Developments in destemming and sorting technology

Part one: In the winery

Crushing

DESTEMMERS are devices that detach grapes from stems and separate the detached stems from the grapes. Sorters are devices that remove further vegetal matter (stem fragments, petioles and leaves), other contaminants (e.g. insects) or undesirable grapes and parts of grapes (e.g. diseased or unripe grapes). The past 10 years have seen major developments in grape destemmers and sorters and some shift from these devices being located at the winery to some being mounted on machine harvesters. This article by **Simon Nordestgaard**, Australian Wine Research Institute senior engineer, reviews developments in winery-based destemming and sorting equipment. A second article, to be published in the next issue, will review developments in harvester-mounted destemming and sorting equipment.

Winery destemmers (including those with integrated sorters)

Rotary destemmers have been widely used for destemming since at least the 1920s (Figure 1). In these devices a rotating shaft with beaters detaches the grapes from the stems. The grapes then fall through holes in a cage, while the stems are conveyed out the end of the cage. Rotary destemmers have been used to destem prior to crushing (a destemmer-crusher), after crushing (a crusher-destemmer), or during crushing (using a high beater speed). The most common design in recent years has been destemmer-crushers where the cage turns in the same direction as the beater shaft, just at a slower speed. The destemmed grapes are then crushed by pairs of removable rollers integrated underneath the destemmer (Figure 2). The rotary destemmer concept is relatively simple, robust and scalable with models available capable of processing over 100 tonnes/hour.

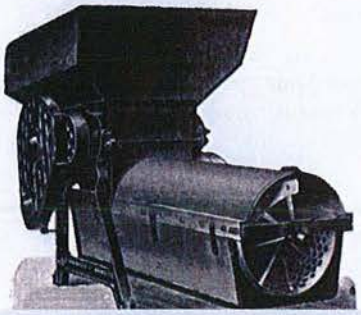

Figure 1: Roller crusher-rotary destemmer, c.1920s (Fabre 1929)

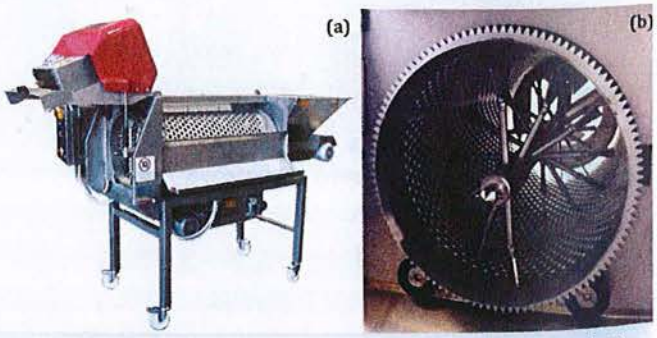

Figure 2: Modern rotary destemmer-roller crusher, (a) System overview, (b) Close-up view of destemmer

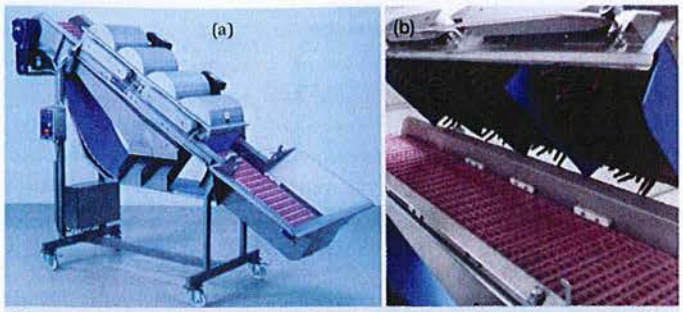

Figure 3: Scharfenberger EuroSelect destemmer (a) System overview, (b) Close-up view with hood open showing destemming finger wheels and bunch/stem grid conveyor (licensed from Socma)

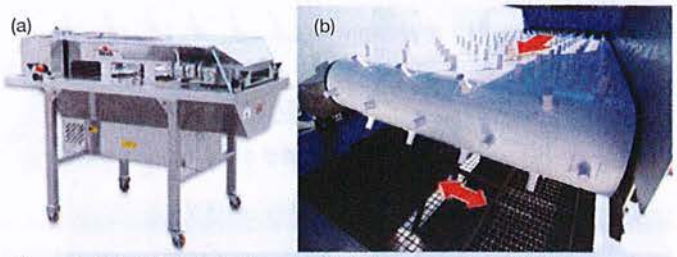

Figure 4: Milani Estasi destemmer (a) System overview, (b) Close-up view showing knobbed bunch/stem conveyor and swaying destemming grille

