Material change for a better environment

**Final Report: GlassRite: Wine**

# Bulk Shipping of Wine and its Implications for Product Quality


Shipping wine in bulk has economic benefits but also has implications for product quality.

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WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

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**Front cover photography:** Transporting Containers by Sea

# Executive summary

This report has been prepared as part of the WRAP-funded GlassRite suite of projects which are intended to reduce the volume of packaging entering the UK waste stream. The GlassRite projects aim to encourage the lightweighting of glass containers as a means of reducing the tonnage of glass in the waste stream. The GlassRite – Wine project has the additional objectives of seeking to promote the bulk importation of wine into the UK to be filled in lightweighted bottles and also of encouraging importers of bottled wine to consider the use of clear glass.

This report is concerned with the effects of bulk transportation on the quality of wine. Its target audience is those involved in the large-scale importation of wine, particularly those who are considering the use of bulk shipments. The report examines the practice of shipping wine in bulk for bottling close to the final market and its impact on wine quality. Bulk shipping of wine offers some logistical and environmental benefits, the latter being the subject of a specific study within this project[1]. This report thus gives only brief consideration to the logistical and environmental benefits of bulk importation.

The UK is the world's largest importer of wine which brings an influx of predominantly green bottles into the country which then enter the waste stream. Bulk importation of wine with bottling in the country of sale has been proposed as a means of both reducing the amount of glass imported into the UK and providing a market for green glass through increased local production of wine bottles.

This report finds that the practice of bulk importation of wine does not impair quality and has some environmental and logistical advantages; specifically it concludes that:-

- bulk wine is less prone to experience large temperature variations during transit, as a larger single volume of liquid has a greater thermal inertia than a smaller one. Transporting wine in bulk volumes will therefore lessen the temperature variation experienced. High temperatures accelerate wine development and, in bottles this can cause pressures that can compromise closures;
- apart from top end wine specifically made with bottle ageing and longevity in mind, wine effectively begins to deteriorate from the time it is filled into bottles and it is at this filling point that the shelf life is deemed to start. Bulk shipping defers the moment of bottling and thus the start of the shelf life. This has implications for the retailer in regards to stock levels and rotation, as the entirety of the shelf life is spent in the country of sale rather than during transport, which may be an advantage for entry level wines with a more limited shelf life;
- bulk shipments are more cost effective. A standard container typically holds 12,000 to 13,000 bottles, whilst a standard flexi-tank holds the equivalent of approximately 32,000 bottles and ISO tanks hold nearly 35,000 bottles. This improved utilisation translates into a cost saving;
- bulk shipments are a better environmental option than transporting bottled wine from the producer country. By more than doubling the amount of product that can be shipped in a standard container and by avoiding the transport of bottles, bulk importing greatly reduces environmental emissions associated with transport;
- the finished product is filled closer to the final market. Filling and packaging close to market may also give the sellers more flexibility to change packaging formats to meet changing market demands and even enable them to respond to short term promotional campaigns; and
- damage to packaging e.g. bottle and label scuffing, may be reduced if the product is filled locally to the point of sale and problems that do occur can be readily resolved with a local supplier.

[1] *The life cycle emissions of wine imported into the UK, WRAP report, http://www.wrap.org.uk/docs/The%20Life%20Cycle%20Emissions%20of%20Wine%20Imported%20to%20the%20UK%20Final%20Report.pdf, May 2007*

Bulk shipping of wine thus has some clear advantages and the technology has greatly improved in recent years as has operating expertise though a number of problems can still arise; these include:

- contamination and taint can be experienced with both imported bulk and bottled wine. ISO tanks can be contaminated with the residue of previous cargoes whilst flexitanks require barrier layers to prevent chemicals used to fumigate or repair containers diffusing through the bags into the wine;
- oxidation as a potential problem with bulk containers. Defective seals or the use of a permeable material to contain the wine can allow oxygen ingress which can react with the wine causing it to degrade; and
- customers potential negative perception of bulked wine. This is more likely to be a concern with premium wine where there is a customer expectation that the wine is bottled at source. However, bulk importation is not really an option for wines which are produced, or sold, in comparatively small volumes. The size of bulk containers would mean that a large proportion of a year's production could be tied up which in turn would limit markets and destinations for that wine.

On balance the report concludes that the practice of bulk importing wines need have no adverse quality implications on the wine and brings actual benefits with respect to cost efficiencies, carbon emission reductions and recycling.

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## 1.0 Introduction

The purpose of this report is to provide a comprehensive overview of key issues and assumed barriers to bulk importing. Quality, economic and logistical considerations associated with the bulk importation of wine into the UK are considered and contributions from major stakeholders have been sought.

Wine consumption in the UK has increased year on year for the last 30 years. The UK is a very small wine producer and consequently demand is met by imports which now exceed 1 billion litres making the UK the world's largest importer of wine.

Much of this wine arrives bottled in green glass. The UK has an effective glass recycling infrastructure and recovers approximately 1.3 million tonnes of glass for recycling (cullet) per year. Of this total some 750,000 tonnes is of a high enough quality to be used by the container manufacturers. However, the colour profile of the recycled glass does not match the requirements of the glass manufacturers as approximately 50% of this collected cullet is green. The UK's container industry does not produce many items in green glass so demand for the collected green cullet is limited. The large inflow of wine bottles accounts for a significant proportion of the green glass found in the UK's waste stream.

The UK wine consumers have a preference for wines produced in the New World which, by necessity, are transported by sea. If this wine could be shipped in bulk form to be filled on arrival, it would greatly increase the demand for green glass, help redress the current colour imbalance and provide support for the UK's glass recycling infrastructure. Bulk importing would also reduce transportation costs and the environmental impacts of shipping movements.

However, shipping wine in bulk has implications for wine quality. This is because wine comprises a complex organic mixture of subtle flavours and aromas that give individual wines and brands their distinctive tastes. The science behind making, bottling and transporting wine is well established and modern analytical techniques are now quite advanced thus significantly improving understanding. The effect of oxygen, fermentation and the impact of temperature are now well documented, and thus control of product integrity is more easily managed.

With a better understanding of the wine making process, better materials in which to transport the wine and much improved facilities within the UK to handle and bottle the product, bulk filling has become an attractive option.

Shipping wine in bulk has many environmental benefits and these are the subject of a separate study[1] and consequently are not covered in detail in this report.

## 2.0 Bulk Shipping

Wine producers exporting their produce overseas have to decide on the logistics of transportation. The wine can be bottled at source, the bottles boxed into cases and packed into a large container. The container will be transported by truck to a suitable port for shipment to the export market.

Alternatively the wine may leave the winery in some form of bulk tanker which will itself be shipped to the export market. On arrival the wine and holding tanker will be transported to a filling facility for bottling prior to distribution. The advantages and/or disadvantages of both systems are discussed in some detail in later sections of this report. This section is intended to give some basic overview of shipping options available to the wine sector exporting to the UK.

