7. RESULTS

ANOVA with sample as main effect was performed with each of the 29 descriptive attributes as dependent variables. Based on the ANOVA results, 23 of the 29 attributes significantly discriminated among the samples at the 95% significance level. The nature of these differences was determined with the LSD multiple range test. Attributes which did not significantly discriminate among the samples were mushroom aroma, fenugreek aroma, malty flavour, earthy aroma and flavour and acidic aroma.

7.1 The appearance of the coffee samples

PCA of the appearance characteristics of the coffee granules and prepared coffee (in cup) revealed that 83% of the variance in the 11 coffee samples could be explained by the first two components (Fig 15). The first of which might best be described as a coarse-dense dimension (54%) and the second a colour-solubility dimension (29%). The coarse-dense measurements separated the coffee samples into two groups, coffees that had a fine dense appearance such as CID_Y, CB_{Y3} and CB_{Y1} (on the left of Fig 15) and coffees with a coarse sponge-like appearance including CB_{X2}, $CBdec_X$, PC_X, PC_y and $PCdec_X$ (on the right of Fig 15). PC_Z was dense (not significantly different from CID_Y) and coarse (not significantly different from PC_X) but did not have a sponge-like appearance, whilst CB_{Y2} was significantly different from all the other samples except PC_Z (Table 15). With regard to colour, the samples could be divided into two groups with similar ranges in the colour continuim. The two groups consisted of CID_Y, PC_Z, PC_X, $CBdec_X$ and CB_{X2} (on top half of Fig 15) which were identified as lighter in colour and the darker coffee samples were CB_{Y3}, $PCdec_X$, PC_Y, CB_{Y1}, CB_{Y2}, and lastly CB_{X1} (on bottom half of Fig 15). Sample PC_z was lighter than most samples (but similar to $CBdec_X$ and CB_{X2}) and did not solubilize as easily as the other coffee products (Table 15).

The instrumental L a b colour measurements supported the evaluation by the trained sensory panel to some extent as Pearson correlations indicated that there was a significant albeit low negative correlation (r^2 = 16%) between saturation value as determined using the chromometer and human assessment of colour intensity of the coffee granules as per trained sensory panel (Table 16).