Figure 5: Armbruster Rotovib destemmer

While there have been many incremental improvements to rotary destemmers during the 20th century, fundamentally they still operate on similar principles. Undesirably, they can crush some grapes and stems and some vegetal matter can fall through holes in the cage. There has therefore been some interest in alternative designs. Around 1999 Socma introduced a destemmer where bunches/stems move on a grid conveyor and four sets of finger wheels rotating in the same direction as the conveyor immediately above it detach the grapes from the stems through the grid. Data presented on the Socma website suggest that this destemmer results in less juicing than rotary destemmers and slightly less residual vegetal matter [0.9% compared with 1.5% (by weight) for hand-picked grapes (Socma 2011)]. This destemmer is now produced under licence by Scharfenberger (Figure 3). Scharfenberger states the capacity as being up to 8 tonnes/hour.

As a general point, nominal capacities provided by manufacturers for destemming and sorting equipment should be treated with some caution. In some cases they may overstate the capacity at which desirable separation performance is achieved.

Milani introduced another style of destemmer around 2006 (Figure 4). In this device bunches are loaded on top of a knobbed conveyor. This conveyor then drops the bunches onto a grille that sways from side to side. The knobs on the underside of the conveyor move the bunches/stems along the grille and the ▸

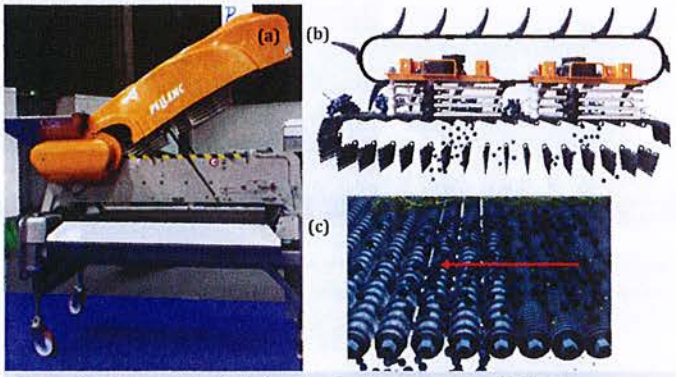

Figure 6: Pellenc Selectiv' vibrating destemmer-sorter (a) System overview with hood open, (b) Vibrating destemmer schematic, (c) Roller sorter schematic

swaying action of the grille detaches the grapes, which then fall through the grille. Milani states the capacity of this device as being up to 5 tonnes/hour.

Higher beater shaft rotation speeds in rotary destemmers have been shown by Vinsonneau and Vergnes (2000a) to result in more burst berries and higher levels of residual vegetal matter. In around 2006, Armbruster introduced a rotary destemmer whose beater shaft vibrates (Figure 5). This partial use of vibration for berry detachment allows the destemmer to operate at slower beater shaft speeds than standard rotary destemmers. Armbruster offers three models, with stated capacities of up to 10, 20 or 30 tonnes/hour.

The first destemmer to rely purely on vibration for berry detachment was introduced by Pellenc in around 2008 (Figure 6). This also appears to be the first device where the destemmer is only sold packaged with a sorting system and where the sorting system relies on rollers. In this device bunches/stems are conveyed by a sectioned grid conveyor and an overhead shark fin conveyor. Grapes are detached by one or two pairs of vibrating destemming beater sets. The mode of operation is similar to the beaters on a machine harvester. The grapes fall through the grid and onto the integrated two-section roller sorting table. The first section of rollers is tightly spaced allowing only juice/small materials to pass through. The gaps in the second section of rollers are larger and the grapes fall through, while the vegetal matter that is larger than the gaps is conveyed off the edge. The first section of rollers is specially

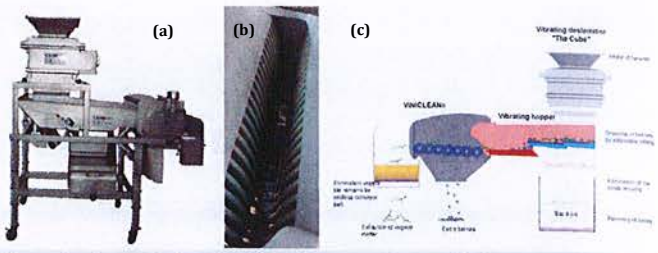

Figure 7: Socma Cube vibrating destemmer-sorter (a) System overview, (b) Top-view with white vibrating destemming beaters and blue feeding star-wheels, (c) Schematic

shaped to encourage the petioles to orient perpendicular to the roller axes so that they tend to pass across the second section of rollers without falling through with the grapes. This system comes in three models with capacities stated by Pellenc as being less than 4, 3-10 and 7-20 tonnes/hour.

