NUT QUALITY CHARACTERISTICS OF MACADAMIA CULTIVARS
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ABSTRACT
Sixteen macadamia cultivars were chosen in order to assess nut quality. Samples of these cultivars were taken from two cultivar trials planted at four different localities. The samples were evaluated for crack out percentage, kernel mass, percentage No.1 kernels, oil content, susceptibility to rancidity and organoleptic aspects. Due to R-square values above 0.8 for the first three characteristics it can be concluded that most of the variation in quality is due to cultivar characteristics or genotypic variance. Therefore, the environment does not play a large role in macadamia nut quality expression. It can further be concluded that cultivars Hidden Valley A4 and A16 as well as cultivar 788 performed the best according to these quality indicators. However, cultivars performed differently in specific regions regarding sound kernel recovery per tree.

INTRODUCTION
The macadamia industry in South Africa is growing at an enormous pace. In the past the emphasis was primarily placed on high yield and crackout percentage in identifying cultivars for new plantings. The cultivar trials now coming into bearing provide the opportunity to shift the emphasis towards quality attributes, in order to provide growers with a more comprehensive picture of cultivar performance.

To compete on international markets, macadamia nut quality is becoming more important in order to improve the general perception regarding quality of South African macadamia export products. Macadamia is thus no different from other subtropical crops in the sense that superior quality kernels obtain the highest prices. It is therefore necessary to evaluate all the cultivars available in South Africa for quality indicators such as nut mass, kernel mass, crack out percentage, percentage No.1 kernels, oil content, susceptibility to rancidity and organoleptic aspects.

This paper reports on quality characteristics of the different cultivars at various cultivar trial sites in South Africa. This will make it possible to consider the quality indicators in future when cultivar recommendations are made. The yield and the tree dimension data of these trials are described in an article by Swanepoel, Kuperus, Smart, Hobson and Grové (1998) published elsewhere in this yearbook.

MATERIALS AND METHODS
The experimental design of the different orchards are described in the above-mentioned article (Swanepoel, Kuperus, Smart, Hobson and Grové, 1998). Samples were taken from the Sapekoe trials when nuts were harvested in March, April and May. Nuts collected from ITSC trials were stored after dehusking and at the end of the harvesting season one sample was taken from each plot. A representative sample was then taken from the different samples of the same cultivar and analysed for the quality indicators for each locality.

From each sample the mass of one hundred nuts was determined before cracking. After the nuts were cracked, the kernels were separated from the shells by hand. The kernels were then weighed to determine the crack out percentages. After the No. 1 kernels were isolated from the rest by floatation in tap water, the first grade whole kernels were counted.

The oil percentages for the different cultivars were only done for the first grade kernels (floaters). The oil extraction was done by the Soxtec analyser with petroleum ether. Kernels
used for this process were dried to a moisture content of 0%, after being grated. As a result of this the oil content was presented as a percentage of the dry mass of the kernels.

The Oxidative Stability Indexes (Rancimat) for the Sapekoe trials were determined by the Perishable Products Export Control Board Quality Assurance Laboratory (PPECB). These indexes can be used as an indication of the shelf life of the kernels.

RESULTS AND DISCUSSION
The results for the quality characteristics for the four different localities are presented in Figures 1, 2, 3, 4, and 5. In each graph the different bars illustrate the performance of a specific cultivar at a specific locality. However, the sequence of the cultivars on the X-axis is an indication of the relative performance of the cultivars averaged over all the localities. As an example, Fig. 3 illustrates that A4 produced the highest percentage No. 1 kernels over all the localities, with 816 at the lower end of the range and 300 performing the best at Merensky. The statistical grouping indicating significant differences between cultivars, are in each case showed on the different bars.

Kernel size
In Fig. 1 the kernel mass of the different cultivars are presented. A tendency, where two groups can be noticed, is present in the variation at all the localities. The first group consist of A4, N2 and A16, which consistently produce large kernels. All three of these cultivars are hybrids with average kernel mass over the four localities of 3,338 g.kernel\(^{-1}\), 3,124 g.kernel\(^{-1}\) and 2,869 g.kernel\(^{-1}\) respectively. The other group contains all the *Macadamia integrifolia* cultivars as well as 695. The boundary between these two groups is most clearly seen at Burgershall and Sapekoe where the differences between cultivars proved to be significant. However, the average mass of A4 is also significantly larger than that of A16. It is also interesting that the smallest average kernel mass is produced at Merensky, probably because they produced the heaviest crop in 1998. The only cultivars that produced overall smaller kernels than 344 (the most widely planted cultivar in South Africa) is 789 and 660, which averaged 1,874 g.kernel\(^{-1}\) and 1,800 g.kernel\(^{-1}\) respectively. The R-square for kernel mass over the four localities varied from 0.897 to 0.981, indicating that variation in mass is almost entirely attributable to the genotype of a cultivar. Therefore, environment does not seem to influence the mass of the kernels.

Crack out percentage
The different crack out percentages for the respective trial sites are presented in Fig. 2. Hidden Valley A4 performed the best with an average crack out percentage of 38.1% calculated for all trial sites. In contrast 344's average crack out percentage was as low as 27.3%. In the whole cultivar range significant differences occurred between the localities, but the tendency for the variation within different trial sites, proved to be the same. Again, like in the case of kernel size, the R-square values for Burgershall, Merensky and Sapekoe were very high (0.857 - 0.975), indicating that environmental influence on crack out percentage was negligible.