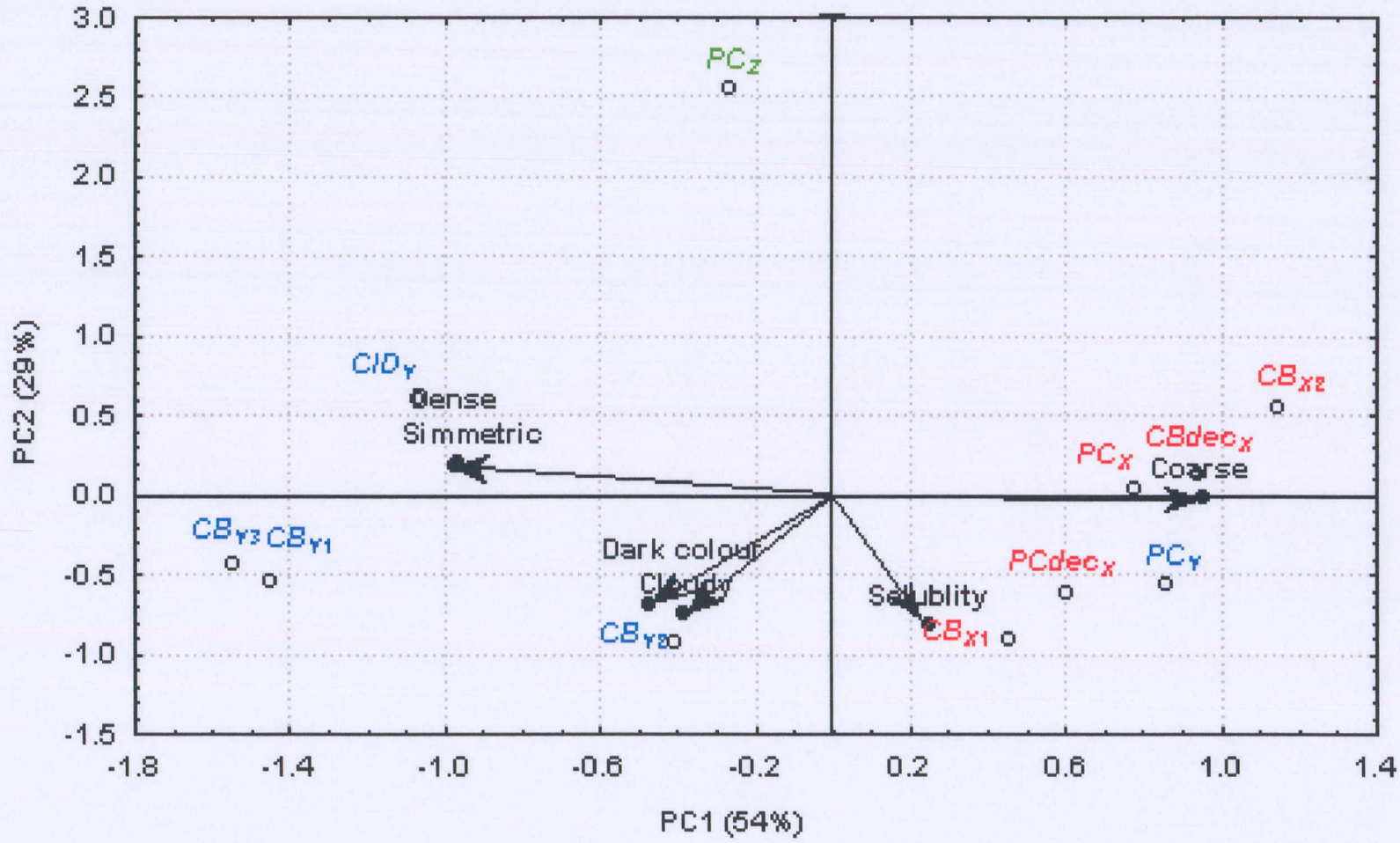

Fig 15: Principal Component Analysis (PCA) loadings for appearance descriptors showing differences among the 11 coffee samples (PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers).

Table 15: Means[1] , p-values and least significant difference (LSD) values for the descriptive sensory analysis of coffee[2] appearance

Attributes	CID_Y	CB_{X1}	CB_{X2}	$CBdec_X$	CB_{Y1}	CB_{Y2}	CB_{Y3}	PC_Y	PC_Z	PC_X	$PCdec_X$	LSD	p-value
Colour intensity of granules 0 = light brown, 100 = black brown	33.3^{b}	37.9^{b}	11.1^{a}	14.5^{a}	69.0^{c}	84.5^{d}	57.4^{c}	64.6^{c}	10.6^{a}	42.2^{b}	57.9^{c}	**6.6**	**<0.001**
Coarseness of granules 0 = very fine (powdery), 100 = very coarse	5.5^{a}	71.7^{de}	71.7^{de}	78.2^{e}	11.1^{a}	52.0^{b}	6.1^{a}	77.8^{de}	57.5^{bc}	66.1^{cd}	73.2^{de}	**7.5**	**<0.001**
Simmetry of granules 0 =asymmetrical, 100 = symmetrical	87.2^{d}	23.8^{a}	17.9^{a}	20.6^{a}	88.6^{d}	49.9^{b}	90.7^{d}	19.8^{a}	66.0^{c}	25.8^{a}	21.7^{a}	**8.2**	**<0.001**
Density of granules 0 = perforated 100 = compact/dense	89.7^{de}	32.1^{b}	22.5^{ab}	28.5^{ab}	90.6^{e}	63.7^{c}	91.5^{e}	17.6^{a}	76.7^{cd}	30.1^{ab}	35.1^{b}	**7.8**	**<0.001**
Solubility in cup 0 =insoluble, 100 = rapidly soluble	93.1^{b}	94.9^{b}	95.3^{b}	94.7^{b}	90.4^{b}	90.0^{b}	88.5^{b}	92.9^{b}	52.4^{a}	94.5^{b}	94.8^{b}	**4.1**	**<0.001**
Cloudiness in cup 0 = clear, 100 = cloudy (opaque)	48.4^{ab}	69.0^{c}	41.4^{a}	50.3^{ab}	62.0^{bc}	$59.3b^{c}$	70.0^{c}	47.8^{ab}	41.6^{a}	43.8^{a}	52.7^{ab}	**5.1**	**<0.001**

