TIMBER PROPERTIES AND MARKET POTENTIAL OF SELECTED WHEATBELT SPECIES. 2. RASPBERRY JAM, BROWN MALLET AND YORK GUM

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SUMMARY

The wood properties and wood quality of raspberry jam (*Acacia acuminata* Benth.) brown mallet *(E. astringens* Maiden (Maiden)) and York gum (*Eucalyptus loxophleba* Benth.) from the Western Australian Wheatbelt were assessed. Logs were harvested from trees grown on private property or State Forest, with ages from 25 to 62-years-old. Logs were cut into 25 mm boards using a 'Forestor 150' breakdown saw and a 'Jonserreds' band re-saw, and the boards dried to 12 per cent moisture content in solar-assisted kilns. Basic wood properties (i.e. green density, basic density, air-dry density and shrinkage) as well as recoveries, sawing, drying behaviour, gluing and wood working properties (i.e. sawing, sanding, planing, nailing, routing and finishing) were assessed.

Green sawn recoveries for raspberry jam, brown mallet and York gum were 17.3 per cent, 26.7 per cent and 24.6 per cent respectively. The mean small end diameter under bark (sedub) was similar for all three species with good log form and shape, and size would not have contributed to a reduced recovery in the raspberry jam logs. The high frequency and size of knots and knots associated with rot in raspberry jam would have contributed to a reduced recovery. Raspberry jam samples had a mean basic density of 940 $kg.m^{-3}$ and mean air-dry density of 1080 $kg.m^{-3}$, brown mallet a mean basic density of 865 $kg.m^{-3}$ and mean air-dry density of 1090 $kg.m^{-3}$ and York gum a mean basic density of 885 $kg.m^{-3}$ and mean air-dry density of 1060 $kg.m^{-3}$. The boards produced were made into edge-glued panels, by gluing with urea formaldehyde ('Grasp'), hand clamping and cold pressing for 24 h at 30°C. For exterior applications resorcinol formaldehyde, a waterproof exterior adhesive is recommended. High densities of the timbers can restrict adhesive penetration and curing by hot pressing is not recommended. Guidelines for gluing W.A. Wheatbelt species are given.

All three species indicated good working and finishing properties. To dress these three timbers to a smooth even finish it is recommended that a slow feed speed, between 8 and 10m/min, and high cutter head speed be used. Nailing raspberry jam and York gum boards resulted in either splitting or the nails bending in the hard timber, while ninety per cent of the brown mallet samples split during nailing. It is recommended that dried boards of all three timbers be pre-drilled before nailing. The colour of raspberry jam is a reddish brown to dark brown or honey brown with green streaks in the timber, brown mallet is pale red-brown to grey-brown with dark streaks and York gum is yellowish brown to dark brown. The attractive colours, smoothness of the wood surface and straight or interlocked grain make raspberry jam, brown mallet and York gum excellent timbers for furniture, turning and carving.

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INTRODUCTION

The Department of Conservation and Land Management's (CALM) Wheatbelt Region and CALM Timber Technology (CTT) are assessing possible commercial uses of native trees from the Western Australian Wheatbelt, growing in annual rainfall zones of less than 600 mm. The project will provide information to assist Wheatbelt farmers and land owners to manage vegetation on their land, and to protect soil, water and wildlife as an integrated part of sustainable and profitable agriculture. Specific objectives of this project are :

(i) assess the timber properties and uses for major potential species for revegetation.

(ii) publish this information in a form which will assist in marketing W.A. Wheatbelt timbers.

(iii) update information available to farmers and others on the commercial potential of W.A. Wheatbelt species.

This trial complements the research and development programs for eucalyptus oil, sandalwood, and tannin studies being carried out in the Wheatbelt. In addition Goldfields timber research project which includes the Goldfields Region and CALM Timber Technology is assessing processing characteristics and wood properties of a large number of species. These species are predominantly eucalypts, which have a considerable economic potential because of their grain, figure and colour. Potential uses include musical instruments, turnery, furniture and flooring (Kealley and Clews 1995 and Skowronek and Kealley 1995). Similar potential exists for timbers from the W.A. Wheatbelt, but the existing resource is not as large as occurs in the Goldfields Region.

The first study assessed rock sheoak (*Allocasuarina huegeliana* (Miq.) L. Johnson) and swamp sheoak (*Casuarina obesa* Miq.) (Siemon and Pitcher 1994). This study assessed the following species :

Raspberry jam (*Acacia acuminata* Benth.).
Brown mallet *(E. astringens* Maiden(Maiden)).
York gum (*Eucalyptus loxophleba* Benth.).

Other species that require assessment include :

Wandoo (*E. wandoo* Blakely).
Swamp yate (*E. occidentalis* Endl.).
Salmon gum (*E. salmonophloia* F.Muell.).
Red morrel (*E. longicornis* (F. Muell.) F.Muell. ex Maiden).
E. 'myriadena' (Brooker).

Raspberry jam may be a large bushy shrub 3 to 5 m tall with a short main stem which may divide about 1 m from the ground into numerous spreading-erect branches. It

grows in low woodland and tall shrubland where it is associated with eucalypts e.g. York gum, salmon gum and wandoo. Trees are generally used for shade and shelter and amenity plantings. The unusual name of raspberry jam comes from the odour of the wood when freshly cut and the timber has been used in turnery and decorative woodware and furniture. Heartwood is reddish brown to dark brown or honey brown and sapwood is a distinctive pale yellow. It is not considered a commercial timber, but has been used extensively for fence posts. Kingston and Risdon (1961) quoted mean basic density of 900 $kg.m^{-3}$ and mean air-dry density (after reconditioning) of 1035 $kg.m^{-3}$, and shrinkage (after reconditioning) tangential - 1.2 per cent and radial - 1.1 per cent.