### 2.1 Shipping in Standard Containers

Bottling wine at source and shipping in standard containers is the most common means of transporting wine. Internationally there are three common standard lengths of container - 20ft (6.25m), 40ft (12.5m) and 45ft (16m). The USA uses containers of 48ft (15m) or 53ft (16.6m) for domestic movements. The standard height of the containers is 8ft 6in (2.65m), although a new "high cube" format with a height of 9ft 6in (3m) is becoming more common. Container capacity is measured in 20ft equivalent units (TEU) equal to one standard 20ft container. The standard sizes of the 20ft and 40ft containers are given in Table 1. The 20ft container is the most common format worldwide but the 40ft option is becoming increasingly popular as it is far more cost effective to ship the longer container.

**Table 1** Dimensions of Standard Shipping Containers.

| Standard Shipping Containers | | 20ft (6.25m) | 40ft (12.50m) |
|---|---|---|---|
| **External Dimensions (m)** | | | |
| Length | | 6.06 | 12.19 |
| Width | | 2.44 | 2.44 |
| Height: | Standard | 2.59 | 2.59 |
| | High Cube | 2.89 | 2.89 |
| **Internal Dimensions (m)** | | | |
| Length | | 5.87 | 12.00 |
| Width | | 2.33 | 2.33 |
| Height: | Standard | 2.26 | 2.26 |
| | High Cube | 2.56 | 2.56 |
| Capacity($m^3$) | Standard | 32.85 | 66.83 |
| | High Cube | 37.09 | 75.32 |
| **Maximum weight gross (kg)** | | 24,000 | 30,480 |
| **Maximum weight net (kg)** | | 21,670 | 26,480 |

Most wine bottles shipped in containers are first packed in boxes and then stacked on pallets. The number of bottles that can be transported in a container is usually determined by the internal container dimensions, rather than by the consignment's weight. In simple terms, a 500g bottle holding 750ml of wine would weigh 1.25kg and therefore a 20ft container could transport 17,336 bottles (21,670 divided by 1.25). In practice a 20ft container may only hold 12,000 to 13,000 bottles i.e. the quantity transported is limited by the container's volume. On this basis, a 40ft container with 750ml wine in 500g bottles could hold 23,000 bottles. However, these bottles would weigh 28.75t which is above the weight restriction. Should lighter bottles be used, for example 400g, this would enable a 40ft container to be filled to capacity without exceeding the weight restriction.

## 2.2 Bulk Shipping of Liquids

The alternative to shipping bottled wine is to transport it in bulk in a large vessel. For the movement of bulk liquids two systems are available:

- ISO tanks - which are reusable steel tanks; and
- Flexitanks - which are disposable plastic bags that are fitted inside a standard 20ft container.

### *2.2.1 ISO Tanks*

ISO tanks (Figure 1) are stainless steel vessels which are designed to fit directly onto standard trucks and can readily be transferred to rail or sea transport. The vessels used for wine have a capacity of 26,000 litres, slightly larger than flexitanks. The tanks are reusable and are designed to be very robust as they can also be used to transport hazardous materials. The stainless steel used for the tank's construction will not contaminate the wine but, being reusable, must be cleaned between uses.

**Figure 1** A typical ISO tank (photograph courtesy of John S Braid & Co Ltd).


### *2.2.2 Flexitanks*

Flexitanks (Figure 2) are flexible bags that are fitted into a standard 20ft (6.25m) container. Most bags are used once, but in some circumstances the bags can be re-used. The materials used to make the bags vary, depending on the product being transported. Considerable development work has been done to find suitable materials to hold wine without impairing its quality. The latest systems are constructed of polyethylene with a barrier material of ethylene vinyl alcohol (EVOH) copolymer. The bags now offer a very low oxygen migration rate and are an effective barrier to the organic materials that can taint wine, for example naphthalene. Flexitanks come in a range of sizes, the largest of which having a capacity of 24,000 litres filling a 20ft (6.25m) container.

Flexitank operators claim that their system offers logistical advantages over ISO tanks, and that in most cases they are cheaper to operate. ISO tanks are inherently more robust than flexitank systems which can be damaged during shipping by the movement of the bag within the container.

**Figure 2** A typical flexitank (photograph courtesy of Trans Ocean Distribution Limited).


## 3.0 Quality Considerations

This section of the report discusses the potential quality risks associated with bulk shipping wine.

The wine industry is an international business with a substantial turnover. The industry has invested heavily in research and development and many wine producing countries have dedicated wine technical organisations, which typically handle technical and commercial issues. Most areas of concern have been investigated in some detail, including that of bulk transportation. Many papers have been written on the subject, but that published by Gibson[2] of Scorpex Wine Services, provides an excellent overview. Gibson's paper considers the quality risks of shipping wine in either bottle or bulk. He contends that bulk shipping has helped to avoid or reduce some of the risks associated with transporting wine in bottles, such as oxidation, re-fermentation, contamination and taint, and temperature variation. The paper identifies some significant risks that are reduced or avoided by bulk shipping and highlights other risks that need to be addressed when wine is shipped in bulk containers. Some of these risks are outlined below.

### 3.1 Oxidation

Wine in prolonged contact with air (oxygen) will spoil. Louis Pasteur described oxygen as the 'enemy of wine'. This is perhaps an exaggeration as certain stages of the wine making process require oxygen, and some wines derive their distinctive taste from controlled oxidation. However, in general, wine makers seek to prevent air ingress, as wine in contact with air will oxidise rapidly and produce a "flatness" to the wine as some of the volatile chemicals are changed. The actual process is extremely complex and the mechanism is still the subject of research and debate amongst wine technologists.

Oxidation is an obvious potential problem with any form of wine shipment but especially so when large volumes are shipped in a single container. A defective seal on an ISO tanker or the use of a flexitank material that is highly permeable to oxygen can allow oxygen entry leading to degradation of the entire shipment. Good

