The Aroma and Taste Characteristics of Different Cultivars of *Olea Europaea* Grown at Roseworthy, South Australia.

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Abstract

The aroma and taste profiles of olive oils made from three different cultivars (Arbequina, Coratina, and Picual) grown at Roseworthy, South Australia and harvested at similar maturities were compared over two seasons. The aroma and taste profiles of three further varieties (Barnea, Paragon and Pendolino) harvested in a single season were also assessed. In the first season, the Picual oil was significantly lower, and the Pendolino and Coratina oils were significantly higher in bitterness and pungency compared to the other varieties. The Coratina oil was also significantly more flavoursome than the Arbequina oil. However, the tasters were unable to discriminate any specific aroma differences between the oils. In the second season, the oils were perceived to have different aroma profiles. The Arbequina oil showed the most intense caramel and raw potato characters, the Picual was highest in guava character, and the Paragon and Coratina oils higher in grassy character. The Barnea and Paragon cultivars produced oils with the least overall aroma. Consistent with the previous season, the Coratina oil was the most bitter and pungent.

Introduction

The plantings of most olive growing regions in Europe are dominated by a single or at most, a small number of cultivars. As an example, the variety Picual accounts for over 90% of plantings in the Jaen region of Andalucia. Similarly, the Koroneiki cultivar dominates plantings in the Peleponese Peninsula of Greece, as does Frantoio in Tuscany.

In contrast to this varietal concentration, most Australian regions are typically planted to a large number of varieties of various national origins. For example, it is not unusual for a single Australian region to have substantial plantings of the cultivars Picual, Paragon, Manzanillo, Leccino, Frantoio, Koroneiki and others. Furthermore, as other varieties such as Coratina and Arbequina have become available, they too have been trialed and planted for commercial production.

To date, the selection of varieties by Australian olive growers appears to have been conducted primarily on the basis of expected oil yield, horticultural factors such as frost tolerance, expected time to bearing, perceived market acceptability of the variety, and the availability of planting material. However, it appears that sensory aspects of the olive oil such as desirable aroma/flavour profiles or appropriate levels of bitterness and pungency to meet a particular market requirement, have rarely been considered when the varieties have been selected. For example, some anecdotal evidence exists that some Australian regions are currently dominated by varieties that produce oils with bitterness in excess of what the market currently demands, and that due to the

dominance of stylistically similar varieties, blending options are not readily available (Gawel, 2005).

It is likely that a lack of information concerning the sensory characteristics of different varieties grown under Australian conditions has been one of the reasons why aroma and taste criteria have not been widely applied in variety selection decisions. This research begins to address the lack of knowledge regarding the aroma and taste profiles by comparing olive oils made from different varieties of trees grown at a single Australian site and made in an identical fashion. Such information is necessary to ensure that growers plant varieties which have both the aromas and flavours, and perhaps more importantly, are of a style desired by their customers. With more reliable information arising from formal sensory assessment, it is hoped that better informed planting decisions may be made in the future.

Methods

The Site and Varieties Selected for Comparison

The olive varieties selected for sensory analysis for the 2002 season were (with their maturity index as described by Hermosa et al. (1997) given in brackets): Picual (3.2), Coratina (3.1), Arbequina (3.0) and Pendolino (2.7). For the 2003 season the varieties compared were Picual (3.4), Coratina (2.5), Arbequina (3.8) and Paragon (3.0). Samples were collected as close to maturity index 3 as possible but it was difficult to achieve this exact maturity index due to variability within the varieties. Some varieties chosen in this study - Barnea, Picual, Pendolino and Paragon have been planted in many Australian regions while Arbequina and Coratina are becoming increasingly popular and as such were included for comparison.

The site was chosen for this study was at the Roseworthy Campus of the University of Adelaide, 45 km NNE of Adelaide, South Australia (34^{o} 31' 35'' S, 138^{o} 41' 26''W), elevation 72 metres. Its climate can be categorised as 'Mediterranean' with hot dry summers and mild to cool wet winters. As such, it can be considered to be typical of a number of olive growing regions of South Eastern and South Western Australia. The collection was planted in 1998 and was sourced from nurseries and collections across Australia. The identity of the cultivars used in this study were confirmed by comparing their DNA fingerprints with standards obtained from trees in a number of international and Australian collections (Sweeney, 2003).