Brown mallet is a small to medium-sized tree, 10 to 25 m in height and with diameters at breast height (dbh) to 0.7 m, but is occasionally found up to 30 m tall and 1m dbh. The timber is used in general construction (particularly on farms), tool handles, mining timbers and fuel. The bark has a high tannin content (40 per cent or more), which can be used for tanning leather and adhesives manufacture. Heartwood is light red-brown to dark grey-brown, with reddish streaks. Sapwood is up to 30 mm wide and distinctly paler. Timber is rather hard to work but dresses well. The grain is often interlocked and timber is easy to dry (Bootle 1983). Kingston and Risdon (1961) mean basic density of 770 $kg.m^{-3}$ and mean air-dry density (after reconditioning) of 950 $kg.m^{-3}$, and shrinkage (after reconditioning) tangential - 5.5 per cent and radial - 3.6 per cent.

York gum varies from a small tree to 15 m tall with a dbh up to 0.6 m and a reasonable form to a low, straggly mallee. Trees grow in woodland formation, which formerly covered much of what is now the Wheatbelt and in tall shrubland or mallee formation in drier areas. The heartwood is yellow-brown to dark brown, very dense, hard, tough, and has a closely interlocked grain, often giving an attractive figure. Texture is fine and even. The air-dry density is about 1070 $kg.m^{-3}$ and the wood has been used for wheelwright and similar work, poles, posts and mallets and has the potential for decorative woodware (Bootle 1983).

METHODS

Logs were harvested from either State Forest or private property in the Wheatbelt Region near Narrogin, Western Australia. The log source, age and number of logs harvested are given in Table 1.

Table 1.
Log source, age and number of logs harvested for raspberry jam, brown mallet and York gum

Species	Log source	Age (years)	No of logs harvested
Raspberry jam	P.P.	30 - 40	4
	S.F.	Unknown	5
Brown mallet	P.P.	25 - 30	4
	S.F.	62	4
York gum	P.P.	40	8
	S.F.	60 - 70	1

Note : - P.P. - private property.
- S.F. - State Forest.
- The brown mallet logs from State Forest were plantation grown.

Milling

Small and large end diameters under bark and log lengths were measured and individual log volumes calculated. Logs were milled in the CALM's Timber Technologies sawmill in Harvey into 25 mm boards using a 'Forestor 150' breakdown saw and a 'Jonserreds' band re-saw. Recoveries were estimated by determining the total green sawn recovery for each species on a batch basis, not by taking the mean recovery of each individual log within each species. Twenty samples were randomly selected from each species for assessing basic density, tangential and radial shrinkage from green to 12 per cent moisture and initial moisture contents.

Shrinkage and density

The shrinkage of a piece of wood is expressed as a percentage of its green size (i.e. when the moisture content was above fibre saturation point).

$$\text{Shrinkage (\%) is determined by : } \frac{\text{green dimension - dry dimension}}{\text{green dimension}} \times 100$$

Specimens 25 x 25 x 100 mm were cut from randomly selected boards from all three species and were measured for tangential (parallel to the growth rings) and radial (perpendicular to the growth rings) shrinkage, before drying in the CALM solar-assisted kilns, and regularly re-measured at the same positions until the moisture content was 12 per cent.

The density of a piece of wood (or any other substance) is defined as its mass divided by its volume, usually expressed in kilograms per cubic metre ($kg.m^{-3}$). Three methods of estimating density were used in this trial. They were :

Green density - The ratio of the mass of green or unseasoned wood to green volume ($kg.m^{-3}$). This density is useful when determining log transport costs by relating tonnes to cubic metres, the basis of weight-scaling. However, the moisture content of the logs varies during the year.

Air-dry density - The weight of a piece of wood divided by its volume after seasoning (generally to 12 per cent moisture content). This condition relates to wood in use and is the usual figure used when comparing densities of different species in practical situations.

Basic density - The oven-dry mass divided by green volume. This measure has the advantage that moisture content variations during the year are avoided.

Samples for assessing density were taken from green boards in the case of estimating green density and basic density and from dry boards for estimating air-dry density.

Drying

After specimens for density and shrinkage assessment were prepared, the residual boards and remaining timber were strip stacked and dried in the CALM solar-assisted kilns. The drying schedule was the standard used at CALM Timber Technology for jarrah, based on floating temperature initially, and decreasing relative humidity through the schedule.

Appearance grading

After dressing to 20 mm the timber was graded according to the W.A. Industry Standard (FIFWA 1992).

Wood and working properties

After drying to 12 per cent moisture content, air-dry density and width and thickness shrinkages were determined using standard procedures. The working properties of sawing, planing, sanding, routing, nailing and finishing were assessed by semi-quantitative methods. Colour was determined using the Methuen Handbook of Colour (Pavey 1978) and the wood textures were described.