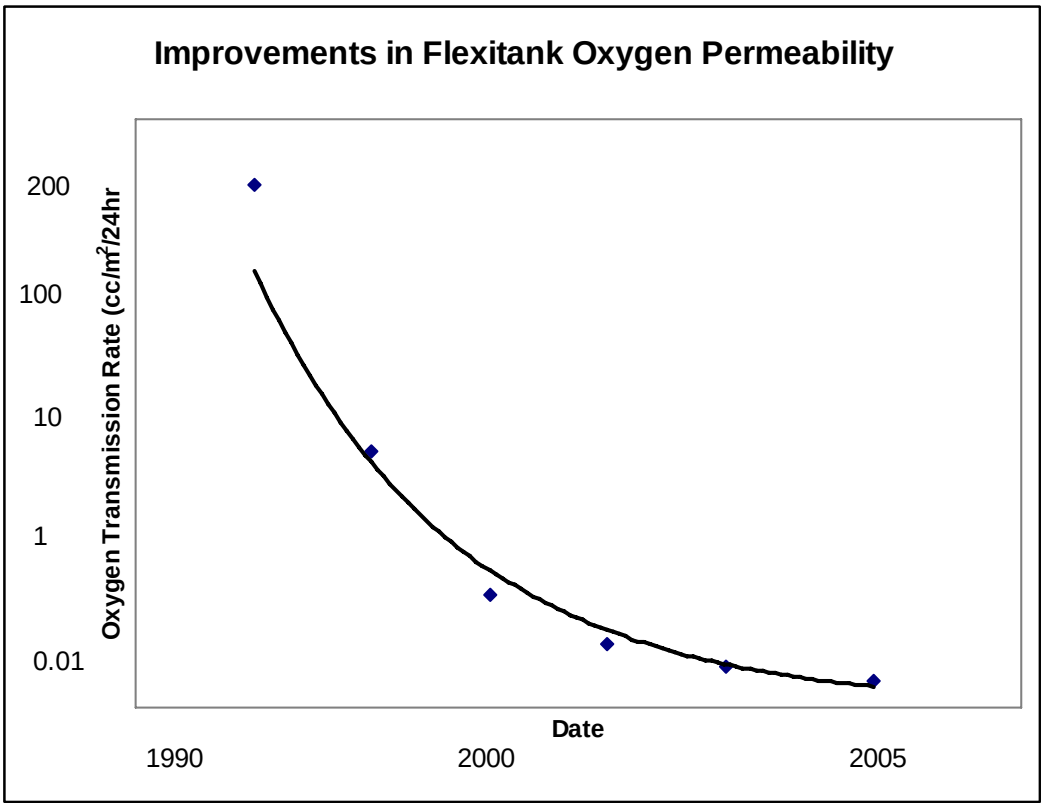
[2] *Gibson, R., Quality Risks – Shipment of Bulk and Bottled Wine, Scorpex Wine Services, 2006.*

housekeeping, careful checking of ISO tank seals and/or the selection of suitable and appropriate flexitanks can mitigate this risk.

Since the introduction of flexitanks in the early 1980s, the permeability of flexitank materials has decreased exponentially[3] (Figure 3). In the 1990s, flexitanks were made from thermoplastic (PVC and polyurethane) and had an Oxygen Transmission Rate (OTR) of 100 – 200 cc/m$^2$/24hr. In the early 2000s the tanks were a multi-layered design constructed from a polyethylene film incorporating an ethylene vinyl alcohol copolymer (EVOH) barrier and had an OTR rating of 1 – 2 cc/m$^2$/24hr. The latest systems have an advanced gas barrier layer with an OTR rating of less than 0.05 cc/m$^2$/24hr.

OTR is not an issue for steel ISO tanks or glass bottles but obviously, and in common with flexitanks, oxygen can permeate through defective seals and closures.

**Figure 3** Improvement in Flexitank Oxygen Permeability[3].




## 3.2 Re-fermentation

The presence of residual or added grape sugar in wine introduces a risk of quality loss through re-fermentation by yeast. This process can take place during the bulk shipment of wine. However, the risk primarily relates to sweet wines, but can also affect large commercial wines that contain residual sugar.

The Scorpex report[4] considers the bulk shipment of sweet wine and concludes that the risks of re-fermentation are greater during a sea voyage than when the wine is stored in tanks in a winery. The reasons cited are that microbial testing and remedial processes, such as filtration or the addition of antimicrobial agents to reduce viable cell numbers cannot be carried out when in transit at sea. Also, the wine is rarely refrigerated and is thus exposed to higher ambient temperatures which increase yeast activity.

*[3] Quality issues raised regarding bulk wine shipments to the consideration of changing packaged product to bulk export, Trans Ocean Distribution internal communication (not publicly available), Technical Summary Report, 2006.*

Yeast growth may lead to quality issues, such as:

- increase in carbon dioxide content to a point where bag swelling and failure may occur;
- depletion of free sulphur dioxide due to acetaldehyde production;
- formation of sulphides and other off notes; and
- reduction in sweetness levels; and formation of haze and deposits through yeast cell growth.

To avoid these risks and ensure successful bulk transportation the report lists three key areas for consideration:

- the microbial status of the wine;
- the loading equipment; and
- the containment / tank.

The wine must be free of yeast and other wine spoilage organisms when loaded into the shipment tank. The most effective means of achieving this microbial status is sterile filtration or the use of membrane filters to remove micro-organisms. Unfortunately, cold-sterile filtration alone can be very risky because there is nothing to ensure that the wine will not be re-infected after being filtered. The presence of $SO_2$, which is added at many stages in the wine making process, will act to inhibit yeast growth. The inhibiting action of the $SO_2$ is frequently augmented by the addition of 100ppm of dimethyl dicarbonate (DMDC).

All equipment that may come in contact with the wine must be treated to ensure that it is free of microbial contamination. In particular, the membrane filter, the hoses and/or pipelines connecting the filter to the tank and any other equipment downstream of the filter must be thoroughly sanitised.

Finally, the tank must be free of organisms that can cause secondary fermentation in wine. The temperature of the manufacturing process should ensure that new flexitanks are sterile, whilst the stainless steel construction of ISO tanks presents no problems with their sterilisation.

In conclusion, re-fermentation is a risk. However, it is reported that table wines containing approximately 20 grams per litre of sugar have been shipped from Australia to Europe in bulk without loss of quality[4].

## 3.3 Contamination and Taint

Contamination and taint can be experienced in both bulk and bottled wine shipments. Bulk wine shipped in reusable ISO tanks can be tainted by residues of previous cargoes or through the permeation of compounds found in the walls of single use flexitanks. Contamination and taint can be avoided or limited by ensuring that ISO tanks are thoroughly cleaned before re-use and that the structure of flexitanks includes barrier layers that do not allow the passage of taint compounds.

Trans Ocean Distribution Ltd (TOD), a major shipper and now part of the JF Hillebrand group, has produced two reports which investigate two types of possible taint from using flexitanks, TCA[3] taint and naphthalene[5].

**TCA taint:** This refers to a set of undesirable smells or tastes that impart a musty or earthy smell to the wine that masks or dominates its fruity aroma and reduces the overall wine quality. The condition, invariably blamed on the cork, is the result of a mould that can be transferred to the wine from a variety of sources including wooden barrels or racks, tanks, cardboard, plastic and other types of winery equipment or facilities.

The action of mould is to produce the chemical compound 2,4,6-trichloroanisole (TCA), the first source identified and thought to be the primary cause of cork taint. Other chloroanisole contaminants of wine may include 2,3,4,6-tetrachloroanisole (TeCA) and pentachloroanisole (PCA).

Some flexitank manufacturers now incorporate an ethylene vinyl alcohol copolymer (EVOH) barrier film, which the Australian Wine Research Institute (AWRI) found has excellent barrier properties[3]. TOD introduced EVOH barrier films in 2000 and claim to have had no TCA taint incidents in any of their wine shipments since[3].