Production of Oil Samples for Tasting

Oil samples were extracted from 1.8 kg of freshly picked and washed fruit using a mini-extraction unit. The fruit was crushed with a hammer mill, malaxed for 30 minutes at 28^{o}C for 30 minutes. The oil was separated from the aqueous material following 2 minutes of centrifugation and decantation. The oils were then filtered through cotton wool before being stored in the dark at 4^{o}C in dark amber bottles. The 2002 Picual sample was treated with 2% talc due to difficulties in extracting the oil.

Sensory Methods

Twelve tasters assessed the oils approximately 8 weeks after they were extracted. All tasters were initially selected by demonstrating their ability to accurately rate the intensity of olive fruit and of olive oil defects. Nine of the twelve tasters had participated in an ongoing oil assessment training program for a period of six years and had regularly assessed the intensity of fruit, bitterness and pungency of Australian and European olive oils. The remaining three tasters had six months experience conducting this form of tasting.

The five oils were presented to the tasters in blue olive oil tasting glasses which masked the appearance of the oils. No information regarding the identity of the oils was provided to the tasters. The tasters were asked to smell the oils and independently list the aroma attributes perceived. The chosen aroma

descriptors were compiled and discussed amongst the tasters until a consensus was achieved regarding the relevant aroma attributes of the oils.

The olive oils were presented in a randomised order and the intensities of the selected aroma attributes, overall flavour, bitterness and pungency were assessed using a ten point structured category scale, with 0 being not detected, 1=just perceptible, 3=slight, 5=moderate, 7=strong and 10=extremely strong. The presentation order was then re-randomised and the oils re-evaluated.

As there was no prior training in the identification or rating of aroma attributes, the ability of tasters to reproduce their ratings was used as a criterion for inclusion of the taster's data to create the sensory profiles. Reproducibility was calculated by simply correlating the ratings given to the same oil over the repeat tastings.

The sensory profile of the five oils was produced by calculating the mean of the intensity ratings provided by the judges who were able to adequately reproduce their ratings. Significance between means was determined by two way ANOVA with interaction (assessor x variety) whereby assessors were considered a random effect and variety a fixed effect.

Results and Discussion

Variety Effect on the Aroma and Taste Profile

For the 2003 season, significant intensity differences were observed for the overall aroma, and for the specific aroma attributes 'caramel', 'green grass', 'guava', and 'raw potato' (Table 1). Specifically, Arbequina was significantly higher in 'caramel' aroma than all other varieties and was also significantly higher in 'raw potato' character than all varieties other than Coratina (Table 2 and Figure 1). Morales et al. (1995) found that compared with Coratina and Picual, Arbequina produced oils with more intense 'artichoke' aromas, a trait which was independent of ripeness of the olive fruit at harvest (Morales et al. 1996). These authors attribute this character to the existence of the compound (E)-3-hexenal. This compound has also been described as being green vegetable like (Anon, 2003) which may equate to the 'green potato' characters perceived by the tasters in this study. Many of the oils displayed a similar degree of 'green grassy' and 'green tomato' aroma, although Paragon and Coratina were most distinct in these respects (Table 2). These two varieties were picked at a less mature stage which may explain the 'greener' nose displayed by these oils. However, green aroma notes and/or high levels of the herbaceous compound (E)-2-hexenal have previously been reported in Coratina oils from Puglia (Morales et al. 1995) and Sicily (Benincasa et al. 2003).

The 2003 Picual oil was strongly characterised by an intense 'guava' like aroma, an attribute perceived in very low levels in the other varieties (Table 2 and Figure 1). This aroma characterised this variety for this harvest season, and to the best of our knowledge this descriptor for Picual oils has not been reported elsewhere in the literature. However, together with 'tomato', the term 'guava' has often been used to describe Australian Picual oils by judges in Australian olive oil shows (Gawel, 2005). Further studies are required to determine whether this is a characteristic of Picual oils grown at this site, or whether it was simply a different interpretation of another aroma. The latter explanation is a possibility as tasters did not have access to aroma references, and were therefore reliant on their past experience and memories of the selected aroma attributes. However, as it can also be reasonably expected that climatic conditions affect the formation of volatile compounds contributing to aroma and flavour (Vichi et al. 2003), the occurrence of a guava like aroma in this Australian Picual is equally feasible.