Assessing the nailing properties involved hammering a standard smooth shank nail (2 mm thick and 30 mm long) into randomly selected backsawn and quartersawn pieces of timber. The nail was hammered in 20 mm from the end and 10 mm from the edge of the piece of timber and the amount of splitting and the ease of nailing were assessed. The raspberry jam, brown mallet and York gum samples were 20 mm thick.

Gluing Trials

(a)

Six raspberry jam, six brown mallet and five York gum panels were constructed. Each edge of each board was dressed immediately prior to gluing with urea formaldehyde ('Grasp'), allowing a maximum time of three hours between dressing and gluing. An 'Orma' glue press with an oil-heated platen was set at 100°C with downward pressure of 1500 p.s.i. (10.3 MPa) and lateral pressure of 250 p.s.i. (1.7 MPa). Curing time was 15 minutes.

A 100 mm wide strip was cut 200 mm from each end of the test panels, to give between four and nine gluelines per panel to assess. Each glueline was tested, using the requirements of AS 1328 -1987 dry cleavage test (Standards Association of Australia 1987). The percentage of wood failure was estimated for each glueline.

(b)

After assessing glueline strengths using the method above, four raspberry jam, all six brown mallet panels and all five York gum panels were considered inadequately glued and consequently required re-gluing. Panels were re-sawn on their existing gluelines, boards re-dressed on their edges and re-glued with 'Grasp' by cold pressing. Panels were hand clamped within one hour of dressing according to manufacturer's specification, and the glue was allowed to cure for 24 hours under winter (July) ambient temperatures, between 10 and 15°C. Further cleavage tests indicated that only one jam panel passed the requirements of AS 1328 -1987 and the other panels needed re-gluing.

(c)

In a third gluing trial one York gum and one brown mallet panel were glued with the following schedule :

(i) Re-saw the panels into board components.
(ii) Re-dress the edges of half the boards.
(iii) Match a dressed edge to a dressed edge (dressed/dressed) and a sawn edge to a sawn edge (sawn/sawn).
(iv) Re-glue the panels with 'Grasp' by hand clamping and
(v) Cure the glue under winter ambient (August) temperatures between 10 and 16°C in the processing shed for 24h.

Comparing gluing performance on boards that were dressed or sawn i.e. glued dressed/dressed or sawn/sawn would show the effect of surface preparation on the overall strength of the glueline.

All gluelines, whether glued edge dressed to edge dressed (dressed/dressed) or edge sawn to edge sawn (sawn/sawn), failed the cleavage tests and further trials were required.

(d)

In a fourth gluing trial the same York gum and brown mallet panels used in the third trial were re-glued with the following schedule :

(i) Re-saw the panels into board components.
(ii) Re-dress all edges.
(iii) Re-glue the panels with Bunning's Timbachem 'Resobond RA 3' (resorcinol formaldehyde) and P4 hardener by hand clamping immediately after glue application and
(iv) Cure the glue under spring ambient (September) temperatures between 10 and 17°C in the processing shed for 24h.

'Resobond RA 3' is waterproof exterior adhesive for gluing products used in external applications (e.g. signboards). Previous adhesive trials using lower density timbers (e.g. regrowth jarrah) have produced strong gluelines that have passed the requirements of both the wet and dry cleavage tests in AS 1328 - 1987 (Brennan *et al.* 1996). Despite the good results achieved when gluing lower density species, all gluelines in both species failed the cleavage test.

(e)

In a fifth gluing trial another York gum and brown mallet panel were re-glued with the following schedule :

(i) Re-saw the panels into board components.
(ii) Re-dress the board edges and place them in a controlled environment room at 30 °C for 24 h.
(iii) Re-glue the panels with Bunning's Timbachem 'Resobond RA 3 - W' (a winter grade resorcinol formaldehyde) and P4 hardener by hand clamping immediately after glue application and
(iv Cure the glue in a controlled environment room at 30° C for another 24 h.

Bunning's Timbachem manufacture a winter grade resorcinol formaldehyde ('Resobond RA3 -W') which has half the pot life of 'Resobond RA3', but is more suited to gluing under cooler ambient conditions (Fletcher personal communication). Pre-heating the boards for 24 h and curing at 30°C for another 24 h also improved glue penetration.

Mr John Fletcher, Bunnings Forest Products, Welshpool W.A.

The York gum panel was successfully glued with 'Resobond RA3 - W' under these gluing conditions, but the brown mallet panel did not perform as well, owing to poor contact on some gluelines at the end of the panel. Those gluelines that received secure clamping and a close contact between the two edges produced a strong bond with 100 per cent wood failure, therefore gluing brown mallet with 'Resobond RA3-W' by this method was considered successful. 'Resobond RA3 - W' is a dark adhesive and gluelines are dark red, which may be a disadvantage when panels are used in interior applications, where appearance is important. For these interior applications a clear adhesive e.g. 'Grasp' may be required.

(f)

York gum and brown mallet were successfully glued with 'Resobond RA3 - W' and P4 hardener using the gluing schedule described in (e) above. A gluing schedule, using a clear adhesive e.g. 'Grasp' was required. Another York gum and a brown mallet panel were glued with 'Grasp' using the following schedule :

York gum

(i) Re-saw the panels into board components.
(ii) Re-dress the board edges, pre-treat edges with one molar (1M) sodium hydroxide (NaOH) and place them in a controlled environment room at 30°C for 24 h.
(iii) Re-glue the panels with 'Grasp' by hand clamping immediately after glue application and
(iv) Cure the glue in a controlled environment room at 30°C for another 24 h.