[1] Means in a row with the same letters (abcde) are not significantly different (p>0.05)
[2] PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers

Table 16: Pearson correlation coefficients (r) between dimensions of colour obtained by means of a chromometer and the trained sensory panel

	L-value[1]	a-value[2]	b value[3]	Saturation value ($\sqrt{a^2 + b^2}$)	Colour intensity of granules (trained panel)
L value	1.0				
a value	0.4**	1.0			
b value	0.7**	0.8**	1.0		
Saturation value ($\sqrt{a^2 + b^2}$)	0.8**	0.8**	1.0**	1.0	
Colour intensity of granules (trained panel)	-0.3*	-0.3	-0.4*	-0.4*	1.0

**Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

[1] The higher the L-value the lighter the products' colour

[2] a-value denotes red when positive and green when negative

[3] b-value denotes yellow when positive and blue when negative.

The L-values indicated that CB_{X2}, $CBdec_X$, PC_X, CID_Y, CB_{Y3} and PC_Z were lighter in colour (Table 17). Samples CB_{X2}, $CBdec_X$, PC_X and PC_Z also had higher a-values and b-values that resulted in these samples having significantly higher saturation values than the remainder of the coffee samples (Table 17). The trained panel rated CB_{X2}, $CBdec_X$ and PC_Z significantly lighter than the rest of the samples (Table 15).

7.2 The aroma of the coffee samples

PCA of the aroma attributes showed that 84% of the variance was also explained by the first two principal components (Fig 16). The first component separated samples PC_Z, PC_X, $CBdec_X$, $PCdec_X$, PC_Y and CB_{X1} with aroma profiles that included fishy (of dry granules), roasted, toasted, spicy, nutty, cocoa character from those with a root-like aroma (CB_{X2}, CB_{Y1}, CB_{Y2}, CB_{Y3} and CID_Y) (Fig 16).

Table 17: Means[1] and least significant difference (LSD) values for the chromometer measurements of coffee granule colour

	L-value[2]	a-value[3]	b-value[4]	Saturation[5] = $\sqrt{(a^2+b^2)}$
CID_Y	47.2^{bc}	3.0^{bc}	11.2^{bcd}	11.6^{bc}
CB_{X1}	43.4^{a}	3.7^{cd}	10.0^{b}	10.6^{b}
CB_{X2}	50.2^{d}	4.3^{def}	17.2^{f}	17.7^{e}
$CBdec_X$	48.9^{cd}	5.1^{f}	17.6^{f}	18.3^{e}
CB_{Y1}	42.6^{a}	2.7^{b}	9.2^{ab}	9.6^{ab}
CB_{Y2}	42.0^{a}	1.2^{a}	7.4^{a}	7.5^{a}
CB_{Y3}	47.1^{bc}	3.6^{cd}	12.9^{cde}	13.4^{cd}
PC_Y	43.0^{a}	3.7^{cd}	9.1^{ab}	9.8^{ab}
PC_Z	46.4^{b}	4.0^{de}	13.9^{e}	14.5^{d}
PC_X	48.3^{bcd}	4.7^{ef}	13.4^{de}	14.2^{d}
$PCdec_X$	42.5^{a}	4.1^{de}	10.3^{b}	11.1^{bc}
LDS	**2.33**	**0.82**	**2.45**	**2.52**
p-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**

[1] Means with the same letters (abcdef) are not significantly different (p>0.05)

[2] The higher the L-value the lighter the products' colour, means with the same letters (abcd) are not significantly different (p>0.05)