The 2003 Picual, Coratina and Arbequina oils had equally intense overall aromas, and were in turn more intense than the Barnea or Paragon oils (Table 2). Little difference in the overall aroma intensity of Coratina, Picual and Arbequina oils grown in three different regions have also previously been reported (Morales et al. 1996). The differences in overall flavour were less pronounced, with no variety showing significantly higher levels than another. However, the Coratina oil was more pungent and bitter than the other varieties. The Arbequina, and Paragon were the least bitter of all the varieties. The Coratina variety has been consistently reported as being a high polyphenol producer compared with Picual and Koroneiki oils (Stefanoukaki et al. 2000). In direct taste comparisons, the bitterness and pungency of Coratina oils have been shown to be higher that that of Picual and Arbequina oils (Aparicio and Luna, 2002) and of Picual and Koroneiki oils (Stefanoukaki et al. 2000). It is noteworthy that in this study the 2003 Coratina olives were harvested at a less mature stage than the other varieties which may explain the higher level of bitterness and pungency displayed in these oils (Morello et al. 2004). However, the Coratina oil produced in the previous year also displayed a high level of bitterness and pungency but was picked at an intermediate ripeness compared with the other varieties (Table 4). This suggests that the robustness displayed by the Coratina oil was a variety rather than a maturity effect.

For the 2002 harvest oils the judges did not discriminate any significant differences between the intensities of any of the individual aroma attributes (Table 4). This may have been either the result of climatic factors which reduced varietial differences between the oils or a lack of aroma discriminative power of the assessors. Significant differences in palate attributes were observed with the Coratina oil being the most flavoursome, and the Pendolino oil, the most bitter and pungent. The latter result may be a maturity effect as the Pendolino oil was harvested at a less mature stage than the other varieties. At the other end of the style spectrum, the Picual oil was the least bitter and pungent, and the Arbequina and Pendolino oils the least flavoursome. The reasons for these differences are unclear.

Conclusion

Olive oils made from different cultivars grown at the same location at Roseworthy, South Australia displayed different aroma and flavour profiles in one of the two years under study. The different cultivars also produced oils which differed stylistically in that they showed different levels of flavour, bitterness and pungency. This study shows that sensory criteria can be used in addition to horticultural criteria when deciding upon appropriate cultivars to plant for a given site. However, the cultivar effects reported here are only relevant to the site under study as their generality to different sites and climatic conditions has yet to be tested.

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	Variety	p	Judge x Variety Interaction	p
Aroma Attributes				
Rocket	0.46	0.765	1.42	0.123
Caramel	2.68	0.050	3.70	0.001
Green grass	5.27	0.002	1.09	0.383
Apple	0.64	0.640	2.04	0.010
Guava	19.71	0.001	0.79	0.770
Green banana	0.96	0.439	1.16	0.310
Green tomato	1.04	0.402	1.53	0.082
Raw potato	4.17	0.007	1.54	0.077
Floral	0.88	0.483	1.31	0.184
Overall aroma	2.81	0.040	1.57	0.070
Palate Attributes				
Flavour	1.43	0.245	1.61	0.061
Bitterness	14.86	0.001	1.27	0.213
Pungency	14.06	0.001	1.62	0.057

Table 1: Analysis of variance statistics of aroma and palate attribute ratings of 2003 varietal olive oils.