Socma introduced their own vibrating destemmer-sorter in around 2010 (Figure 7). Like the Pellenc system it uses vibrating beaters, but they point downwards. Material is fed from the top and rotating star wheels located between the beaters ensure an even flow rate of material through the destemming chamber. Underneath the destemming chamber, the detached grapes fall out with stems on top of them. There is a vibrating sorting section where juice/small materials pass through, followed by a roller sorting section with larger gaps where the grapes fall through. The system capacity stated by Socma is 8-10 tonnes/hour.

Bucher-Vaslin introduced a different style of vibrating destemmer-sorter in around 2011 (Figure 8). In this device, bunches enter an angled cylindrical slotted cage that swings from side to side. Grapes are detached from the stems as bunches/stems travel down through the cage. Stems and grapes all pass onto a single-section roller sorting table, through which the grapes, juice and small materials all fall. Bucher-Vaslin states that its model with a single cage has a capacity of 3-8 tonnes/hour, while the model with dual cages has a capacity of up to 20 tonnes/hour.

There are fairly limited published comparisons on the performance of the newer styles of destemmers relative to rotary destemmers. In one set of French trials with hand-picked grapes (Vinsonneau et al. 2013), the Pellenc Selectiv', the Socma Cube and the Bucher-Vaslin Delta Oscillys vibrating destemmer-

sorters were trialled and found to offer broadly similar and satisfactory performance (there were some differences – e.g. the level of juicing – the reader is directed to the original article available online for specifics). Typical residual vegetal matter was 0.3-0.4%. This compares favourably with previous studies using rotary destemmers with no sorting, where for hand-picked grapes there was typically 1-2% residual vegetal matter (Vinsonneau and Vergnes 2000a). For machine-harvested grapes the residual vegetal matter with the new devices would be even lower given the much lower quantity of vegetal matter in machine-harvested fruit than hand-picked fruit. Some of the manufacturers of the new devices also stress that many raisined berries will remain on the stems during destemming and therefore will not end up in red ferments.

The new generation of vibrating destemmer-sorters are approximately two to three times more expensive than rotary destemmers, with models capable of processing nominally 8 tonnes/hour costing in the order of $50,000-$70,000. They also have more moving parts than rotary destemmers, so it is possible that there may be greater maintenance requirements. Despite this, it appears that vibrating destemmer-sorters are being chosen relatively commonly for new destemmer purchases in low throughput facilities (they are not available in very high throughput models). Currently in Australia there are approximately 20 vibrating destemmer-sorters in use, with about 1,000 in use worldwide.

Winery sorters

Manual sorting has been practised in some regions in some form for as long as wines have been produced. This is of course slow and highly labour intensive and requires great concentration. Manual sorting is typically now facilitated by conveying tables that spread the grapes and present them to the people sorting. Belt conveyor tables and/or vibrating conveyor tables (sometimes with draining/small material slots) are used. Manual sorting may be carried out before and/or after destemming. Automated sorters on the other hand are only employed after destemming. It should be noted that the performance of sorting post-destemming will always be dependent on the condition of the grapes and the gentleness of the destemming process. Sorting performance is likely to be reduced if the grapes have been broken down too much.

Figure 8: Bucher-Vaslin Delta Oscillys vibrating destemmer-sorter

Figure 9: Enoveneta TSA two-section vibrating screen sorter

The first section of this article presented a number of new vibrating destemmers that incorporate roller sorting and/or vibratory screen sorting. Similar sorting systems are also available as individual units that can be fitted after an existing destemmer. Some vibrating screen sorters have two sections (Figure 9). In the first section, juice and small materials are ▸