NaOH was applied to the board edges with a foam roller. Protective clothing of full rubber gloves, overalls and safety glasses were worn when diluting and applying NaOH solution. Board moisture contents were taken before gluing to determine that the timber was dry and suitable for gluing. The mean moisture content of the York gum boards was 10.9 per cent, indicating that the timber was suitable for gluing.

Brown mallet - control

(i) Re-saw the panels into board components.
(ii) Re-dress the board edges and place them in a controlled environment room at 30°C for 24 h.
(iii) Re-glue the panels with 'Grasp' by hand clamping immediately after glue application and
(iv) Cure the glue in a controlled environment room at 30° C for another 24 h.

Board moisture contents were taken before gluing, to ensure that the timber was dry and suitable for gluing. The mean moisture content of the brown mallet boards was 11.8 per cent and suitable for gluing.

Gluing brown mallet under these conditions (without a surface pre-treatment) produced strong glue joints. Following the success with gluing this brown mallet panel, panels that had failed the cleavage tests in (b) above and the remaining brown

mallet and York gum panels were successfully re-glued by this method i.e. four raspberry jam, three brown mallet and two York gum panels.

RESULTS AND DISCUSSION

Table 2 gives the small end diameter under bark (sedub) and green sawn recoveries, based on total green sawn recovery for each species, not the mean recovery for each individual log. The mean sedub was similar for all three species, but the mean recovery of raspberry jam was lower than the brown mallet and York gum. Brown mallet and York gum each had a log with a sedub two to three standard deviations greater than the mean, i.e. 37.5 cm and 33.5 cm sedub respectively. These logs were presumably from the butt section of the trees which would have increased the overall recovery. Log form and shape were good for all species and would not have contributed to a reduced recovery in the raspberry jam logs. The high frequency and size of knots and knots associated with rot would have caused a reduced recovery. In general most studies (e.g. Brennan and Ward (1990) and Brennan *et al.* (1991)) have shown that log size is directly related to recovery. Brennan and Newby (1992) found a mean recovery of 29.6 per cent for four eastern Goldfield's eucalypts, with a mean sedub of 23.0 cm. The range was from 21.5 per cent (sedub 25.6 cm) for gimlet to 33.6 per cent (mean sedub 14.0 cm) for York gum. Mulga (*Acacia aneura* F. Muell. ex Benth.), a similar species and log form to raspberry jam, was also assessed by Brennan and Newby (1992), with a mean recovery of 28.4 per cent from logs 14.4 cm sedub, which is similar to the recovery achieved in this trial.

TABLE 2
Sedub's and Green Sawn Recoveries of
Raspberry Jam, Brown Mallet and York Gum

Species	Sedub (cm)				Green off saw recovery (%)
	Mean	S.D.	Range	Sample size	Mean
Raspberry jam	23.1	3.9	18.5 - 29.5	9	23.0
Brown mallet	23.8	5.9	19.5 - 37.5	8	34.4
York gum	22.1	6.1	17.0 - 33.5	9	30.9

Mean green, basic and air-dry densities are listed in Table 3. Green and basic densities of brown mallet and York gum are very similar and raspberry jam has a slightly higher mean basic density of 940 $kg.m^{-3}$. Air-dry densities of all three species were similar and ranged from 1060 $kg.m^{-3}$, for York gum to 1080 $kg.m^{-3}$, for raspberry jam. Kingston and Risdon (1961) give similar densities, with a mean basic density of 900 $kg.m^{-3}$ and mean air-dry density after reconditioning of 1035 $kg.m^{-3}$ for raspberry jam, and brown mallet they give a mean basic density of 770 $kg.m^{-3}$ and mean air-dry density after reconditioning of 950 $kg.m^{-3}$. Bootle (1983) gives an air-dry density for York gum of about 1070 $kg.m^{-3}$. Brennan and Newby (1992), in a study of some Western Australian eastern Goldfields timbers, also estimated similar densities for

York gum with green, basic and air-dry densities respectively 1104 $kg.m^{-3}$, 785 $kg.m^{-3}$ and 1129 $kg.m^{-3}$. In comparison jarrah has a mean green density of 1170 $kg.m^{-3}$, mean basic density of 670 $kg.m^{-3}$ and mean air-dry density of 820 $kg.m^{-3}$ (Bootle 1983). The basic and air-dry densities are lower than the three species assessed in this trial, but the green density is higher, due to the greater amount of moisture in jarrah. Brennan and Newby (1992) found that Goldfields timbers had low initial moisture contents although green densities were between 1100 and 1200 $kg.m^{-3}$. These high densities influenced sawing, drying, gluing and machining characteristics.

TABLE 3
Green, basic and air-dry densities of Raspberry Jam, Brown mallet and York gum

Species	Green Density ($kg.m^{-3}$)			Basic Density ($kg.m^{-3}$)			Air-dry Density ($kg.m^{-3}$)		
	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range
Raspberry jam	1260	25	1195 - 1310	940	40	830 - 1015	1080	45	990- 1180
Brown mallet	1130	45	1065 - 1215	865	40	815 - 940	1090	45	1020- 1170
York gum	1185	25	1135 - 1230	885	60	770 - 975	1060	45	995 - 1140

Note : Sample size was 20 for assessing density in all species.

