Oat groat colour - a quality factor

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Abstract

Colour has been identified as an important component of consumer judgement of oat (*Avena sativa* L.) based products. In this study, industry experts assessed colour preference for 30 cereal samples (including oat cultivars Makuru, Drummond and Charlton) that had been selected from 129 samples screened to maximise the colour range. Colour of the samples was quantified with a chroma meter using the CIE L*a*b* system. This measures colour on a three dimensional model using a* (red-green axis), b* (yellow-blue axis) and L* (reflectance). L*a*b* are combined to define colour through hue, chroma and lightness. Regression analysis indicated preference was related to the a* (r^2 = 0.64) and hue (r^2 = 0.59) components of colour, and not L*, b* or chroma (r^2 <0.04). The most preferred samples had low a* (<6.0) and high hue (>77) values, indicating preference was related to movement from the red to the yellow region of the colour space. Drummond was the most preferred (P<0.05) cultivar, and had a lower (P<0.05) a* value (6.5) than Charlton (7.5). Kilning increased (P<0.05) the L* and b* components of colour but did not affect the a* component and therefore would not affect preference. Results from a 1994/95 field experiment with Drummond grown at three sites in Gore indicated that nitrogen application (100 and 200 kg N/ha) and sowing rate (100 and 200 kg/ha) did not influence a* or hue values. The application of chlormequat (1.5 kg ai/ha) increased (P<0.05) the a* value from 5.32 to 5.52, but both values were in the preferred range. Agronomic and processing options to improve consumer preference for the colour of oats seem limited. However, 40 of the original 80 breeders lines screened had a* values lower than 6.0 and thus offer potential for improved consumer preference.

Additional key words: *chlormequat, chroma, CIE L*a* b*, groat colour, hue, kilning, nitrogen, oat quality, sowing rate*

Introduction

Oats (*Avena sativa* L.)for milling, or industrial oats, represent about 25% of the total New Zealand crop (Dunbier and Bezar, 1996). Milling removes the husks from the kernel with the objective to produce a finished product that has an attractive appearance, agreeable taste, and meets end user's demands (Ganβmann, and Vorwerck, 1995). If a colour is unappealing, consumers have been shown to decide products are of poor quality without trial (Francis, 1980).

The cultivation of milling oats, under contract, worldwide and in New Zealand, means it is important for oat breeders and farmers to know millers' requirements for high quality oats. In New Zealand, the most commonly grown industrial oat cultivar has been Makuru. Cameron (1994) reported that Makuru produced dark uneven coloured groats that were unacceptable to industrial customers. This was consistent with international quality guidelines that exclude dark groats (Ganβmann and Vorwerck, 1995). However, visual perception of colour is qualitative and differs between individuals (Gonnet, 1995), and thus quality guidelines are often qualitative and ambiguous. This study was undertaken to quantify the industry preferred colour of oat groats, and to identify reasons for colour variation in New Zealand oats.

The perception of colour can be fully described by three components; hue, chroma and lightness. Hue is described by a word (e.g., red) while chroma relates to the intensity of colour (e.g., pink to red), and lightness is related to the total amount of light that the eye receives (Gonnett, 1995). These three parameters cannot be measured directly from the reflectance of an object (Morgenstern, 1992) and therefore the "L*a*b* colour spacer", as defined by the International Commission of Illumination (CIE), is used to quantify human perception of colour. L* denotes the lightness of an object on a scale from zero (black) to 100 (white) and is equal to the reflectance of an object. The a* is a value on a red-green scale and b* is on a yellow-blue scale. The a* and b* values are transformed to generate values for hue and chroma with the following equations (Little, 1975).

$$\text{Hue angle} = \tan^{-1} b/a \quad (1)$$
$$\text{Chroma} = (a^2 + b^2)^{1/2} \quad (2)$$

The first objective of this study was to quantify the range of groat colours from New Zealand oats and to identify the industry preferred colour. A second objective was to determine whether any colour components were influenced by common agronomic and processing practices. Specifically, the effects of nitrogen and chlormequat applications, sowing rate and kilning on oat groat colour were examined. Awareness of the causes of variation may enable the development of on-farm, processing, or breeding strategies to enhance oat colour.

Materials and Methods

Colour Assessment

The 125 hulled oat samples screened for colour were from three sources. Duplicate samples of cultivars Drummond, Makuru and Charlton were obtained from 1995 seed stocks from Fleming and Co. in Gore. Also included were 80 breeders lines from Crop & Food Research in Gore, 24 samples from a Crop & Food agronomic trial in Gore, and 15 samples from a kilning trial at Lincoln. Three cultivars of wheat (*Triticum aestivum* L., cvs. Arawa, Endeavour and Kotuku) and a breeders line of grey barley (*Hordeum vulgare* L.), obtained from Crop & Food Research, Lincoln, were added to extend the grain colour range (Penno, 1996).