[3] a-value denotes red when positive and green when negative, means with the same letters (abcdef) are not significantly different (p>0.05)

[4] b-value denotes yellow when positive and blue when negative, means with the same letters (abcdef) are not significantly different (p>0.05)

[5] Saturation means with the same letters (abcde) are not significantly different (p>0.05)

The trained panel ratings indicated that CID_Y, CB_{Y1}, CB_{Y2}, and CB_{Y3} had significantly higher root-like notes (Table 18). The second dimension separated samples with sweet nuances from those with a leather aroma characteristic. Indications were that CID_Y, CB_{Y1} and PC_X had significantly more sweet notes than CB_{X1}, whilst CB_{X1} and PC_y had significantly more leather characteristics than samples PC_X and PC_Z (Table 18). The first two components of the PCA of the electronic nose data explained more than 90% of the total variance. The measurements

.indicated clear separation, based on headspace analysis, between pure coffee and coffee blends (Fig 17). Four sample clusters were identified, all the pure coffees clustered together. CB_{X1} was the only coffee blend that clustered close to the pure coffees whilst the other coffee blends clustered together with variants CB_{X2} and $CBdec_X$ forming a cluster separately from the other coffee blends.

Table 18: Means[1] and least significant difference (LSD) values for the descriptive sensory analysis of coffee aroma

Attributes	CID_Y	CB_{X1}	CB_{X2}	$CBdec_X$	CB_{Y1}	CB_{Y2}	CB_{Y3}	PC_Y	PC_Z	PC_X	$PCdec_X$	LSD	p-value
Fishy 0 = no fishiness, 100 = strong fishy	5.8^{a}	23.9^{cd}	15.4^{abc}	14.6^{abc}	15.1^{abc}	13.8^{abc}	6.1^{ab}	58.8^{e}	19.1^{abcd}	23.2^{bcd}	34.1_{d}	**6.05**	**<0.001**
Roasted 0 = lightly roasted, 100 = burnt	30.3^{a}	66.8^{def}	57.7^{cd}	62.8^{def}	36.9^{ab}	59.7^{cd}	47.1^{bc}	73.9^{ef}	77.1^{e}	72.0^{def}	72.1^{def}	**5.73**	**<0.001**
Sweet 0 =bland, 100 = intensely sweet	56.0b	31.3a	44.7ab	51.5ab	57.8b	50.5ab	44.4ab	43.4ab	53.9ab	48.3b	47.2ab	**6.23**	**<0.001**
Sour/acidic 0 = bland 100 = strongly acidic	49.1^{b}	73.1^{b}	36.7^{a}	39.1^{a}	52.1^{b}	52.5^{b}	52.6^{b}	48.3^{b}	43.7^{a}	33.9^{a}	36.1^{a}	**28.16**	**0.116**
Malty 0 =no maltiness, 100 = intensely malty	34.4^{b}	34.1^{b}	39.7^{b}	46.0^{a}	38.8^{b}	46.7^{a}	44.5^{a}	48.4^{a}	48.0^{a}	46.5^{a}	24.7^{c}	**5.78**	**0.002**
Meaty (fenugreek) 0 = no fenugreek, 100 = high fenugreek	31.1	46.1	33.5	37.6	39.0	47.2	44.7	42.6	33.4	34.3	38.2	**19.88**	**0.30**
Spicy 0 = no spicyness, 100 = intensely spicy	30.6^{a}	50.2^{b}	40.0^{ab}	41.9^{ab}	38.2^{ab}	45.7^{ab}	41.8^{ab}	52.7^{b}	56.5^{ab}	46.7^{b}	44.5^{ab}	**5.87**	**<0.001**

1 Means in a row with the same letters (abcde) are not significantly different ($p>0.05$)
2 PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