**Naphthalene taint:** Naphthalene is a common organic compound that that has many industrial uses. Traces of the vapour often can be found in many environments including shipping and storage facilities and it can

*[4] Royans, R., Bulk Shipment of Sweet Table Wines, Scorpex Wine Services, Internal report commissioned by Trans Ocean Distribution (not publicly available), 2005.*

*[5] Recent Occurrences of Wine Tainting Involving Naphthalene, Internal report commissioned by Trans Ocean Distribution (not publicly available), 2005.*

sometimes diffuse into storage vessels and contaminate the contents. It has been experienced in wine transported in bulk from the 'New World' to Europe. The sources of naphthalene are numerous, but four potential instances during the loading and transportation have been identified as opportunities for taint:

- residues from prior cargos transported by shipping containers;
- fumigation of containers;
- insecticides placed in containers; and
- container "repairs" using sealants that could possibly contain traces of naphthalene.

The problem can be avoided by good industrial practice which includes: careful container selection, preparation and use of an EVOH barrier to be effective in avoiding naphthalene taint[5].

## 3.4 Temperature

Several factors can influence the quality of wine, temperature being perhaps the most important. Most experts agree that ideal storage temperature is 13° to 15°C. Wine is a complex chemical mixture in which the individual components continually interact with one another. These reactions are not necessarily unwanted, indeed many add to the wine's flavour. Unfortunately, some reactions produce unwelcome products which can impair the taste or age the wine.

Chemical reactions do not occur instantly, all proceed at a rates governed by the laws of chemistry. The rates of the chemical reactions occurring in wine vary considerably; some proceed at an imperceptible rate whilst others move quickly. Whilst there may not be a full understanding of the nature or relative importance of all the reactions, what is clear is that the rates of all the chemical reactions are influenced by temperature.

Normally an increase in temperature will speed up a chemical reaction. The rate of increase with temperature varies between reactions and this becomes an important consideration for wine storage. If all the speeds of all the reactions were the same then storing wine at 25°C for a given period would produce an identical wine to one stored at 15°C for a shorter period. With different reaction rates this does not hold. Storing the wine at higher temperatures will accelerate some reactions more that others and in time will produce a different chemical mix in this wine than in wine stored at a lower temperature.

In general, reactions that promote unwanted oxidation reactions are favoured by higher temperatures. The following section deals at some length with this important aspect and considers the temperature variations to which wine in transport will be subjected and what benefits might arise if the wine is shipped in a bulk form.

A review of the effect of temperature on wine quality was presented by Christian Butzke, from the University of California, at the Unified Wine & Grape Symposium[6]. He reported that temperature fluctuations can have an impact not only on the aroma of wine, but also on more general chemical reactions, such as oxygen uptake, browning reactions in white wines, ethyl carbamate formation, and the decline of free $SO_2$ in white wines. The rates at which these reactions occur are very sensitive to temperature and a small temperature rise can produce a large increase in the reaction rate. For example, increasing the temperature by 8°C can double the speed of the reaction responsible for browning in white wines.

Table 2 shows the temperature rises required to double the reaction rates of some of the more important processes that affect wine quality. The result of all these factors is that, even if there is no discernable damage to the wine, temperature can produce some subtle changes in the wine.

*[6] Butzke, C., Final Report - Monitoring of Wine Heat Exposure During Commercial Shipments, American Vineyard Foundation, 2001.*

**Table 2** Temperature rises needed to double the rate of bottle ageing reactions[7].

| Bottle Ageing reactions | Doubling of rate (°C) | Reference (given by Butzke) |
|---|---|---|
| $O_2$ uptake | 4 | Ribereau-Gayon 1933 |
| Browning | 8 | Berg & Akiyoshi 1956 |
| Ethyl carbamate formation | 16 | CEB 2001 |
| $SO_2$ decline | 37 | Ough 1985 |

High temperatures also cause problems to bottle closures in general but to driven closures such as cork and synthetic stoppers in particular. Patrick Mahaney of Robert Mondavi Winery speaking at the Unified Wine & Grape Symposium in Sacramento, California said "Clearly you're going to have some serious problems with corks pushing. Even if you fill with proper ullage you're still going to have enough expansion under those conditions to get cork pushing." Mahaney noted that corks will get pushed somewhere between 32°C and 38°C with proper ullage. With less ullage, the critical temperature is lower and even with insulating blankets the temperature can be 29°C to 32°C.

Mahaney explained that "whilst damage from wine overheating or freezing during transport is "not too frequent", having a whole container of damaged bottles is a big problem. The major problem is however the next level down, if the wine is exposed to heat it may have no obvious damage, but it's just that the wine is not going to be what we'd hoped it would be."[7].

Daniel Meyer in his review paper[8] highlights a study carried out by Dr Johann Marais[9], of the Viticultural and Oenological Research Institute, on how temperature affects the shelf life of foods and beverages. Marais studied wine bottled at 10°C with 25 mg/l free $SO_2$. Four samples of the wine were stored at four different constant temperatures, 0, 10, 20 and 30°C. The wine was assessed at regular periods up to 24 months and again after 6 years.

The first analysis took place after two weeks. Gas chromatography was used to analyse for esters, higher alcohols and dimethyl sulphide. Sensory evaluation was carried out by a panel of twelve judges. The storage temperature was found to influence the bouquet of the wine. As the storage temperature increased, so the observed intensity of young wine bouquet decreased. The opposite was found to be true for the intensity of the maturation bouquet which was found to increase with storage temperature.

The main conclusion of the work was that there was an overall decrease in wine quality after 24 months for wines stored at 10, 20 and 30°C. Lower temperature (10°C) was better for keeping youthful qualities and higher temperature (30°C) for developing mature qualities. No discernable deterioration in quality was found for wine stored at 0°C.

The other important conclusion was that under certain conditions, significant changes could arise in the character of the wine within two weeks of bottling. Thus the temperatures experienced by wines during shipping, even at a young age, can have a significant effect on wine quality.

### *3.4.1 Temperature Variation during Shipping*

Two main studies on the variation of temperature during shipment and the effect on wine quality exist. Meyer of the Technology Exploitation Centre carried out a literature study in 2002 for Winetech in South Africa[8] and Christian Butzke of the University of California, conducted a study in 2001 on behalf of the American Vineyard Foundation[6]. Additional information has also been considered from information published by several shipping and

[7] *Winter, M., When Shipping Wine Weather is Not Always Your friend, Wine Business Monthly Online, March 2002*

[8] *Meyer, M., Final Report - A Study of the Impact of Shipping/Transportation Conditions and Practices on Wine, Internal report commissioned by Winetech, 2002.*

[9] *Marais, J., Van Wyk, C.J., Rapp, A., Effect of storage time and temperature on the volatile composition and quality of South African Vitis vinifera L. cv. Colombar wines, Proceedings of the Fourth International Flavour Conference, Rhodes, Greece, 1985.*

distribution companies who have investigated and reported on the issue[6,8]. Containers can be protected against temperature fluctuations. Solutions include: refrigerated containers, thermal blankets, polystyrene and a reflective aluminium-based foil (Templiner).

The discussion below covers wine bottled at source and shipped in standard containers and wine shipped in bulk in flexitanks or steel containers.