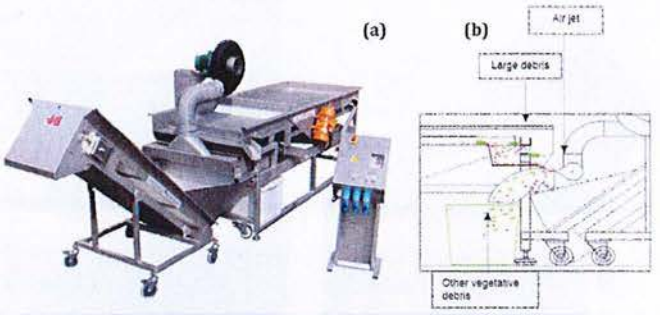

Figure 10: Vaucher-Beguet Mistral with gravity-fed air-jet sorting following two sections of vibration sorting (a) System overview, (b) Schematic of air-jet sorting section

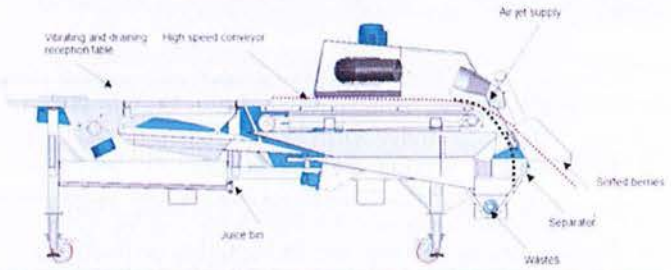

Figure 11: Bucher-Vaslin Rflow with high-speed conveyor belt-fed air-jet

Figure 12: Amos Industrie Tribaie sorting system schematic (density bath circled)

removed and in the second section, the grapes pass through larger slots or between prongs, with the vegetal matter vibrating off the end. A levelling bar/flap typically ensures that only a single-layer of fruit enters the second screening section, preventing excessive grape losses off the end of the devices. It should be noted, that in the first section of a sorting system, the size of small materials that will be removed with the juice will depend on the slot size. Slots may potentially allow for the removal of some shot berries, small raisins, Botrytis-affected berries, insects, etc. in addition to small vegetal matter. There is also an associated screen underneath where juice can be recovered from the small wastes.

In around 2004 Vaucher-Beguet introduced a system that in addition to using a two stage vibrating screen employed a subsequent air-jet to blow away remaining light materials (Figure 10). This air-jet can remove petioles, leaves, larger raisins and smashed grape skins (Fraser 2012). The air-jet operates on materials as they are falling off an edge. For it to be effective the material must be well spaced as otherwise good components may obstruct the air-jet from removing bad components. The material flow rate therefore has to be fairly slow. Vaucher-Beguet offers single-table models with nominal capacities of 2-3, 5-7 or 6-9 tonnes/hour. An alternative system

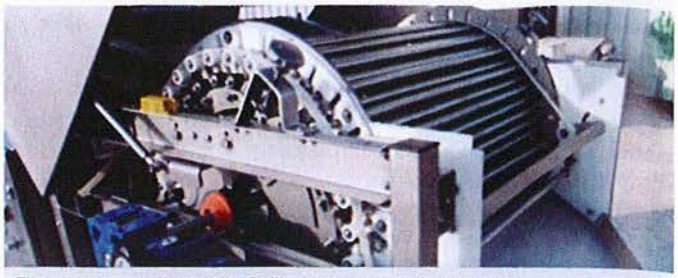

Figure 13: Amos Industrie Calibaie grape grading system

Figure 14: Optical grape sorters (a) Low throughput gravity-fed system with integrated overhead pre-draining screen, (b) High-speed belt conveyor fed system (additional pre-draining screen is required but not shown)

also relying on the air-jet concept was introduced in around 2013 by Bucher-Vaslin (Figure 11). Instead of relying on gravity-feeding of the grapes to the air-jet zone, it uses a high-speed conveyor belt to space the material to be sorted. Under the influence of the air-jet the lighter wastes follow a different trajectory off the end of the belt and are removed. This mode of operation allows for a higher throughput per device width. The nominal capacity of the Bucher-Vaslin system is 15 tonnes/hour.

In the sorting systems presented so far, sorting has been related to size, shape and mass and while these systems do have some ability to perform some limited removal of undesirable grape components (e.g. shot berries or raisins), their focus is more on the removal of vegetal matter. In around 2005 Amos Industrie introduced a different style of system, which in addition to several mechanical separation systems, also employs a density bath to separate ripe and unripe grapes (Figure 12). The ripe grapes sink, while unripe grapes float in a sugar or juice solution of set density. The density bath can also be employed to cool the grapes if connected to a refrigeration system. Models with nominal capacities of around 5, 10 and 20 tonnes/hour are available.