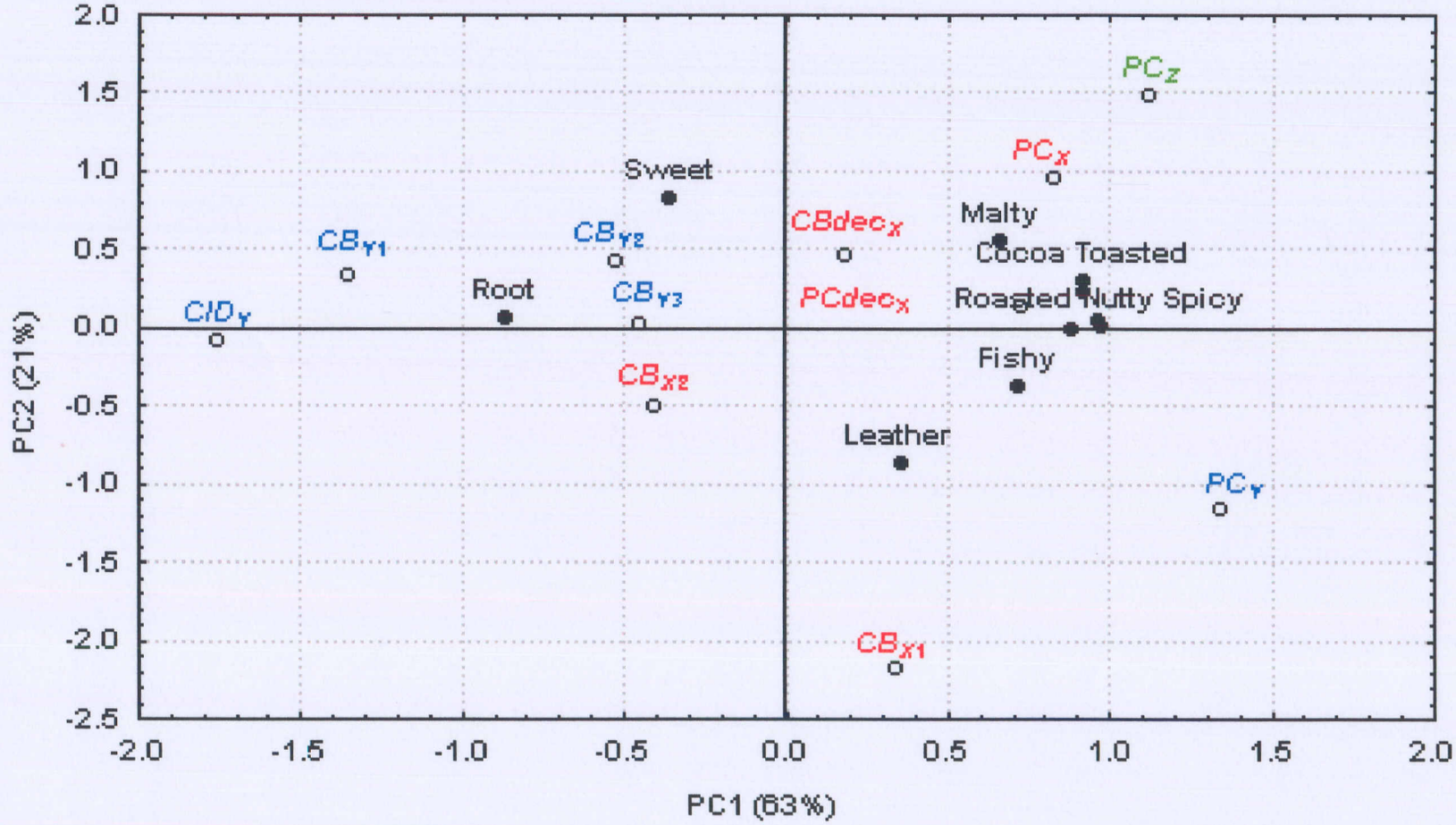

Fig 16: Principal Component Analysis (PCA) loadings for aroma descriptors showing differences among the 11 coffee samples. (PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.)