A Minolta CR-210 chroma meter calibrated to a standard white tile (L* = 98.07, a* = -6.23, b* = 1.88) was used to obtain duplicate L*a*b* readings for each grain sample. Readings were taken under standard fluorescent light conditions, with grain placed in a 20 mm deep glass petri dish on non-shiny black paper.

After this initial screening a subsample of the two samples with the highest and lowest L*a*b* values, and the three oat cultivars, was placed in an oven calibrated to 128°C for 30 minutes to simulate kilning (Cameron, 1994).

Thirty samples with the widest L*a*b* values (Table 1), that included kilned and unkilned oats, duplicates of the oat cultivars, wheat cultivars Arawa and Endeavour and the grey barley sample were selected for preference evaluation by three industry experts. Each expert ranked the set of 30 from most (1) to least (30) preferred.

Agronomic experiment

Samples from a 2 x 2 x 2 factorial experiment of Drummond, replicated over three sites in Southland, were used to examine the effect of sowing rate (100 and 200 kg/ha), nitrogen (0 and 100 N kg/ha) and chlormequat (Cycocel® 750) growth regulator (0 and 1.5 kg ai/ha) on groat colour. Further experimental details were reported by Penno (1996).

Statistical analyses

Least squares regression (Minitab, 1989) was used to examine the relationship between the mean preference rank and colour components. The difference in colour between the 15 kilned and unkilned oats was analysed with a 't-test'. A one-way analysis of variance was used to examine differences among the three cultivars. The factorial agronomic experiment was analysed using analysis of variance (Minitab, 1989), with least significant difference (LSD) tests used for means separation.

Results

Colour preference

Results of the initial screening of oat and wheat samples showed L* values ranged from 57.51-64.29, a* values from 5.01-8.65 and b* values from 22.10-28.70 (Table 1). Kilning increased ($P<0.05$) the mean L* value from 60.8 to 62.1 and b* from 24.6 to 26.6, but the a* (6.4) component was unchanged. The grey barley sample was the least preferred by all experts and had significantly lower L*a*b* values than all other samples (Table 1). It was therefore considered an outlier and excluded from further analysis of preference. There was no relationship between preference and L* ($r^2 = 0.05$), b* ($r^2 = 0.03$) or chroma ($r^2 = 0.00$). For example, b* values were spread throughout the range 21.2 to 28.2, with samples at both ends of the yellow-blue scale receiving a similar preference rank. In contrast, there

Table 1. Maximum and minimuum L*, a* and b* values from the 125 oat samples, three wheat samples and a grey barley sample, screened to select the colour range for preference ranking.

	L*	a*	b*
Maxumum	64.29	8.65	28.30
Minimum	57.51	5.01	22.10
Grey Barley	49.01	4.05	19.41

was a significant positive relationship between preference and a* (Fig. 1), and a negative relationship with hue (Fig. 2). The wheat samples received lower rankings than any of the oat samples. Drummond was the most preferred ($P<0.05$) cultivar and had the lowest a* value (Table 2).

Agronomic Experiment

There were no differences in b* or chroma of Drummond groats resulting from the differences in sowing rate, nitrogen or chlormequat. However, chlormequat increased ($P<0.05$) the a* value from 5.32 to 5.52 and decreased hue from 77.1 to 76.7 (Table 3). Reflectance (L*) was changed ($P<0.05$) by the interaction

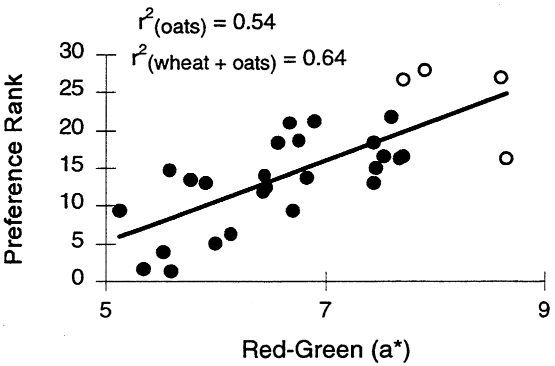

Figure 1. Preference against the a* component of colour for 25 oat (●) and four wheat (O) samples. (Note: 1 = most preferred)

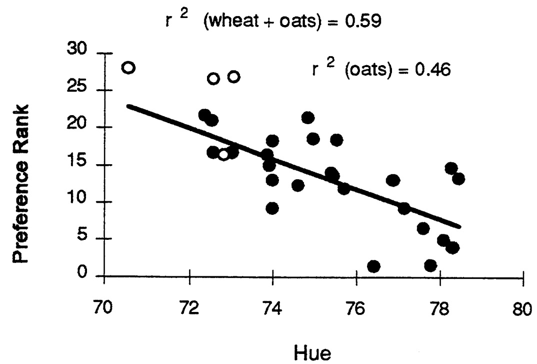

Figure 2. Preference against the hue component of colour for 25 oat (●) and four wheat (O) samples. (Note: 1 = most preferred)

Table 2. Mean preference rank and colour measurement of duplicate samples from 3 oat cultivars.