Variety	Arbequina	Barnea	Coratina	Paragon	Picual	LSD 5%
Aroma Attributes						
Rocket	1.7 ^{a}	1.5 ^{a}	1.8 ^{a}	2.0 ^{a}	1.3 ^{a}	ns
Caramel	2.8 ^{b}	1.2 ^{a}	1.1 ^{a}	0.5 ^{a}	0.4 ^{a}	1.0
Green grass	4.1 ^{bc}	3.7 ^{ab}	4.8 ^{cd}	5.1 ^{d}	2.9 ^{a}	1.0
Apple	1.8 ^{a}	2.1 ^{a}	2.1 ^{a}	2.9 ^{a}	1.9 ^{a}	ns
Guava	1.3 ^{a}	0.8 ^{a}	0.4 ^{a}	0.5 ^{a}	4.4 ^{b}	1.1
Green Banana	2.2 ^{a}	2.2 ^{a}	1.9 ^{a}	1.3 ^{a}	1.8 ^{a}	ns
Green Tomato	2.6 ^{ab}	1.8 ^{a}	2.8 ^{ab}	3.1 ^{b}	2.5 ^{ab}	ns
Raw Potato	3.5 ^{c}	1.1 ^{a}	2.4 ^{bc}	0.9 ^{a}	1.9 ^{ab}	1.3
Floral	0.6 ^{a}	1.1 ^{a}	0.9 ^{a}	1.1 ^{a}	1.2 ^{a}	ns
Overall aroma	6.3 ^{b}	5.5 ^{a}	6.1 ^{b}	5.4 ^{a}	6.3 ^{b}	0.6
Palate Attributes						
Flavour	5.0 ^{a}	4.8 ^{a}	5.4 ^{a}	4.6 ^{a}	5.1 ^{a}	ns
Bitterness	4.2 ^{ab}	4.7 ^{b}	6.7 ^{c}	3.8 ^{a}	4.7 ^{b}	0.7
Pungency	4.7 ^{a}	4.7 ^{a}	7.0 ^{b}	4.9 ^{a}	4.6 ^{a}	0.7

Means superscripted with different letters are significantly different at 5% significance level.

Table 2: Mean Attribute Ratings of 2003 Varietal Olive Oils

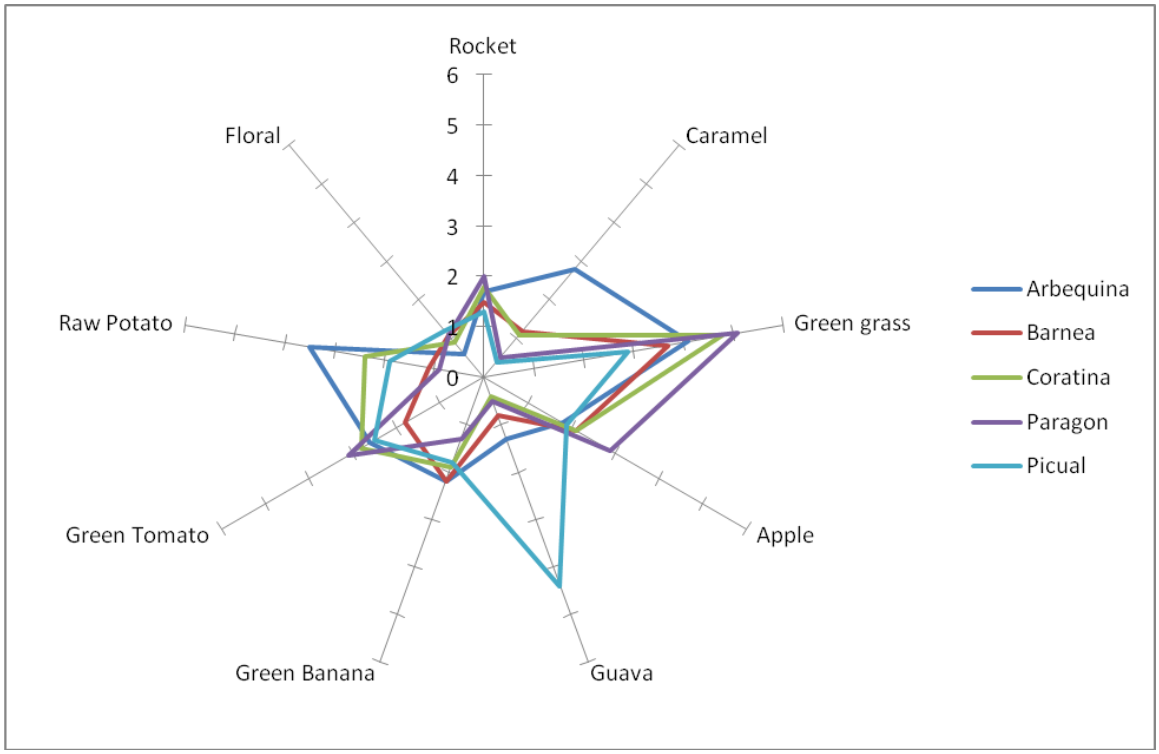

Figure 1: Mean attribute ratings for aroma attributes of 2003 varietal oils.