Shrinkage

Table 4 gives the tangential and radial shrinkages for raspberry jam, brown mallet and York gum. Comparing shrinkage within each species, tangential shrinkages for brown mallet and York gum were double their radial shrinkages and for raspberry jam tangential shrinkage was 1.5 times radial shrinkage. Tangential shrinkage of raspberry jam was 3.5 to 5.0 times less than tangential shrinkage and 2.5 to 3.3 times less than the radial shrinkage of York gum and brown mallet respectively. Kingston and Risdon (1961) quoted a mean tangential shrinkage after reconditioning of 1.2 per cent and radial shrinkage of 1.1 per cent for raspberry jam, which are similar to the shrinkages found in this trial. For brown mallet they give a mean tangential shrinkage after reconditioning of 5.5 per cent and radial shrinkage of 3.6 per cent, which are also similar to the shrinkages found in this trial, but do not give have data for York gum.

Table 4
Shrinkage of Raspberry Jam, Brown mallet and York gum

Species	Tangential (%)			Radial (%)			
	Mean	S.D.	Range	Mean	S.D.	Range	Sample size
Raspberry jam	1.4	0.5	0.9 - 2.6	1.0	0.4	0.3 - 1.7	20
Brown mallet	6.6	0.8	5.9 - 8.8	3.3	0.7	2.0 - 5.0	20
York gum	4.8	1.9	2.4 - 8.3	2.5	1.0	0.9 - 4.6	20

Colour

Colours of the three species have been described using the Methuen Handbook of Colour (Pavey 1978), which is a universal reference for colour description. Raspberry jam has been coded as 8E7 or 8D5/8D6 i.e. mahogany brown to reddish brown, brown mallet 6D4, 5C3 or 5D3 i.e. cinnamon (brown), reddish blonde to brownish orange or nougat (greyish brown) and York gum 4C3, 5C3 or 5D4 i.e. beige to light blonde, reddish blonde to brownish orange or dark blonde.

A general description for raspberry jam would be reddish brown to dark brown or honey brown with green streaks in the timber, brown mallet pale red-brown to grey-brown with dark streaks and York gum yellowish brown to dark brown. Sapwood of raspberry jam is a distinctive pale yellow colour.

Texture

Raspberry jam, brown mallet and York gum have a fine and even texture and the grain is often interlocked, producing an attractive fiddleback figure.

Appearance grading

After dressing the boards to 20 mm, they were graded for appearance use, using the FIFWA (1992) standard (Table 5). Prime Grade is based on the best face and two edges and standard on four sides, and this grading exercise aimed at maximising recovery in the highest grade and longest lengths. Based on log volume, 7.5 per cent of raspberry jam, 20.5 per cent of brown mallet and 13.4 per cent of York gum made Prime Grade. For all three species, approximately 15 per cent was below grade and required docking. The timber was graded to a minimum length of 0.9 m and this allowed many imperfections to be docked from longer boards, increasing the recovery into Prime Grade. Raspberry jam had a high proportion of boards with knots and knots associated with rot which reduced the recovery into Prime Grade.

Table 5
Percentage Recovery by Log and Green Sawn Volume of each Appearance Grade

Species	Appearance Grade	
	Prime Recovery - based on log vol. (%)	Below grade Recovery - based on log vol. (%)
Raspberry Jam	7.5	15.5
Brown mallet	20.5	13.9
York Gum	13.4	17.7

Note : No boards made Standard Grade.

All boards were graded as Prime Grade or below grade instead of Standard. The grading rules allowed a greater tolerance of imperfections for Standard Grade than Prime, but grading on all four sides restricted the amount of boards that could be graded as Standard. Table 6 gives the reasons for downgrading from Prime Grade to below grade. The main reason for downgrading all species was heart, with approximately 50 per cent of brown mallet and York gum, and 25 per cent of raspberry jam downgraded. Knots and knots associated with rot were also major causes of downgrade in raspberry jam and undersized boards in brown mallet.

Table 6
Reasons for downgrading boards from Prime Grade to below grade

Reason for downgrade	Percentage downgrade		
	Raspberry jam	Brown mallet	York gum
Heart	24.8	52.2	50.6
Heart / rot	7.8	9.2	14.3
Heart / knots		3.4	7.1
Heart / knot / rot	7.8		
Heart / undersize		6.9	
Knots	14.4	6.0	0.9
Knots / rot	23.1	5.8	13.3
Knots / encased bark	1.1	2.4	
Knots / shake	4.1		3.1
Wane	6.4	1.8	4.2
Wane / heart			2.2
Wane / knot	4.4		
Undersize	5.8	12.3	1.9
Other	0.3		2.4

Gluing

Table 7 gives the effect of gluing conditions on percentage wood failure in edge-glued raspberry jam, York gum and brown mallet panels. Each glue line was tested, using the requirements of the AS 1328 - 1987 dry cleavage test (Standards Association of Australia 1987). The percentage of wood failure compared with adhesive failure was estimated for each glue line. As stated in Methods, the panels were glued initially by hot pressing in an 'Orma' glue press at 100°C, with only two raspberry jam panels passing the requirements of AS 1328 - 1987. The panels that failed the initial cleavage test were subsequently re-glued in schedule B by cold pressing under winter (July) ambient temperatures, between 10 and 15°C in the processing shed. Only one raspberry jam panel passed and this schedule was considered unsuitable for gluing these species and further trials were required.