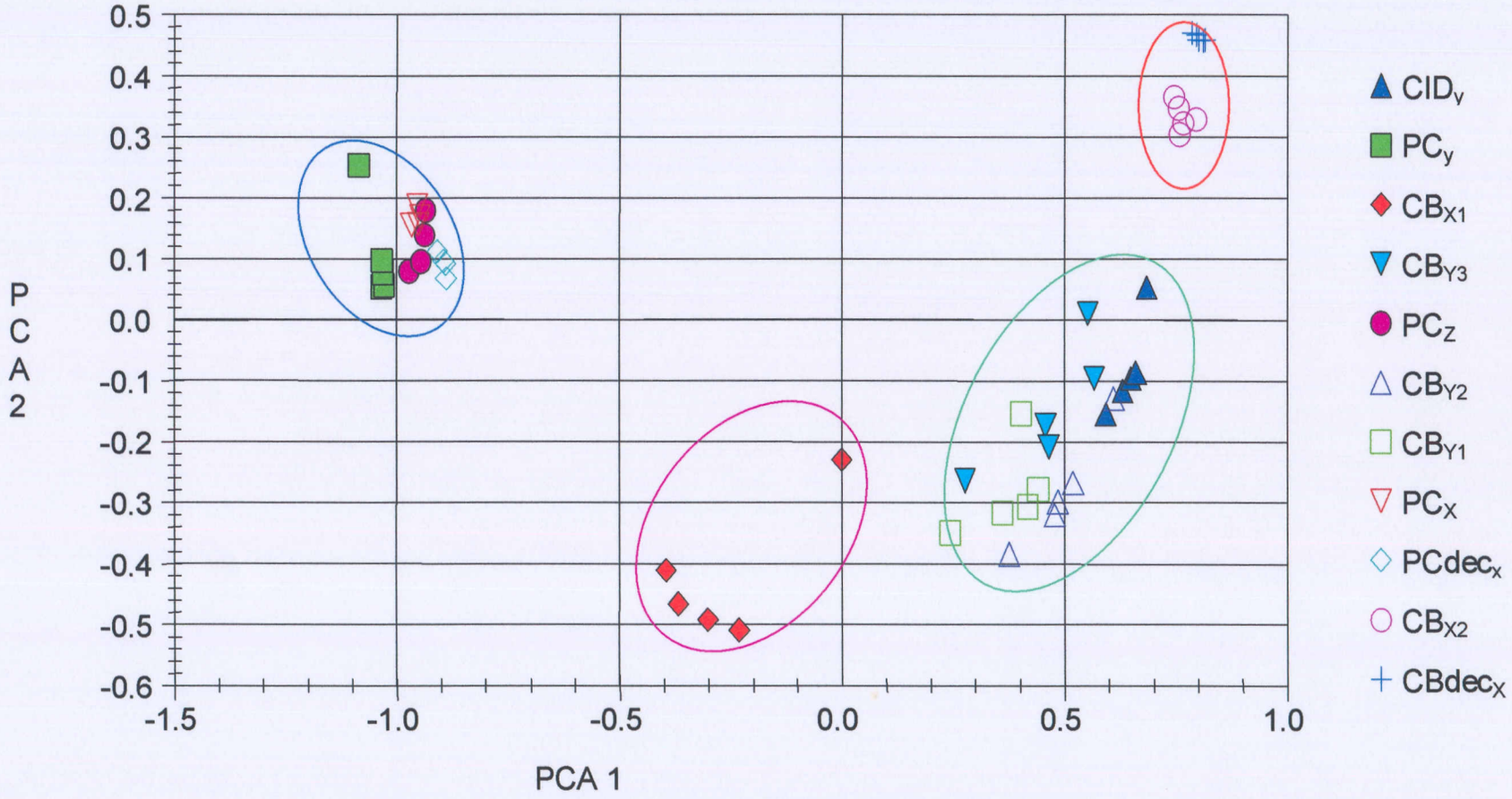

Fig 17: Principal Component Analysis (PCA) loadings for aroma measurements, showing differences among the 11 coffee samples, on the basis of headspace analysis by means of the electronic nose
PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

