types of wine; in fact, in red wines the values of *t* indicated that there were no differences between glass bottles and the alternative containers examined, although it can be observed that there was a tendency for the oxygen content to be higher in red wines held in alternative materials than in wine packaged in glass bottles, and this could have been due to the fact that these materials have a higher permeability to gases in comparison with glass (Galassi, 1985). In contrast (Figure 1) there were significant differences over 24 months for white wines packaged in bag in box, with much higher levels of oxygen in this container than in glass bottles, especially at longer storage times, which must have been caused by a higher gas permeability. The analysis of the shade of color of red wines and the absorbance at 520 nm values (Table 3) did not reveal any significant differences in behavior between the experimental containers and glass. Thus, it appears that the polyphenolic compounds which characterize red wines are not subject to variations in their concentration caused by the type of container.

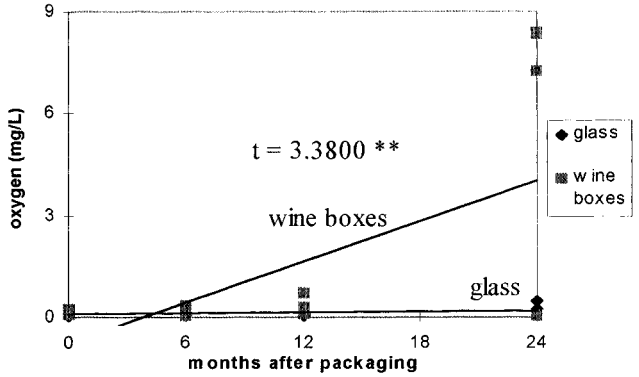

Figure 1. Regression line and parallelism test (Student's *t* test) for the dissolved oxygen in the white wines packaged in glass and in wine boxes over the 0−24 month period. Value of *t* with asterisks indicates lines with significantly different slopes at $p = 0.01$ (**).

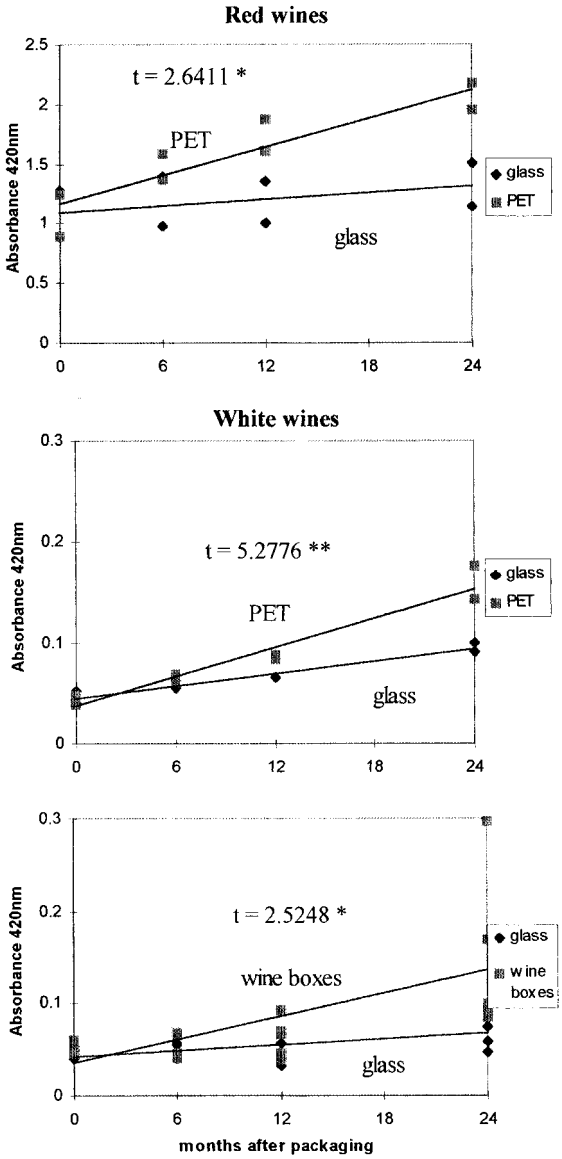

Figure 2. Regression line and parallelism test (Student's *t* test) for the 420 nm absorbance in the red and white wines packaged in glass and in the alternative containers (PET and wine boxes) over the 0−24 month period. Values of *t* with asterisks indicate lines with significantly different slopes at $p = 0.05$ (*) and $p = 0.01$ (**).