Amos Industrie has also recently introduced a device designed to grade grapes into two different diameter categories (Figure 13) that they suggest for use after the density-bath based sorting system. Grapes larger than the set roller gap travel across the top of the roller drum. Grapes smaller than the gap fall into the roller drum at the top and fall out at the bottom. (Spring-loaded rollers that are held in place by a strap at the top of drum rotation are released at the bottom of drum rotation.) Capacity is listed as being 4 to 8 tonnes/hour.

Optical sorters were introduced to the wine industry in around 2008 by several manufacturers (optical sorting had been used for many years in other industries). Installations have a pre-draining screen, after which material is spread and imaged, these images are processed and defects are removed by corresponding valved air-jets across the width of the sorter. In some low throughput devices (<5 tonnes/hour) the material is both imaged and defects removed while it is falling by gravity, while in higher throughput equipment (~10 tonnes/hour) material is spaced out and imaged on a high-speed conveyor belt and the defects are removed as the materials are projected off the belt. Optical sorters can sort by size and shape

Table 1: Automated winery sorters – costs and adoption

Notable mechanism	Example brand/models	Capacity[a] (t/hr)	Cost[b] (AUD)	Number of units in Australia[c]	Number of units worldwide[c]
Rollers	Bucher-Vaslin *Delta Trio*	< 15	$25,000	8	150
	Integrated with a vibrating destemmer – Pellenc *Selectiv'*, SOCMA Cube & Bucher-Vaslin Delta *Oscillys*			20	1,000
2-section vibrating	Enoveneta TSA	7-15	$30,000	3	150
Grape size	Amos Industrie *Calibaie*	4-8	$45,000	0	10
Air-jet (gravity-fed)	Vaucher-Beguet *Mistral*	6-9	$60,000	2	350
Air-jet (fast-belt)	Bucher-Vaslin *Rflow*	<15	$55,000	0	100
Density bath	Amos Industrie *Tribaie*	< 5	$120,000	0	85
		< 20	$200,000		
Optical	Bucher-Vaslin, Pellenc, Defranceschi, Key, WECO	< 5	$90,000	2	250
		<10	$240,000		

[a]Models in additional capacities to those shown are available for some equipment listed.
[b]Costs are order of magnitude values for general comparison purposes only.
[c]Numbers of installed units are best estimates based on discussions with major suppliers with some extrapolation where required.

and also by colour. In some devices they also sort based on the principle of red light fluorescing chlorophyll in vegetal matter that is then detected in the near-infrared (e.g. Defranceshci-Protec X-Tri). Optical sorters have the ability to remove not only vegetal matter but also other contaminants (e.g. snails) and very unripe and diseased grapes. The settings that determine which material is being removed can easily be modified using software. There have been a couple of anecdotal reports that optical sorters are not very good at removing Botrytis-affected red grapes; however, another optical sorter manufacturer has stated that a setting on their machine relating to shiny/matte appearance allows for good separation between Botrytis-affected and good red grapes.

Table 1 provides a summary of available sorting systems including throughputs, costs and adoption in Australia and worldwide. The density bath and optical sorting systems are significantly more expensive (~5-10 times) than the more basic mechanical sorting systems. They do however, offer more sophistication when trying to remove very unripe/diseased grapes and contaminants rather than just vegetal matter. Equipment adoption levels suggest that the principal pathway to the uptake of automated winery sorting equipment, both in Australia and internationally, is through the purchase of vibrating destemmers with integrated mechanical sorters. Table 1 also suggests that there are very few pieces of automated sorting equipment in Australia. This could be a function of ▸

there not having been a huge amount of manual sorting in Australia relative to some other regions of the world, making capital investment in automated equipment difficult to justify because there are no labour savings to offset it.

Whether sorting at all is worthwhile will be dependent on many factors (e.g. wine style, price point, grape condition). For residual vegetal matter, whether white or red wine is being produced is likely to make a big difference. For white wine production, it might be expected that only very high levels of vegetal matter would negatively influence wine quality since there is typically only a very short period of contact between juice and vegetal matter prior to pressing. For red wine production, residual vegetal matter is more likely to impact upon quality, as it will be in contact with juice/wine during fermentation. Anneraud et al. (2012) trialled many of the pieces of sorting equipment discussed in this article. Prior to sorting, vegetal matter fractions ranged from 0.4-1.7% and after sorting the residual vegetal matter ranged from 0.1-0.4% (Note: grape losses ranged from 0.2-4%). Vinsonneau and Vergnes (2000b) have previously reported that 1% residual vegetal matter can have a negative impact on quality for some red wines.