Table 18: Means[1] and least significant difference (LSD) values for the descriptive sensory analysis of coffee aroma (continued)

Attributes	CID_Y	CB_{X1}	CB_{X2}	$CBdec_X$	CB_{Y1}	CB_{Y2}	CB_{Y3}	PC_Y	PC_Z	PC_X	$PCdec_X$	LSD	p-value
Earthy 0 = no earthy, 100 = strong earthy	26.1	36.3	35.9	31.1	39.6	39.3	33.5	39.5	36.2	41.6	38.0	**19.66**	**0.182**
Mushroom 0 = no mushroom, 100 = strong mushroom	22.3	24.7	24.5	19.1	25.0	23.7	25.5	29.5	25.0	24.1	21.3	**17.56**	**0.563**
Cocoa/dark chocolate 0 =light toffee/caramel notes 100 = dark chocolate	23.6^{a}	38.0^{abcd}	33.3^{ab}	43.7^{bcd}	22.7^{a}	33.4^{ab}	36.6^{abc}	49.1^{bcde}	64.1^{e}	52.7^{cde}	56.4^{de}	**6.42**	**<0.001**
Toasted cereal 0 = no toasted cereal 100 = intense toasted cereal	28.0^{a}	37.7^{abc}	34.0^{abc}	42.0^{abc}	29.9^{ab}	34.8^{abc}	38.4^{abc}	46.6^{abc}	44.5^{abc}	53.2^{c}	48.5^{bc}	**6.05**	**<0.001**
Nutty 0 =no nuttiness, 100 = intense nuttiness	24.7^{bc}	35.8^{b}	30.9^{b}	38.3^{a}	24.6^{bc}	26.7^{bc}	32.7^{b}	43.4^{a}	43.1^{a}	40.4^{a}	37.9^{a}	**5.55**	**<0.001**
Leather/animal 0 = no animal/leather, 100 = intense animal/leather	25.8^{ab}	44.7^{bc}	30.2^{abc}	30.5^{abc}	26.5^{ab}	30.2^{abc}	30.1^{abc}	47.4^{c}	23.8^{a}	23.2^{a}	31.2^{abc}	**6.10**	**<0.001**
Root(cooked sweet potato) 0 = no root, 100 = intense root	46.8^{a}	30.0^{b}	30.2^{b}	29.0^{b}	45.8^{a}	44.8^{a}	41.1^{a}	29.6^{b}	27.6^{b}	26.9^{b}	30.3^{b}	**6.69**	**<0.001**

1 Means in a row with the same letters (abcde) are not significantly different (p>0.05)

2 PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

7.3 Analysis of the mouthfeel and flavour of the coffee samples

PCA on the flavour and mouthfeel data indicated that 83% of the variance could be explained by the first two principal components (Fig 18). The significant factors in the first component included the mouthfeel descriptors i.e. astringency and body and the flavour descriptives roasted, sweet and nutty. The second component was best described as an earthy dimension. The pure coffees and coffee blends were separated, with the exception of CB_{X1} grouping on the side of the pure coffees (left side of Fig 18). The pure coffees like PC_X, PC_Z, PC_Y, $PCdec_X$ and coffee blend CB_{X1} were described as full bodied and astringent while the coffee blends that included CB_{x2} and CB_{Y1} were assessed to be thin or watery (Table 19). The pure coffees seemed to be more roasted and nutty in contrast to the coffee blends like CID_Y, $CBdec_X$, CB_{X2}, CB_{Y2}, CB_{y1} and CB_{Y3} which were sweeter. CB_{x1} and PC_Z were the most acidic and as bitter as the other pure coffees (Table 19).

All indications were that pure coffees as well as CB_{X1} and CB_{Y3} were perceived as more bitter (Table 19). Caffeine content measurement by means of capillary electrophoresis indicated that the pure coffees contained more caffeine and that CB_{X1} contained more caffeine than the other coffee blends. Pearson correlations indicated though that there was not a significant correlation between caffeine content measured by capillary electrophoresis and bitterness rated by the trained panel (Table 20).