In a third gluing trial (schedule C) only one York gum and one brown mallet panel were assessed because of the limited number of panels, and samples were required for future display purposes. This trial compared the gluing performance on boards with dressed or sawn edges and glued dressed edge to dressed edge (dressed/dressed) or sawn edge to sawn edge (sawn/sawn). Panels were glued with 'Grasp' by cold pressing under winter ambient conditions. All gluelines, whether dressed or sawn edges failed the cleavage tests. Although edge preparation was assessed, the poor performance could also be caused by the curing conditions, which were cool winter ambient conditions.

A fourth gluing trial (schedule D) assessed the performance of Bunning's Timbachem 'Resobond RA 3', applied to edge dressed boards and cured under spring ambient (September) temperature in the processing shed, for 24 h. 'Resobond RA 3' is a waterproof exterior adhesive and is used to glue products used in external applications (e.g. signboards). Previous adhesive trials using lower density timbers (e.g. regrowth jarrah) have produced strong gluelines that have passed the requirements of both the wet and dry cleavage tests in AS 1328 - 1987 (Brennan *et al.* 1996). Despite the good results achieved when gluing lower density species, all gluelines in both species failed the cleavage test. Gluing under cool spring temperatures between 10 and 17°C did not allow the adhesive to penetrate into the wood and produce strong glue bonds.

TABLE 7
Effect of Gluing Conditions on Percentage Wood Failure in Edge - Glued Raspberry Jam, York Gum and Brown Mallet

Schedule	Species	Wood Failure at Both Ends (%)		No Gluelines Assessed	No Panels Assessed	Percentage of Panels Passed (%)
		Mean	SD			
A	Raspberry jam	70	32	60	6	33
	Brown mallet	58	36	64	6	0
	York gum	56	35	64	5	0
B	Raspberry jam	62	34	42	4	25
	Brown mallet	61	34	61	6	0
	York gum	31	34	47	5	0
C	Brown mallet *	11	25	8	1	0
	York gum*	0	0	18	1	0
D	Brown mallet	6	12	15	1	0
	York gum	28	32	18	1	0
E	Brown mallet	71	24	19	1	100
	York gum	57	43	18	1	100
F +	Brown mallet (Control)	87	15	13	1	100
	York gum	0	0	12	1	0

* Panels glued by either dressed edge to dressed edge (dressed/dressed) or sawn edge to sawn edge (sawn/sawn) failed.

\+ York gum panel in schedule F had a pre-treatment with 1M NaOH, while the brown mallet panel had no pre-treatment and was used as a control.

Bunning's Timbachem also manufacture a winter grade resorcinol formaldehyde, 'Resobond RA 3 - W', which has half the pot life of 'Resobond RA 3' but is more suited to gluing under cooler ambient conditions. A fifth trial (schedule E) evaluated the performance of this adhesive on gluing a brown mallet and a York gum panel. The board edges were re-sawn and re-dressed and placed in a controlled environment room at 30°C for 24 h, before applying the adhesive. Curing was under the same conditions for another 24 h. The York gum panel passed the requirements of AS 1328-1987, but the brown mallet panel did not perform as well, owing to poor contact

on some gluelines at the end of the panel. The brown mallet gluelines that received secure clamping and a close contact between the two edges produced a strong bond with 100 per cent wood failure, therefore gluing brown mallet with 'Resobond RA 3 - W' by this method was considered successful.

As stated previously 'Resobond RA 3 - W' produces dark red gluelines which may be a disadvantage when panels are used in interior applications, where appearance is important. A gluing schedule, using a clear adhesive e.g. 'Grasp' was required. Another York gum and brown mallet panel were re-glued with 'Grasp', in a sixth trial (schedule F). The York gum board edges were pre-treated with 1M NaOH before pre-heating at 30°C for 24 h and the brown mallet panel was used as a control. Mean moisture contents of the York gum boards (10.9 per cent) and brown mallet boards (11.8 per cent) indicated the boards were sufficiently dry for efficient gluing.

Applying the NaOH to the York gum boards before treatment and gluing with 'Grasp' was unsuccessful with all gluelines showing complete adhesive with no wood failure. The NaOH mobilised the extractives, which presumably remained on the surface of the board edges and restricted adhesive penetrating into the wood cells. Removing the extractives by wiping with a cloth may have improved glue penetration, but this would have also removed some NaOH solution. Applying NaOH as a pre-treatment will produce better results when gluing with a resorcinol adhesive compared to gluing with urea formaldehyde (Stone personal communications).

Balfas (1994) used three concentrations of the surfactants lithium hydroxide (LiOH) and sodium hydroxide (NaOH) as pre-treatments, before gluing regrowth jarrah and karri. Testing three concentrations, 0.5 M, 1.0 M and 2.0 M, he found that both surfactants significantly increased wettability and dry shear strength of the two regrowth eucalypts assessed. Increasing the concentration of NaOH increased the wettability of wood surfaces and conversely decreasing the concentration of LiOH increased surface wettability. Balfas found that 2.0 M NaOH gave the best results, but in the present trial 1.0 M NaOH was applied to York gum boards. Using a higher concentration of NaOH e.g. 2.0 M for gluing York gum or other Wheatbelt species may increase the ability of the chemical to remove extractives and other inactivating agents from wood surface and improve glueline strengths. However better results will be achieved when gluing with a resorcinol adhesive compared to gluing with urea formaldehyde.