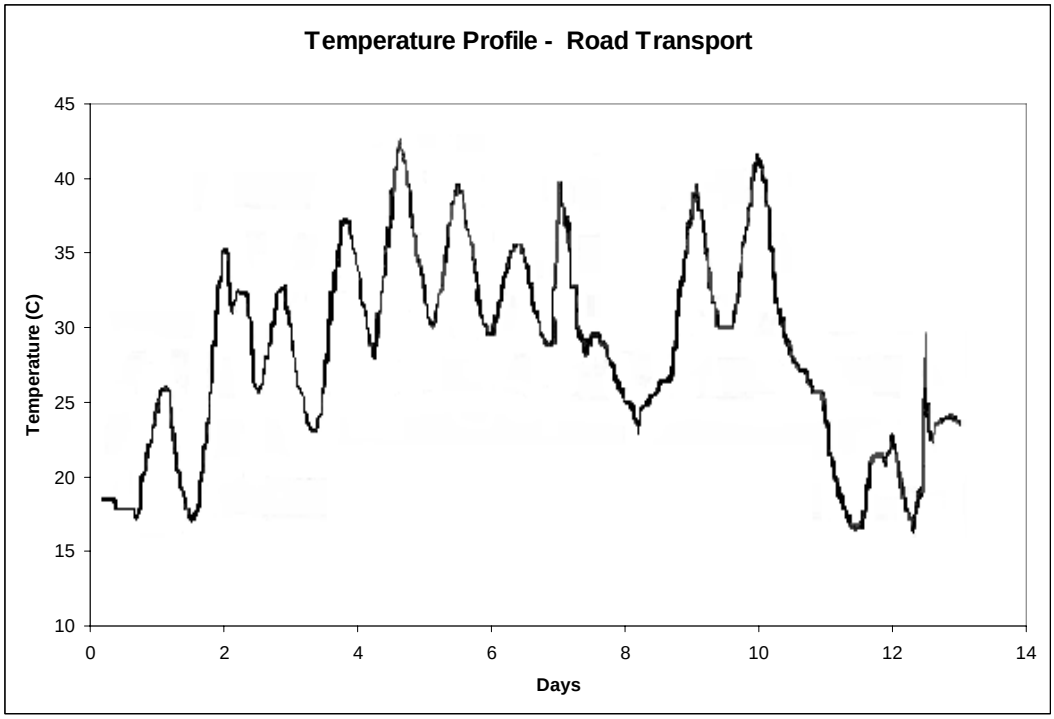
### *3.4.2 Bottled Wine – Road Transport*

Bottled wine will typically be packed into cases and then packed in a standard container and transported by road to a commercial dock facility where it will initially be stored outdoors until it is loaded onto a container ship. Ambient temperatures in some wine producing regions can be very high and unless the wine is protected, it will suffer thermal cycling during this period. Exposure to high temperatures is known to be deleterious to wine quality. Thermal cycling can also produce pressure variations which can compromise the closure and allow ingress of oxygen into the wine.

Temperature controlled units are commercially available for transporting wine by road. Unfortunately, the majority of wine shipments are not transported in such units. The Province of Ontario's Liquor Control Board surveyed 21,500 containers of wines and spirits and found only 23% of the deliveries were made by temperature controlled containers (TCCs).

The Butzke[6] study focused on road transportation of bottled wine within the USA moving from California to the East Coast. Figure 4 shows the temperature variation of the load recorded over the 14 day trip. The wine, which was shipped during summer months in a non-refrigerated truck, was exposed to ambient temperatures as high as 43°C. As would be expected the temperatures fluctuated depending on time of day and direction of sun. Exposure temperatures were regularly above 24°C.

**Figure 4** Temperature variation of a 12 day wine shipment across the USA[6].

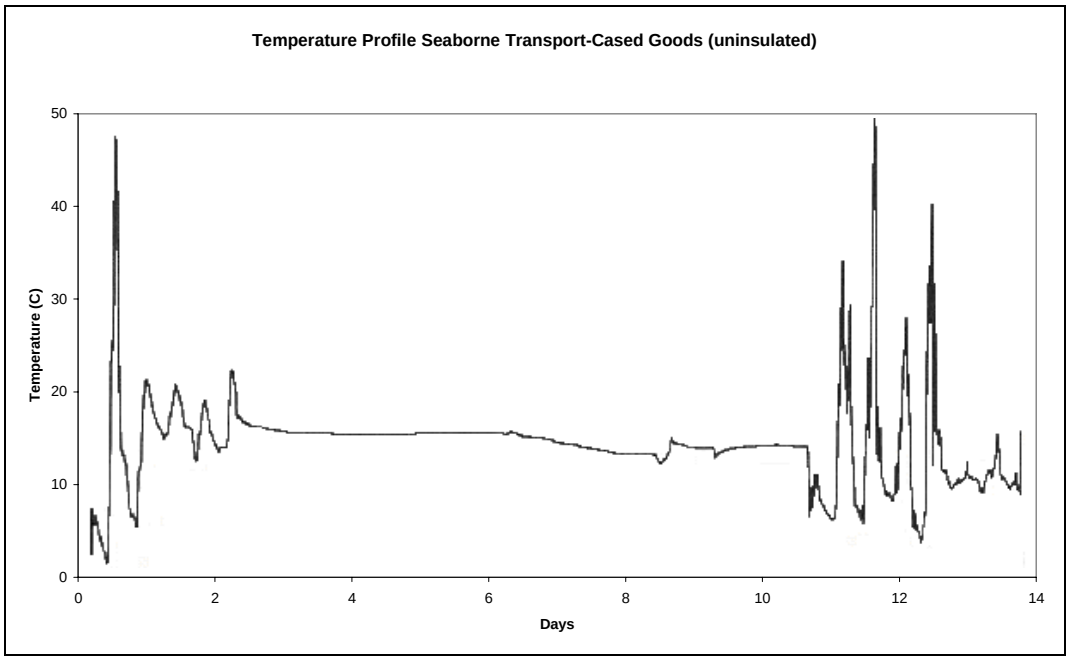



Winter shipments within the USA were also monitored. Insulated wine shipments reached a low point of about -4°C, whilst wine not under an insulating quilt dropped to nearly -15 °C, a temperature which could actually freeze the wine and the accompanying expansion able to fracture the bottles.

### 3.4.3 Bottled Wine – Seaborne Transport (Un-insulated)

The Meyer study[8] gives details of the temperature variations experienced by wine cargoes on journeys from Cape Town in South Africa. Figure 5 shows the temperature variation of un-insulated bottled wine in transit to Finland. There are three distinct regions on the graph. The first section of the graph shows the container on the dockside in Cape Town harbour. The container is subject to ambient weather conditions and demonstrates temperature extremes of 47°C and 6°C. The middle section shows the actual sea journey from South Africa to Finland. The flatness of the graph suggests that the cargo was stored centrally, probably below deck. The final section of the graph again shows the containers on the dockside in Finland, where a maximum of 48°C was reached.