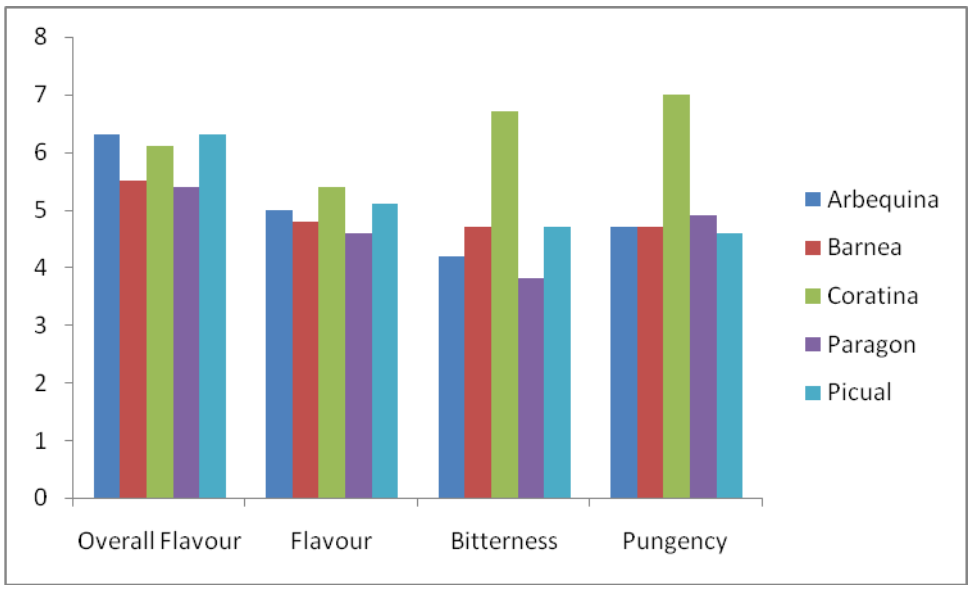

Figure 2: Mean attribute ratings for overall aroma and palate attributes 2003 season.

	Variety	p	Judge x Variety Interaction	p
Aroma Attributes				
Apple	0.67	0.583	1.01	0.478
Green grass	1.87	0.170	1.57	0.139
Hay	0.72	0.554	0.99	0.499
Caramel	0.51	0.683	0.89	0.591
Pepper	0.46	0.712	0.81	0.678
Green tomato	0.19	0.903	0.88	0.600
Floral	0.60	0.623	1.13	0.377
General Attributes				
Overall flavour	2.46	0.095	0.59	0.879
Bitterness	5.26	0.009	0.51	0.928
Pungency	3.68	0.032	0.52	0.924

Table 3: Analysis of variance statistics of aroma and palate attribute ratings of 2002 varietal olive oils.

Variety	Arbequina	Coratina	Pendolino	Picual	LSD 5%
Aroma Attributes					
Apple	0.0 [a]	0.4 [a]	0.2 [a]	0.1 [a]	ns
Green grass	2.8 [a]	3.3 [a]	3.7 [a]	4.1 [a]	ns
Hay	0.7 [a]	0.8 [a]	0.5 [a]	0.3 [a]	ns
Caramel	1.1 [a]	1.0 [a]	0.5 [a]	0.8 [a]	ns
Pepper	2.3 [a]	2.1 [a]	1.7 [a]	2.2 [a]	ns
Green tomato	1.1 [a]	0.7 [a]	0.8 [a]	1.3 [a]	ns
Floral	0.0 [a]	0.1 [a]	0.2 [a]	0.1 [a]	ns
General Attributes					
Overall flavour	2.8 [a]	3.7 [b]	3.1 [ab]	3.5 [ab]	0.9
Bitterness	3.6 [a]	4.5 [ab]	5.3 [b]	2.8 [a]	1.7
Pungency	5.2 [ab]	5.4 [ab]	5.7 [b]	3.8 [a]	1.7