The data for the 420 nm absorbance, shown in Figure 2, indicate different behavior for the PET and the bag in box for both types of wine. These alternative containers had higher absorbance values; this confirms the susceptibility of the product to oxidation, and it is reasonable to infer that the gas barrier offered by these plastic materials is lower than that of a traditional glass bottle. These results confirm earlier experiences from other researchers (Ough, 1987) who reported an increase in oxidation processes in wines caused by the container's permeability to gas.

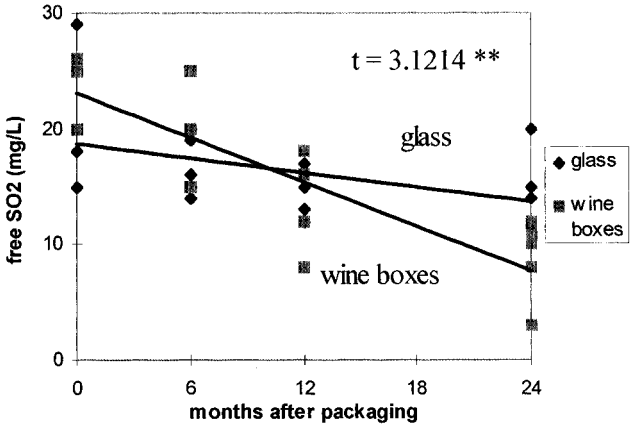

Figure 3. Regression line and parallelism test (Student's *t* test) for the sulfur dioxide in the red wines packaged in glass and in wine boxes over the 0−24 month period. Value of *t* with asterisks indicates lines with significantly different slopes at $p = 0.01$ (**).

The volatile acidity values (Tables 3 and 4) were not significantly affected by the type of container, indicating that the level of oxidation does not produce different quantities of volatile acids. Furthermore, it was confirmed that the various containers guarantee sterility so that there is no risk of abnormal fermentations which could increase the volatile acidity values.

There were significant reductions in sulfur dioxide levels (Figure 3) only in the red wine packaged in the bag in box for longest periods. This result could be related to the higher oxygen content which could have caused the oxidation of part of the sulfur dioxide after longer storage times. However, it is not possible to exclude the possibility that the free sulfur dioxide combined with the polyphenolic compound present in the wine.

A sensory preference test was done at 0, 6, 12, and 24 month; the results were elaborated according to the Friedman statistics test, and the ranks assigned to each wine did not point out significative differences between containers.

CONCLUSIONS

The results obtained have confirmed the validity of containers in materials other than glass for packaging wine. It was seen that the product is preserved for longer periods than those limits set by the present laws. In fact, the tests for preservation carried out after 24 months, well over the limits set by the law, namely, 12 months for cartons and 9 months for wine boxes and PET containers, have proved the efficiency of these materials. However, of the different materials used, the most effective was the multilayer cardboard which ensured better preservation of the product compared to PET containers and to bags in box (or wine boxes) thanks to a better barrier effect in relation to gas.

ACKNOWLEDGMENT

We thank Cantine Covima at Grosseto, Corovin at Forl, Ocone at Ponte (BN), Verga e Figli at Cermenate (CO), Wine Pack at Lonigo (VC), and Bertolli-De Rica at Podenzano (PC) for their kind cooperation.

LITERATURE CITED

Dalpasso, L. Experience with packaging of edible oils, wine and vinegar in PVC bottles. *Rass. Imballaggio Confez.* **1991**, *12*, 15−16.

Galassi, S. Packaging of wines in containers other than glass. *Ind. Bevande* **1985**, *14*, 30−35.

Klemensen, P.; Nissen, J. F. Measurement of dissolved oxygen with the Orbisphere. *Brygmesteren* **1986**, *43*, 20−24.

Official methods of analysis. *Official Gazette of Economic European Community*, 3/10/1990; ECC Regulation No. 2676/90; European Commission of 17/9/1990: Brussels, 1990.

Ough, C. S. Use of PET bottles for wine. *Am. J. Enol. Vitic.* **1987**, *38*, 100−104.

Singleton, V. I.; Rossi, J. A. Colorimetry of total phenolics with phosphomolybdic−phosphotungstic acid reagents. *Am. J. Enol. Vitic.* **1965**, *16*, 144−158.

Spera, G. Reactivity of multilayer carton PET upon wine. *Ind. Bevande* **1994**, *23*, 401−413.

Received for review October 28, 1996. Accepted March 11, 1997.[⊗]

JF960826D

[⊗] Abstract published in *Advance ACS Abstracts,* May 15, 1997.