Acknowledgements

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Disclaimer

The information contained in this article should be considered general in nature, and readers should undertake their own specific investigations before purchasing equipment or making major process changes. The dates when different inventions were introduced and the order in which these inventions were made are presented in good faith based on information currently available. Some limited comparisons between different equipment are made and these are again presented in good faith based on available information. It should be noted that there is fairly limited rigorous independent information available on the relative performance of vineyard/winery equipment, particularly given the importance of equipment performance to all wine producers - both in terms of wine quality and productivity. None of the information presented in this article should be considered an endorsement of any product by the AWRI.

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Developments in destemming and sorting technology

Part Two: Harvester-mounted destemmers and sorters

This article by **Simon Nordestgaard**, Australian Wine Research Institute senior engineer, follows from a previous article that covered in-winery destemming and sorting technology. It presents an overview of the concurrent developments in harvester- mounted destemming and sorting systems.

MACHINE harvesters by their action of shaking the vine have always been destemmers to a degree, with some stems being left on the vine as grapes are shaken off. Anneraud et al. (2012) estimate that there is typically 1-2% vegetal matter in machine harvested loads compared with 7% in hand-picked loads. Machine harvesters have also long featured cleaning fans to remove leaves from the harvested grapes before they enter the bins, apparently almost since their first use. The inclusion of specific destemmers and now sorters on harvesters, however, is a newer innovation. While rotary destemmers have been trialled on harvesters since at least the late 1980s, it was only in the 2000s with the advent of new styles of destemmers, that on-harvester systems were adopted commercially.

Braud New Holland has offered a version of the first Socma destemmer (the winery version of which is now being sold by Scharfenberger) on its machine harvesters since around 2002. These are mounted above the on-board grape bins on each side of the harvester. The removal of vegetal matter using this system was shown to be similar to or better than standard machine harvesting followed by the use of a rotary destemmer at a winery (Vinsonneau et al. 2004). There was slightly more juicing when using the on-board destemmer than not.

In around 2008, Pellenc introduced its new on-harvester destemming and sorting system. This appears to be the first significant commercially available sorting system mounted on a machine harvester. The design is the same as Pellenc's winery vibrating destemming and roller sorting system, except that it is mounted directly above the on-board bins on each side of the harvester and any juice/small materials passing through the first section of tight rollers go into the on-board bins together with the grapes that pass through the second section of rollers.

Shortly afterwards, Gregoire introduced its on-board destemming and sorting system. Gregoire's Cleantech destemmer could be described as a cross between the Socma destemmer from Braud New Holland and a rotary destemmer. It consists of a grid conveyor loop with a single finger wheel that spins inside it at one end. Destemmed material passes through the grid then passes over a roller sorting table. Again, this destemming-sorting system is mounted over the on-board bins on each side of the harvester.

In around 2013, Braud New Holland released its Optigrape sorting system to complement the Socma on-board destemmer. This employs an air-jet to blow away lighter waste materials (Figure 1). In addition to removing vegetal matter, Braud New Holland also claims that it will remove some Botrytis-affected grapes. This device is very much aimed at low yield high quality vineyards - the destemmer without the sorting system is still being sold for other vineyards.

Figure 1: Braud New Holland Optigrape air-jet sorting system

> The capacity of on-harvester destemming-sorting systems varies between brands and models, but as a rough guide it seems likely that slower than usual harvesting speeds would be needed in some cases, particularly in the high-yielding Australian regions.