**Figure 5** Temperature variation on a journey from South Africa to Finland – no insulation[8].




No data was found for cargoes stored above deck but it can reasonably be assumed that they experience far greater temperature fluctuations than those stored below deck. Wine shippers are of course aware of the effects of temperature and will endeavour to get their goods stored below deck, and away from heat sources. Containers loaded with wine bottles will tend to be some of the heaviest. This weight factor will indirectly benefit the wine as the shipper will seek to place heavier loads below decks to improve sailing stability. However, it cannot automatically be assumed that wine will be stowed below deck and many shipments will be made with the container exposed to the elements and thus have a temperature profile closer to a cyclic pattern like that associated with road transport.

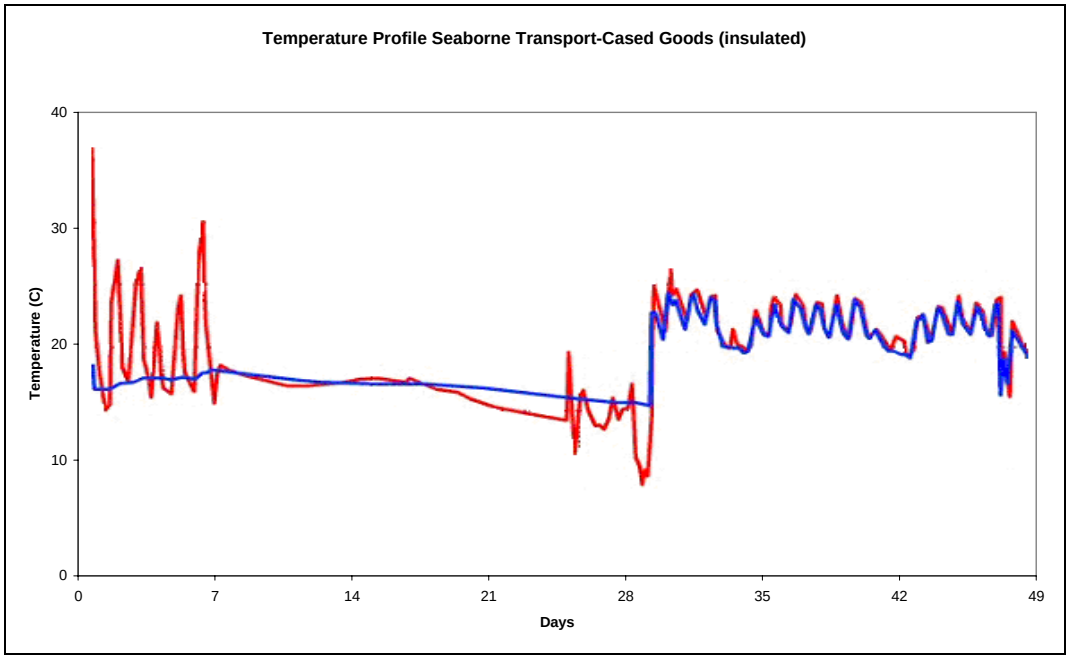
### 3.4.4 Bottled Wine – Seaborne Transport (Insulated)

Figure 6 shows the benefits of using insulation. The graph shows the journey of a container holding bottled wine from South Africa to the UK. The trace, taken from the Templiner website[10], show the temperature variation either side of the proprietary Templiner insulating blanket which was used to line the container.

The trace from the sensor located outside the insulation (red trace) replicates that shown in Figure 6 and shows large variations whilst the cargo is being transported to, and stored on, the dockside either side of a 17-day sea voyage. The container is apparently well placed within the hold during the sea voyage and as such benefits from being surrounded by other containers. The blue trace represents the temperature beneath the insulating blanket and clearly demonstrates its protective properties especially during the road transport and dockside storage phase of the journey. On arrival in the UK the 2 traces coalesce suggesting that the blanket has been removed. It is interesting to note that on arrival in the UK the wine remains in an unprotected condition for approximately 20 days, during which time it is subjected to the UK's fortunately temperate climate.

[10] *Radiant barrier liner for containers, Templiner, http://www.templiner.com/english/index_english.html.*

**Figure 6** Temperature Variation of a Journey from Cape Town to UK; temperature loggers placed above and below insulating blanket[10].




### *3.4.5 Variation of Temperature during Bulk Transportation of Wine*

As with wine shipped in the bottle, wine shipped in bulk containers (ISO or flexi- tanks) is also subject to the effects of temperature variations. However, the large thermal mass of the liquid prevents significant temperature swings within the body of the container. This is because, as the wine closest to the outside of the tank heats, its density decreases slightly causing the wine to rise within the tank. This movement sets up convection currents within the tank and cause the temperature increase to be dissipated throughout the body of the wine.

Trans Ocean Distribution (TOD) has undertaken extensive studies of the effects of temperature on wine bulk transported in flexitanks[3]. Figure 7 shows the temperature profile of a 46-day transfer of a bulk shipment of wine from South Africa to New Zealand. It illustrates that the large thermal mass coupled with the convective mixing currents effectively dampens out all large temperature spikes and produces a gentle temperature swing of just 12°C over the 7 week period.