NaOH is readily available and easier to use than LiOH, although safety procedures need to be followed when diluting and applying NaOH. Other surfactants e.g. acetone, alcohol benezene, nitric acid, hydrogen peroxide or di-ethylene-glycol may also be successful pre-treatments (Stone personal communications). Further trials with surface pre-treatments are required considering the success of Balfas when gluing karri and jarrah. For example, using higher concentrations of NaOH or removing the extractives when they are mobilised to the surface could be tried.

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The control treatment, which had no surface pre-treatment, produced successful results when gluing brown mallet with a mean wood failure of 85 per cent. Based on this result, the panels that failed in the second gluing trial (schedule B) and the remaining brown mallet and York gum panels were re-glued using this schedule i.e. four raspberry jam, three brown mallet and two York gum panels.

Brennan and Newby (1992) had difficulty gluing mulga, Dundas blackbutt (*E. dundasii* Maiden), gimlet (*E. salubris* F. Muell), redwood (*E. transcontinentalis* Maiden), and York gum, (all high density Goldfields timbers) with 'Grasp' and curing by hot pressing in a 'Orma' press for 10 minutes (edge-gluing) and 25 minutes (face pressing). A cold press cycle of hand clamping boards at room temperature (summer conditions in the processing shed) was used for edge gluing (approximately 12 h), then face gluing under 290 kPa in the 'Orma' press (without added heat) for approximately 12 h. This resulted in successful glue penetration and a strong bond.

Greep (1993) found that gluing spotted gum (*E. maculata* Hook.) boards with 'Grasp' by hot pressing could not be recommended, because the high density (air-dry density 1040 $kg.m^{-3}$) and tight curly grain of the timber, restricted adhesive penetration and produced weak bonds. Cold pressing over night at room temperature in the processing shed is recommended for gluing spotted gum with urea formaldehyde. Successful results were found when gluing with 'Resobond RA 3' by hot pressing at 90° C for 8 minute, for edge gluing or cold pressing over night for face gluing.

York gum and brown mallet could be successfully glued with Bunning's Timbachem 'Resobond RA 3 - W' (resorcinol formaldehyde) and P4 hardener by cold pressing for 24 h at 30° C. 'Resobond RA 3 - W' is a winter grade adhesive suited to gluing timber under cooler ambient conditions, as occur in the CTT processing shed during winter months. Resorcinol formaldehyde are waterproof exterior adhesives and are used to glue products used in external applications (e.g. signboards). Their cost is three to four times the cost of the interior adhesives (e.g. urea formaldehyde) and gluelines are dark red, which may be a disadvantage when panels are used in interior applications, where appearance is important (Brennan *et al.* 1996). If panels were used in exterior applications, 'Resobond RA 3 - W' could be used.

Adhesives such as melamine urea formaldehyde, which is used to glue pine particleboard and phenolic based adhesives, that could be used to glue dense Wheatbelt species. The strength of urea formaldehyde may be increased by adding a hardener e.g. ammonium chloride which could improve the performance of 'Grasp' when used to glue W.A. Wheatbelt species (Terrill personal communications).

Mr Stuart Terrill, CSIRO Division of Forest Products, Clayton, Victoria.

Problems with Cleavage Tests on Dense Hardwood

AS 1328 -1987 is used for assessing gluelines in structural timber products which are generally constructed with a lower density timber. The lower density and softer timbers tend to fail, instead of the glue when testing glueline strength using either the wet or dry cleavage tests. When assessing harder and denser timbers, the gluelines fail instead of the wood, even though the glueline strength is similar to that of gluelines in the softer timbers. Using this Standard may not be appropriate for dense timbers from the W.A. Wheatbelt.

Important Points When Gluing Dense W.A. Wheatbelt Species

1 Dry the timber to a moisture content between 10 and 12 per cent or lower. This will allow better penetration of glue into the wood cells, and reduce glueline failure caused by panels shrinking or swelling, which may occur while the timber is in-service.

2 Saw and machine the timber accurately. This will reduce the amount of torn fibres and broken grain, and give an intimate contact between the timber components to allow strong glue bonds to form.

3 Machine at slower feed and higher cutter head speeds. This will prevent excessive heating which can modify the wood surface and make it less adsorptive. Regularly sharpen and change planer blades.

4. Glue the timber within two to three days of machining. CSIRO recommend that in some cases, the timber may need gluing within minutes of dressing, as the surface wettability can change (Collins personal communications). This prevents the dressed surfaces from being contaminated with dust and other contaminants and removes any extractives that have migrated to the surface. In some cases re-machining may be required.

5. Prior to gluing, some species with high extractives and contaminants may need wiping with an organic solvent to remove these extractives and contaminants.

6. Test the wood surfaces to determine if they are wettable.

7. When gluing, apply an even and uniform amount of adhesive onto the wood surface.

8. When gluing with 'Resobond' or 'Grasp', the open assembly time is critical. This requires clamping the boards immediately after applying the glue, preferably within five minutes.

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9. Curing the adhesive requires an intimate contact between the board surfaces and a sufficient pressure needs to be applied by hand or mechanical clamps.

10. Mix and apply the adhesive according to the manufacturer's specifications, paying special attention to the pot life and how it is affected by temperature.

11. Assess glueline strengths using the dry cleavage test, for interior applications or the wet cleavage test for exterior applications, referred to AS 1328 - 1987.