The quality impacts of performing destemming (and sorting) on a harvester instead of performing these operations at the winery are likely to be dependent on whether red or white wine is being made. For red wine production, the key factor is likely to be the residual content of vegetal matter during fermentation, so it may be advantageous to have a sorting system, but if a sorting system is used it probably doesn't matter if it is located on the harvester or at the winery. For white wine production, residual vegetal matter will experience fairly short contact times with juice, so the process of sorting seems less likely to improve quality regardless of where it is performed. An on-harvester destemmer could have a negative impact in white wine production if it is rough and there is a lot of additional juicing compared with not destemming, as this could result in higher levels of grape skin-derived phenolics in the 'free-run' juice fraction. On the other hand if the on-harvester destemmer is very gentle negative impacts from destemming on the harvester would be less likely. On-harvester destemming systems can be switched on or off such that they could

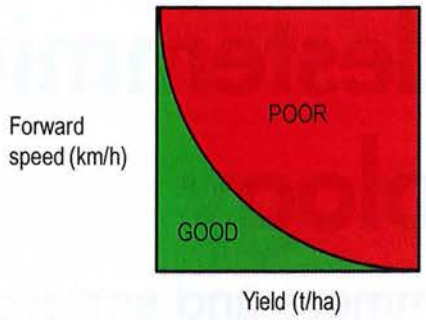

Figure 2: Generalisation of the effect of yield and forward speed on harvester destemming/sorting performance for a given row spacing

conceivably be used when harvesting red grapes and turned off when harvesting white grapes. For the Pellenc and Gregoire harvesters the destemming-sorting units are lifted away by hydraulics allowing the harvest to bypass them directly into the on-board bins. For the Braud New Holland destemming system the conveyor can be run in the reverse direction with the harvest passing straight into the on-board bins without going through the destemmer.

The Braud New Holland, Pellenc and Gregoire systems are all currently only available on harvester models with on-board bins. They are not compatible with discharge conveyors that feed a chaser-tractor/bin – the most commonly used method for grape harvesting in Australia. On-board bins are inefficient in vineyards with long rows since part way along the row the on-board bins may be full and the driver would have to stop harvesting and head to the end of the row to empty them. ERO, a smaller manufacturer of machine harvesters, is offering an on-harvester destemming-sorting system that can work with a discharge conveyor. This has been easier for ERO to achieve than the other manufacturers because after picking, grapes are only conveyed up one side of their harvester instead of up both sides, and there is therefore more space to accommodate the destemming-sorting system. The ERO system employs a rotary destemmer with a roller sorting table underneath. As might be expected, the other major harvester manufacturers are either considering or already developing variants of their own destemming and sorting systems that can work with a discharge conveyor to try to capture additional customers.

The inclusion of a destemmer and/or sorting system on a machine harvester can limit harvesting speed. The destemming and/or sorting system will only be able to process a certain rate of material before performance will decline (Figure 2). If the rate is too high, there may be incomplete destemming/grape losses or grape/stem breakage in the destemmer or grape losses from the sorting system. The harvester manufacturers try to maximise the capacity for their given destemmer by having a pre-sorting section of rollers or a grid where free grapes and juice pass directly to the on-board bin or to the sorting section so that they do not unnecessarily pass through the destemmer. The capacity of on-harvester destemming-sorting systems varies between brands and models, but as a rough guide it seems likely that slower than usual harvesting speeds would be needed in some cases, particularly in the high-yielding Australian regions circled in Figure 3.

The adoption of on-harvester destemming systems in Australia is currently very low. It is a technology that has been much more widely adopted in France, New Zealand and other countries. Some major suppliers in Europe have suggested that 50% of new harvesters sold have destemmers. This relatively high proportion in the huge European market was backed up by discussions during a recent visit to a Bordeaux co-operative winery, where staff estimated that approximately 50% of their grapes were now being harvested using machines with on-board destemmers. There are a number of likely reasons for the low adoption rates of on-harvester destemming systems in Australia relative to other countries but essentially it probably relates to the economics of grapegrowing in many Australian regions and the fact that grape and wine production are often performed by separate entities. On-harvester destemming and sorting means