**Figure 7** Temperature variation of a bulk shipment of wine from South Africa to New Zealand[3].

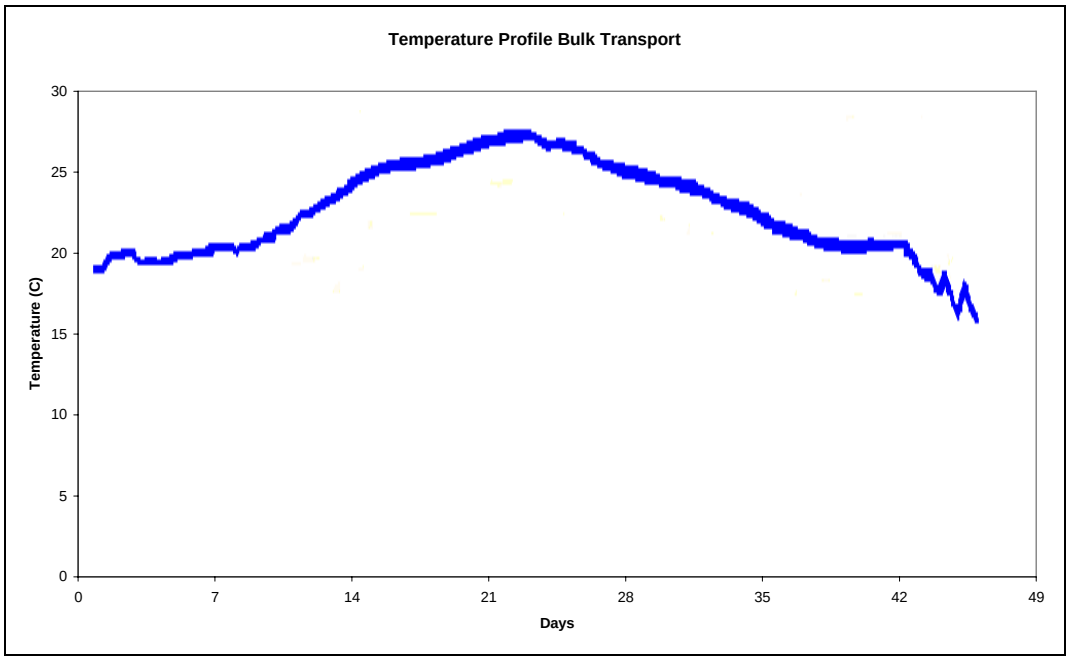
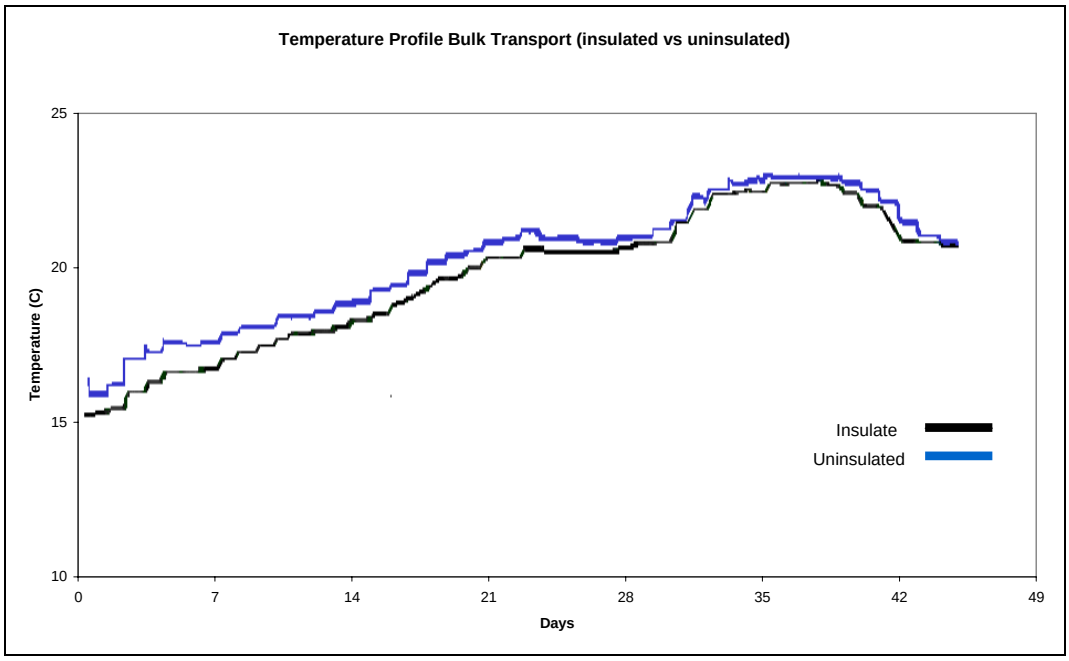



Figure 8 compares the temperature variation of 2 bulk loads making the journey from Australia to the UK. One load is protected by an insulating blanket; the other has no thermal protection. The trace for the un-insulated bulk shipment essentially replicates that shown in Figure 8 and demonstrates the thermal stability of wine shipped in a bulk format. The application of a thermal blanket to the bulk shipment is seen to restrict the already modest temperature variation by just 1 °C over the 45 day transfer period.

**Figure 8** Temperature variation of insulated and un-insulated bulk wine shipments - Australia to UK[3].



The data from the temperature monitoring exercises clearly shows that, all things being equal, wine shipped in a bulk format will not be subject to the same scale of temperature variation as wine shipped in bottles.

Some care must be exercised when comparing data relating to temperature variance for bottled wine and that shipped in bulk. The data for bulk wine gives the actual temperature of the wine. The data for the bottled goods is merely the air temperature to which some of the bottles have been exposed. Thus the two sets of data are not directly comparable. However, whilst perhaps only the outer layer of a bottled consignment may experience the temperature extremes, and whilst the bottles will afford some protection to the wine, clearly a significant number of bottles in an un-insulated load will be subject to large temperature variations. These variations are far more pronounced during the road transport and dockside storage phases of a typical journey. Thermal insulation is seen to be an effective means of reducing the effects of temperature variation for bottled goods.

## 3.5 Filtration

Filtration is widely used as a stabiliser in wine production to remove various inclusions including particulates, yeast, crystals and bacteria. Physical stabilisation prevents the formation of hazes and deposits after bottling, while microbiological stabilisation eliminates yeasts and bacteria that can impair a wine's taste. However, sometimes filtration can lead to the removal of some desirable components in the wine, which may detract from its character. In general though, wine makers believe that wine should be manipulated as little as possible.

Often, wine that has been bulk imported will have been subjected to an "extra" filtration process which could have an effect on a wine's quality or character. In theory, wine should receive enough filtration at source to render it stable during transport and avoid any problems should there be a delay at the docks or during transport. Good practice would involve discussion and agreement of appropriate levels of filtration at all stages in the wine making and filling process, and seek to minimise filtration whilst achieving a stable product.

### *3.5.1 Quality Testing at Source*

Testing the wine at source is an essential part of the quality chain, especially when wine is to be exported in bulk. The Australian Wine & Brandy Corporation and the Winemakers Federation of Australia[11] note a testing procedure that is an integral component of the Australian wine industry's risk management plan and covers three areas: wine preparation, container inspection and preparation, and the loading process.

The UK's Wine and Spirit Trade Association (WSTA) has also published a Code of Practice for its members for the transportation of wines, spirits and concentrated grape must in bulk, which addresses risk management issues and best practices. At the time of writing this code of practice is undergoing a review, with the new issue scheduled for availability to members during the first quarter of 2008.

# 4.0 Environmental Considerations

The life cycle emissions of wine imported to the UK is the subject of a detailed study within this project and readers requiring more detail on this aspect of the bulk trade should consult that report[1].

## 4.1 The Impact on Recycling

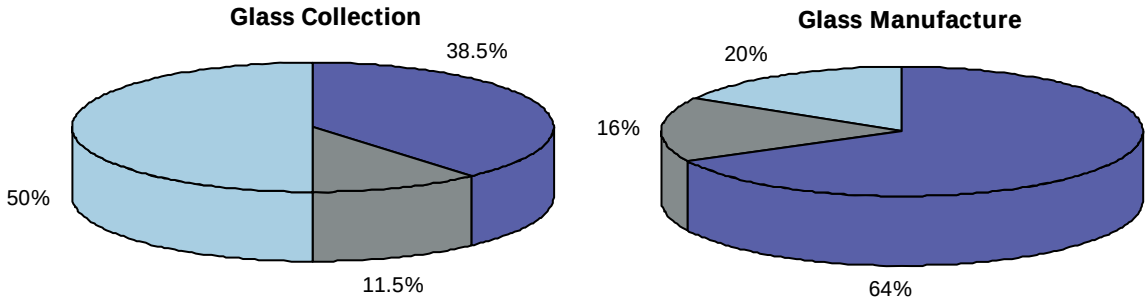
The UK manufactures approximately 2.2 million tonnes of container glass per year of which some 65% is clear.