Cultivar	Rank	L*	a*	b*
Drummond	11.9 b	60.1 ab	6.5 b	24.1 a
Charlton	16.7 a	59.7 b	7.5 a	25.2 a
Makuru	19.8 a	62.1 a	6.7 ab	24.3 a
SEM	0.82	0.46	0.07	0.69

Values within a column followed by a common letter are not significantly different ($\alpha = 0.05$, df = 9)

Table 3. Colour components of oat groats, at two different sowing rates, levels of nitrogen and chlormequat application rates.

Treatment	a*	b*	Hue	Chroma
Sowing rate (kg/ha)				
100	5.38	23.32	77.02	23.93
200	5.46	23.21	76.76	23.84
Nitrogen (kg N/ha)				
0	5.37	23.16	76.93	23.77
100	5.46	23.37	76.85	24.00
Chlormequat (kg ai/ha)				
0	5.32	23.23	77.10	23.83
1.5	5.52	23.30	76.68	23.29
SEM	0.043	0.076	0.078	0.080

Table 4. Reflectance (L*) values for oat samples at two sowing rates, levels of chlormequat, and nitrogen application rates. (SEM = 0.34).

Chlormequat (kg ai/ha)	Nitrogen (kg/ha)	Sowing rate (kg/ha) 100	200
0	0	60.49	59.29
0	100	59.98	60.18
1.5	0	19.73	59.58
1.5	100	60.11	58.94

of sowing rate, nitrogen and chlormequat although there was no consistent pattern (Table 4).

Discussion

The screening of oat samples using the L*a*b* colour space enabled quantifiable differences in groat colour to be identified. The preferred groat colour was related to samples with low a* (Figure 1) and high hue values (Figure 2) rather than to b* values as suggested by Cameron (1994). Preferred colour was in the yellow area of the of the colour space, whereas samples of low preference, including all four wheat samples were in the transition zone between red and yellow. The implication was that samples with an a* value less than 6.0, or those with a decreasing red component were the most preferred. However, the degree of scatter around the regression lines indicates variability among experts for the ranking of individual samples. Thus, confirmation of this result would only come from a full consumer evaluation panel. The inclusion of oats from international sources would also provide an indication of how New Zealand cultivars compare with their competitors and enable previously undefined colour guidelines (Welch, 1995) to be determined. This would also identify whether the colour problems experienced by local processors are unique to New Zealand grown crops.

Results from the grey barley sample also show that low a* or high hue cannot be used as sole indicators of preference. This sample had the lowest a* and b* values (Table 1) and the highest hue and thus, using any of these components as an indicator of preference, it should have received the highest and not the lowest rank. The L* value (49.01), which ranges from 0 for black to 100 for white, was at least 10 units lower than all other samples (Table 1). Thus, the increased level of black in the grey barley sample seems to have overridden any preference associated with other colour components. This implies that any environmental or agronomic condition that shifts the colour spectrum outside the operating region defined in Table 1, particularly by reducing the L* component, may also lead to reduced consumer preference. This result was consistent with qualitative guidelines for oats that exclude dark, discoloured or weather-stained oats (Ganβmann and Vorwerck, 1995).

Although agronomic practices and kilning altered the colour components of the groats, they are unlikely to influence preference. Kilning increased L* and b* values, but did not affect the a* or hue values that were related to preference. Of the agronomic factors examined, only the application of chlormequat altered the a* and hue components but the change, of less than 5% (Table 3), would have had minimal impact on the preference ranking. The conclusion was that, in the short term, growers and processors have limited options to improve the colour preference of groats other than by growing preferred cultivars.

The cultivar comparison from the 1996 harvest showed Drummond was preferred ahead of Makuru, the previous industry standard, and Charlton, and this was probably related to its lower a* value (Table 2). However, there was also an indication that a* and hue may vary between seasons. For Drummond, the a* value was 6.5 from the 1996 harvest but less than 5.9 for all samples in the 1994/95 agronomic experiment. Genetic stability for colour needs to be assessed before the a* or hue components can be utilised as a selection criteria by breeders. If a* is shown to be stable and genetically controlled, then the potential exists to improve preference. Of the 80 breeders lines utilised for the initial screening 40 had a* values below 6.0. This germplasm could lead to improved industry and consumer acceptance of New Zealand bred oat cultivars.

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