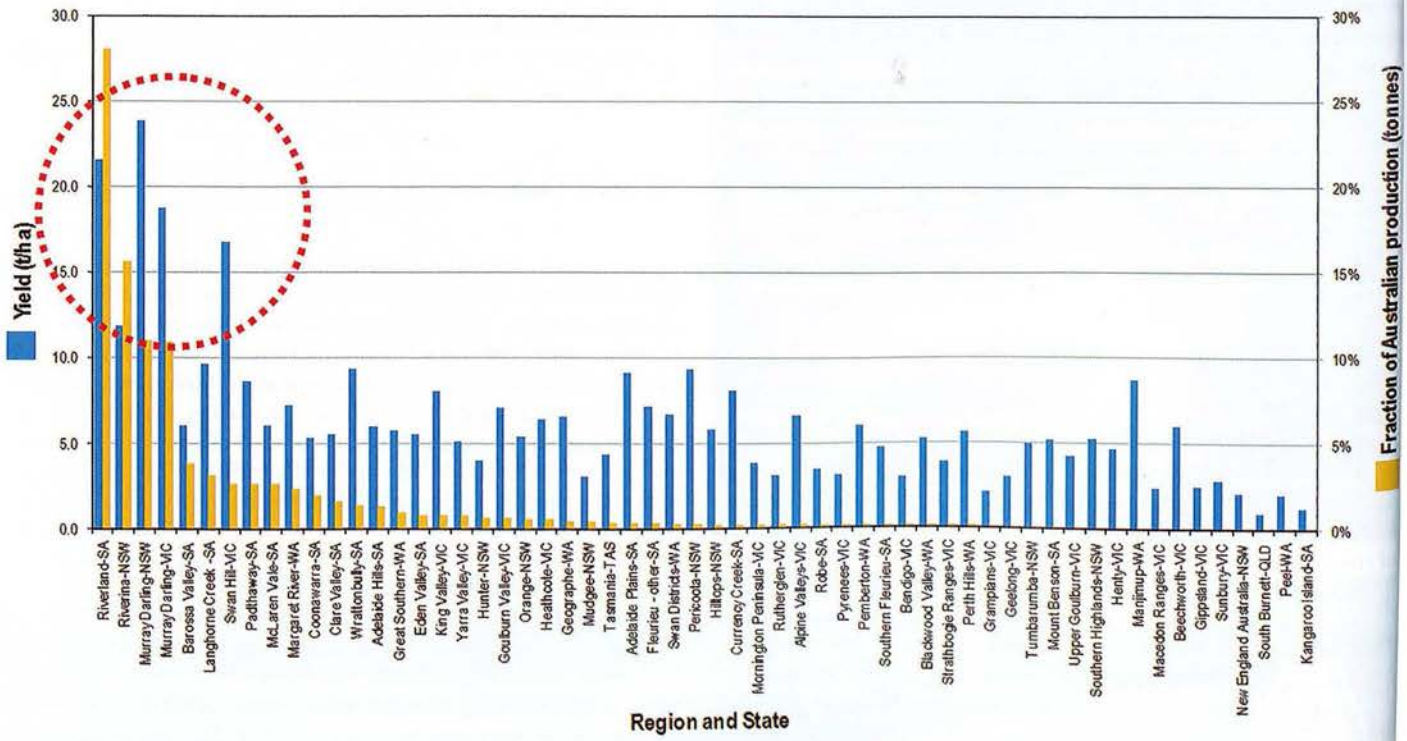

Figure 3: Average yields in different Australian wine regions and the fraction of production in each of those regions (data from Wine Australia 2012, high-yielding regions circled)

For red wine production, the key factor is likely to be the residual content of vegetal matter during fermentation, so it may be advantageous to have a sorting system.

that stems, other vegetal matter and some grapes would get left in the vineyard that growers currently get paid for by weight at the winery. Furthermore, while a destemming (and sorting) system only adds 2-10% to the approximately $400,000 capital cost of a new harvester, other operating costs are increased. As already discussed, slower harvesting speeds would be needed in some high-yielding vineyards and harvesters with on-board bins instead of discharge conveyors might need to be used. The systems also have more mechanical parts that in turn are likely to require more maintenance. A current adoption pathway in Australia for on-harvester destemmers that some companies have been able to use to justify the purchase/lease of a harvester with a destemming system has been as an alternative to hand-picking for some higher quality grapes, such that there are labour savings. Despite some of the drawbacks of on-harvester destemming-sorting systems discussed, in the longer-term as systems evolve and market conditions change, it seems likely that a significant proportion of Australian harvesters will end up having some form of on-board destemming and sorting system.

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Disclaimer

The information contained in this article should be considered general in nature, and readers should undertake their own specific investigations before purchasing equipment or making major process changes. The dates when different inventions were introduced and the order in which these inventions were made are presented in good faith based on information currently available. Some limited comparisons between different equipment are made and these are again presented in good faith based on available information. It should be noted that there is fairly limited rigorous independent information available on the relative performance of vineyard/winery equipment, particularly given the importance of equipment performance to all wine producers - both in terms of wine quality and productivity. None of the information presented in this article should be considered an endorsement of any product by the AWRI.

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