The various recycled glass collection systems operating in the UK collected approximately 1.3 million tonnes of cullet in 2006, of which 750,000 tonnes was used by the container manufacturers in replacement of raw materials. However, the colour profile of the recycled glass does not match the requirements of the glass manufacturers as approximately 50% of this collected cullet consumed by remelt is green (Figure 9).

As shown in Figure 9, green glass accounts for only 20% (approximately 400,000 tonnes) of UK production but comprises 50% of the glass waste arising, so the current supply of cullet to the green furnaces is close to maximum demand. Currently most green glass manufactured in the UK is limited to the production of beer bottles.

[11] *Procedure for the preparation and transportation of exported bulk wine, Australian Wine & Brandy / Winemakers Federation of Australia.*

**Figure 9** Predicted Waste Glass Collections and New Glass Production (2008)[12].




An increase in the bulk importation of wine into the UK could help redress this colour imbalance by creating a demand for green cullet for the bottles which will be needed to fill the wine in the UK. Increasing the UK's demand for green glass would therefore be of great benefit to the UK's recycling infrastructure by creating a much needed high value market for the green glass collected.

## 5.0 Other Considerations

Shipping wine in bulk clearly offers large benefits with respect to the amount of wine that can be transported by a single standard container. Bulk shipments employ either ISO or flexitanks and unsurprisingly the manufacturers of both systems claim advantages. ISO tanks have a slightly larger capacity, are more robust, reusable and are marketed as being "safe, secure and efficient".

Flexitank operators claim their system is more flexible and more suited to one way trips and that in recent years the problems such as taint have been addressed. Irrespective of the system chosen the greater carrying capacity of the bulk system offers considerable cost savings over the cased option.

In addition to transportation costs wine entering the UK from non-EU sources will be liable to common customs tariff (CCT) which is levied at a lower rate for containers exceeding two litres in capacity.

Bulk shipping also offers other less quantifiable benefits in respect of marketing opportunities as wine sellers and fillers are able to respond more quickly to changing market demands. Shipping in bulk allows the finished product to be filled closer to the final market and gives the retailers more flexibility to change packaging formats to meet changing market demands and respond to promotional campaigns. The likelihood of damage to packaging e.g. bottle and label scuffing is reduced when the product is filled near the destination market. Given the time differences from many long haul wine origins, having a UK supplier contact may make it easier for buyers to resolve any problems that may arise.

### 5.1 Bottling Bulk Shipped Wine in the UK

Until the late 19th century the shipment of any wine from its immediate locality was done in barrels. Concerns over loss in quality and the ability of unscrupulous merchants to tamper with the wine or make misleading claims as to its provenance and pedigree led to the introduction of the practice of bottling wine at source. In some instances the requirement to bottle at source may be backed by law. Rioja, for example, must be bottled at source.

Bulk shipping of wine is often a contentious issue as some argue the practice cheapens brands, reduces quality, and losing control of the bottling process could lead to the devaluing of a brand. As part of this debate, it is therefore often easy for wine producers to question the quality procedures of foreign filling facilities. However, assuming that quality issues surrounding filling facilities are addressed, filling at destination can offer several advantages. When managed in an appropriate way, bulk shipment combined with filling close to the destination market can provide less risk to product quality than shipment of bottled wine[4].

[12] *UK Glass industry production and PRN data, British Glass, 2007.*

Modern UK commercial filling lines used by the beverage industry are able to operate at very high speeds on a continuous basis. For the wine industry in particular there are a number of specialist operators, of which most have an internationally recognised quality accreditation and work closely with their customers to ensure quality specifications are agreed. In addition to this capacity, the UK will see the commissioning of a new filling facility in 2009, which will increase the country's capacity by an additional 120 million bottles per year.

Normal industry practice entails an analytical specification being drawn up and agreed between the bottler and the wine producer for each wine bottled. The specification is based upon the analysis of three bottles received from the producers prior to delivery of the bulk shipment. The specification includes: alcohol percentage, $SO_2$ levels, sugar, acidity, microbial, and other properties (Table 3 is an example of a typical test sheet and was supplied by a leading UK filler).

Each indicator has an agreed level and a permitted tolerance. Each shipment of wine delivered is tested before unloading. Only if the quality specifications are met is the wine released for bottling, which should be done in a similar manner to that which would have been used had the wine been bottled at source.

**Table 3** Example of a blank wine quality specification sheet[13].

| Property | Ideal | Permitted tolerance |
|---|---|---|
| Actual alcohol (% volume) | | |
| Density (g/ml) | | |
| Reducing sugars (g/l) | | |
| Colour (at 420 nm) | | |
| Colour (at 520 nm) | | |
| Free $SO_2$ (mg/l) | | |
| Total $SO_2$ (mg/l) | | |
| Dissolved $CO_2$ (mg/l) | | |
| Dissolved $O_2$ (mg/l) | | |
| Sorbic acid (mg/l) | | |
| Vitamin C (mg/l) | | |

## 5.2 Extension of Shelf Life

Shelf life begins when the product is put into its final format. It relates to food quality and is influenced by oxidation (see section 2.1) and temperature (see section 2.4).

Most wine will begin to deteriorate once it is packaged, in particular entry level wines, and white wine more quickly than red. The rate of deterioration is also influenced by the packaging type, with some formats better than others.

As shipping wine in bulk for UK filling postpones the bottling process it delays the point at which shelf life begins to be measured. If the wine has been shipped from Australia, for example, this sea voyage can be several weeks. For the retailer's perspective, shelf life is an important consideration having implications on such matters as stock levels and product rotation, all of which can have an impact on profitability.

## 5.3 Minimising Packaging Damage

All goods subject to handling and transportation will suffer some degree of stress. Rough handling of a container will damage the contents be they in bottle form or bulked. Wine shipped in containers needs more handling as it is palletised and the bottles and labels may become scuffed. In some circumstances labels can become detached from the bottle. Bag-in-a-box format packaging can suffer from flex cracking due to handling which will then reduce its shelf life as it becomes more prone to oxidation. Bulk shipping and packaging in the consuming country

[13] *Private communication from a UK filler.*

minimises the distance that a product travels in its packaged form, thus reducing the opportunity for damage to occur.

## 6.0 Conclusions

The bulk shipping of wine would appear to offer several advantages without necessarily compromising its quality. Indeed, assuming that all those involved in the supply chain follow best practice in regard to handling and material selection, wine transported in bulk should arrive in the UK in a better condition than its bottled-at-source counterparts.

Temperature variations can be responsible for loss in quality but the thermal inertia of a large bulk load effectively smoothes out large variations in temperature. Improvements to the materials used for the construction of the bulk handling systems have significantly reduced the incidences of oxidation and taint.

The UK has sufficient high quality filling capacity to service the current demand for the bulk importation of wine, and additional capacity is being installed to cope with a predicted increase in the volume. Transporting wine in bulk involves fewer ship movements than moving wine in bottles and thus reduces the environmental impact of the wine trade. Filling the product close to the market place gives the sellers greater flexibility to change packaging formats to meet changing market demands and to respond to promotional campaigns.

Bulk shipping will benefit the UK's glass recycling efforts creating a much needed high value market for the green glass collected.

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