Percentage No. 1 kernels
Figure 3 illustrates the average percentage floating kernels (floaters). In this case 741 produced the best results, with an overall average of 97.3% floaters. However, this might be due to the fact that 741 was only included in the Sapekoe trial. In the second place A4 produced an average of 96.4% floaters, calculated for the three trial sites. It is also worthwhile to mention that in the Burgershall trial only A16 and 695 differed significantly from 789, and in the Sapekoe trial only 816 differed from the rest of the cultivars.
FIGURE 2: Average crack out percentage of macadamia cultivars at four different localities.
Oil percentage
As would have been expected, the cultivars with the highest percentage No. 1 kernels produced kernels with the highest average oil percentage. These results are shown in Fig. 4. Hidden Valley A4 produced kernels with the highest oil percentage, like in the case of crack out percentage and kernel mass. At the lower end of the range only 816 performed worse than 344. Of all the quality characteristics discussed in this article, the lowest R-square values were calculated for oil percentage, varying from 0.396 to 0.716 for the different localities. This shows that the environment does influence some quality aspects of cultivars. This is confirmed by the variation in oil percentage of 695. This percentage varies from 78.6 at Sapekoe down to 74.7 at Burgershall.

Oxidative stability index
In Figure 5, the oxidative stability indexes for the kernels as an indication of its shelf life are presented. The principal is that the longer the kernels take to turn rancid, or to oxidate at 110°C, the longer their shelf life would be. Unfortunately the exact length of shelf life cannot be estimated, but the cultivars can relatively be compared with one another. In the graph it can be seen that only 695 and A16 have an estimated shorter shelf life, the shelf life of the other cultivars are approximately the same, with 816 performing the best.

In order to determine which cultivar performed the best according to quality, a rating was given to each cultivar for the characteristics: kernel mass, crack out percentage, percentage No.1 kernels and percentage whole kernels recovered. Further, suggesting that each of these aspects are equally important for quality, the best eight performing cultivars for each locality were ranked in Table 1. The cultivar in the top position performed the best at a specific trial site.

Table 1  Quality comparison for macadamia cultivars in different regions.

<table>
<thead>
<tr>
<th>Burgershall</th>
<th>Levubu</th>
<th>Merensky</th>
<th>Sapekoe</th>
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</thead>
<tbody>
<tr>
<td>A16</td>
<td>A4</td>
<td>816</td>
<td>A4</td>
</tr>
<tr>
<td>A4</td>
<td>A16</td>
<td>789</td>
<td>A16</td>
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<tr>
<td>788</td>
<td>788</td>
<td>788</td>
<td>816</td>
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<tr>
<td>344</td>
<td>660</td>
<td>816</td>
<td>816</td>
</tr>
<tr>
<td>836</td>
<td>Neimak 2</td>
<td>800</td>
<td>695</td>
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<tr>
<td>800</td>
<td>695</td>
<td>814</td>
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<tr>
<td>814</td>
<td>791</td>
<td>863</td>
<td>344</td>
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</table>

The general good performance of A4 is highly noticeable in the preceding table. Unfortunately A4 and A16 were not included in the Merensky trial and 788 not in the Sapekoe trial. However, these three cultivars are repeatedly under the first three top performing cultivars at the respective trial sites. Unfortunately these three cultivars are not the top performers according to yield.

A better indication of which cultivars performed the best is presented in Table 2, according to the estimated sound kernel production. The values were calculated by means of the following equation:
FIGURE 5: Oxidative stability index for macadamia cultivars planted at Sapekeo.
\[ a = \frac{b}{c} \]

Where  
- \( a \) = Sound kernel production relative to the average of the locality  
- \( b \) = Yield x crack out % x %No.1 kernels  
- \( c \) = Average of (Yield x crack out % x %No.1 kernels) per locality

The division by the average was included in order to identify the cultivars performing above/below average, where average is equal to one. The yield data used in these calculations are presented in the article of Swanepoel, Kuperus, Smart, Hobson and Grové elsewhere in this yearbook.

**Table 2** Performance of macadamia cultivars according to sound kernel production for the ITSC trials.

<table>
<thead>
<tr>
<th>Burgershall</th>
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<th>Levubu</th>
<th></th>
<th>Merensky</th>
</tr>
</thead>
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<tr>
<td>863</td>
<td>2.27</td>
<td>A4</td>
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<td>814</td>
<td>1.83</td>
<td>695</td>
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<td>814</td>
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<td>791</td>
<td>1.82</td>
<td>Nelmak 2</td>
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<td>791</td>
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<tr>
<td>695</td>
<td>1.42</td>
<td>791</td>
<td>1.25</td>
<td>344</td>
</tr>
<tr>
<td>A4</td>
<td>1.40</td>
<td>814</td>
<td>0.93</td>
<td>695</td>
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<tr>
<td>Nelmak 2</td>
<td>0.88</td>
<td>A16</td>
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<td>788</td>
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**CONCLUSION**

In general A4, A16 and 788 were the best cultivars regarding production of high quality macadamia kernels, but the yield of these cultivars is low according to preliminary yield data. Although quality is less influenced by the environment than yield, high sound kernel recovery for certain cultivars is highly restricted to certain areas. This results in the fact that although higher quality kernels sell at higher prices, a cultivar with a high yield and a lower quality is not necessarily less profitable than a cultivar with a high quality and lower yield.

**ACKNOWLEDGEMENTS**

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**REFERENCES**