Table 4: Mean Attribute Ratings of 2002 Varietal Olive Oils

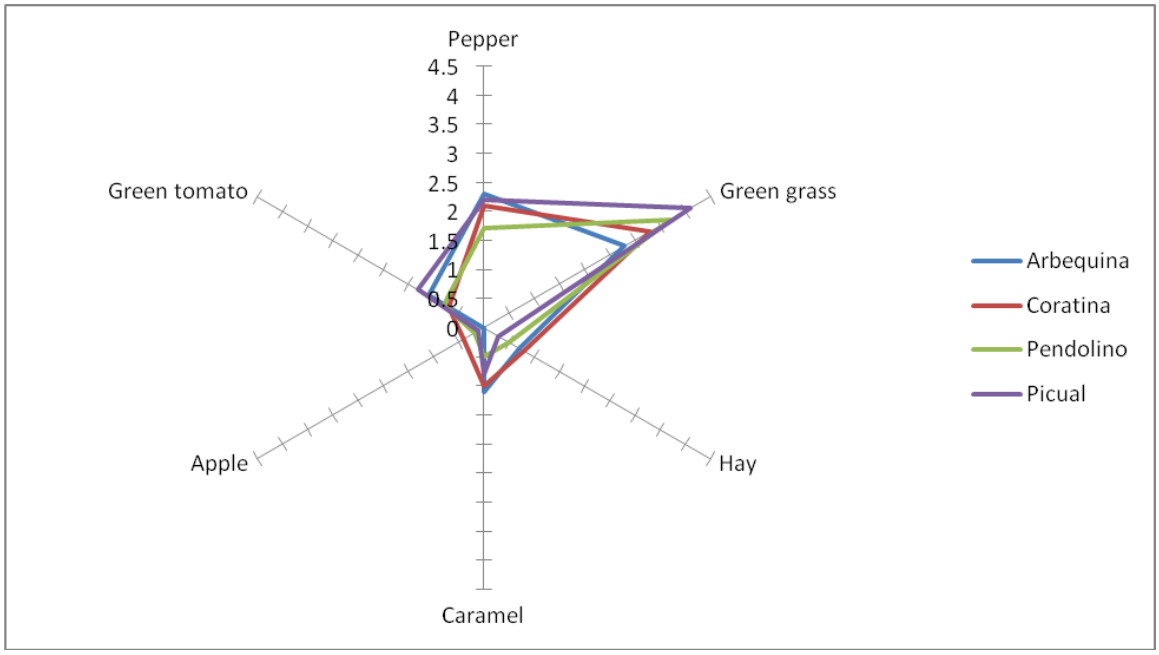

Figure 3: Mean attribute ratings for aroma attributes of 2002 varietal oils.

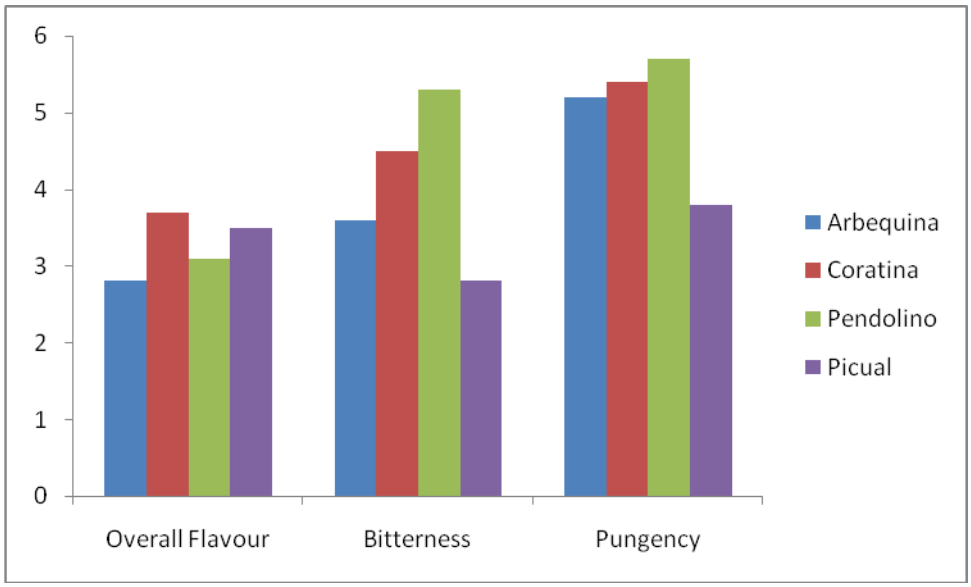

Figure 4: Mean attribute ratings for palate attributes 2002 season.