Recommendations

For interior applications, schedule F above is recommended. This involves :

(i) Accurately machining the boards, at a slow feed and high cutter head speed.
(ii) Place board components into a controlled environment room at 30 °C for 24 h.
(iii) Evenly and uniformly apply 'Grasp' (urea formaldehyde) to the board surfaces.
(iv) Lay out the panel immediately after applying the glue, then apply pressure by hand clamping and
(v) Cure the glue in a controlled environment room at 30°C for another 24 h.

For exterior applications, schedule E above is recommended. This involves :

(i) Accurately machining the boards at a slow feed and high cutter head speed.
(ii) Placing board components into a controlled environment room at 30 °C for 24 h.
(iii) Evenly and uniformly applying 'Resobond RA 3 -W' (resorcinol formaldehyde) to the board surfaces.
(iv) Laying out the panel immediately after applying the glue, then apply pressure by hand clamping and
(v) Curing the glue in a controlled environment room at 30°C for another 24 h.

'Resobond RA 3' may also be suitable for gluing under these conditions, because in schedule D above they were glued at lower temperatures.

Species with a high extractives contents may require a surface pre-treatment e.g. 1M NaOH to remove the extractives and other surface contaminants. These need to be wiped from the surface before applying the adhesive.

Woodworking properties

Table 8 gives the sawing, planing, sanding, routing and finishing properties for raspberry jam, brown mallet and York gum. These wood working properties were assessed semi-quantitatively on a scale of 1 - very poor to 5 - excellent. When machining raspberry jam, York gum and brown mallet, it was difficult to machine at the conventional planing speeds used for regrowth jarrah and karri. To dress and sand these timbers to a smooth even finish required a slow feed and high cutter head speed. Planing speed was between 8 and 10 m/min, which is about half the speed used to

dress standard jarrah and Tasmanian blue gum (*Eucalyptus globulus* Labill. subsp. *globulus*) boards. Panel were sanded between 2.5 and 3.0 m/min, which is the same speed used for jarrah. Similar results were found with machining high density eucalypts from the Goldfields (Brennan and Newby 1992). Dressing and routing was excellent due to the fine grain. Timber with interlocked grain can be difficult to dress to a smooth surface. Working with hand tools can be heavy work and requires sharp tools. Routers and lathes overcome most of these difficulties. Routing with a standard router produced a fine smooth finish both along and across the grain. Local wood turners have reported good turning and polishing properties, producing a glass-like highly polished surface when working with a sample of raspberry jam, brown mallet and York gum.

Table 8
Woodworking properties of raspberry jam, brown mallet and York gum (Rating 1 = very poor to 5 = excellent)

Species	Sawing	Planing	Sanding	Routing	Finishing
Raspberry jam	4*	5	5 #	5	5
Brown mallet	4*	5	5#	5	5
York gum	4*	4*	5#	5	5

Very smooth finish achieved.
* A moderate feed speed required.
Sawing required a slower feed speed.

Nailing

Assessment of nailing behaviour involved hammering (at 20 mm from end of pieces) a standard 2 mm nail into fifteen raspberry jam, twenty brown mallet and eight York gum randomly selected pieces of timber. Forty per cent of the jam samples were severely split by nailing and in the remaining 60 per cent of samples the timber was too hard and the nails bent. All the York gum samples were too hard, with about a quarter of the nail being hammered into the samples before the nails bent. Ninety per cent of the brown mallet samples split during nailing. It is recommended that for dried boards, all three timbers be pre-drilled before nailing.

Sanding

Sanding in a wide belt sander, using 80 grit paper then 120 grit paper resulted in all three species being rated as excellent, i.e. producing very smooth surfaces. Brennan and Newby (1992) found that sanding high density species from the Goldfields also produced very smooth surfaces, when sanding with 80 grit paper then 120 grit paper.

Finishing

Half the panels were sealed with sanding sealer and the other half with two coats of one pack polyurethane. The finish on the panels was excellent with the distinctive colours and grain of the different species clearly shown.

CONCLUSION

Raspberry jam, brown mallet and York gum can be successfully processed into high value products that can be used in furniture manufacture. If gluing is involved, high densities of the timber can restrict adhesive penetration and result in a weak glue bond, particularly if the adhesive is cured in a hot press. Gluing by pre-heating the boards at 30°C for 24 h, applying pressure by hand clamping and curing at 30°C for another 24h is recommended. Using a surface pre-treatment to remove any extractives from the surface may improve glue penetration and increase the strength of the joint, particularly when gluing with resorcinol adhesives.

When machining the timber, it is difficult to machine at the conventional planing speeds used for regrowth jarrah and karri. To dress and sand these three timbers to a smooth even finish it is recommended that a feed of 8 to 10 m/min and high cutter head speed be used for planing and 2.5 to 3.0 m/min for sanding. The smoothness of the wood surface and straight or interlocked grain make raspberry jam, brown mallet and York gum excellent timbers for furniture, turning and carving. Attractive colours are common, with raspberry jam a reddish brown to dark brown or honey brown with green streaks in the timber, brown mallet a pale red-brown to grey-brown with dark streaks and York gum a yellowish brown to dark brown.

Given the high value of the timbers of the W.A. Wheatbelt, particularly the three species studied in this trial, a promising future exists for a value adding industry supplying speciality and craftwood timbers from this region.

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