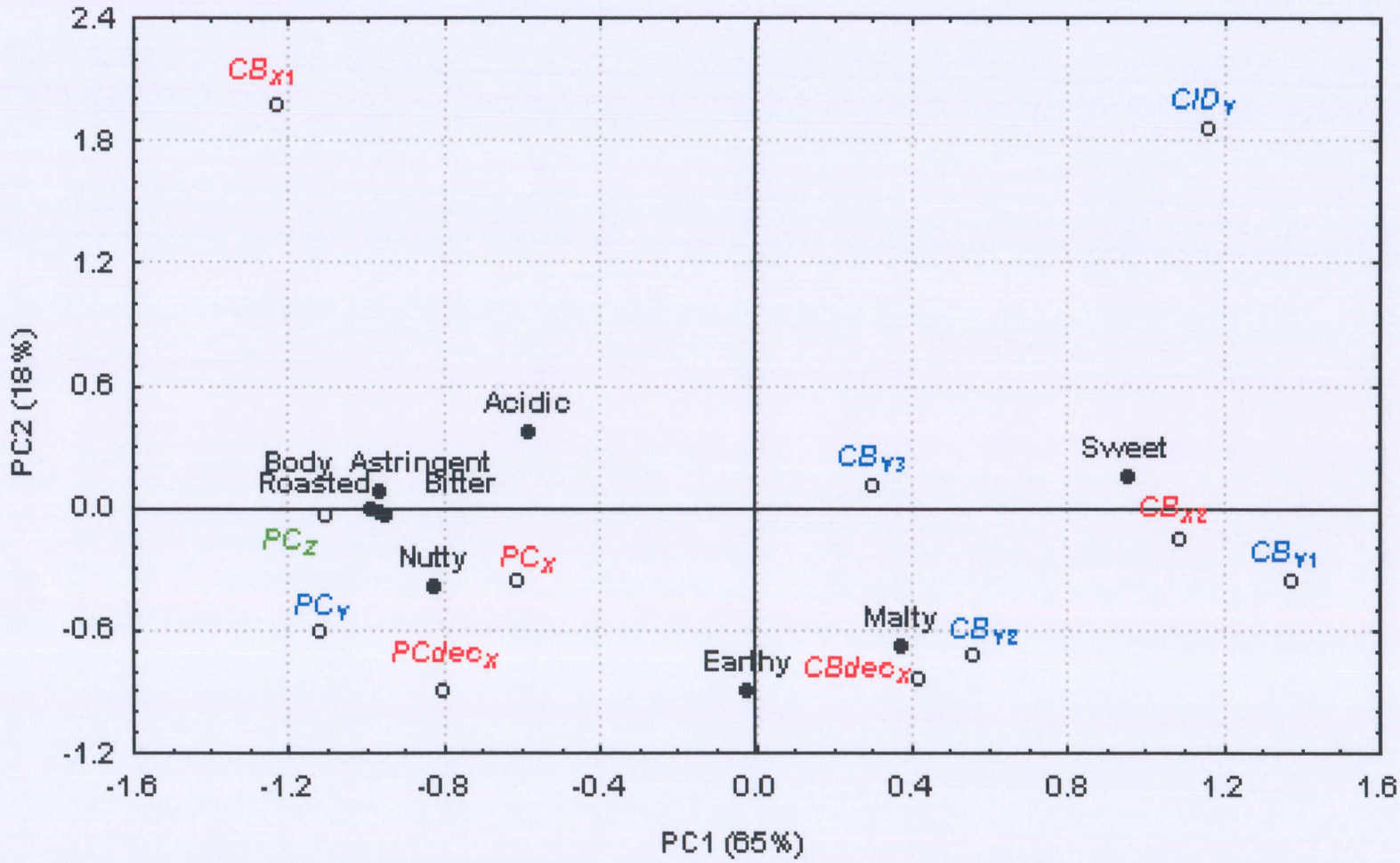

Fig 18: Principal Component Analysis (PCA) for flavour and body descriptors showing differences among the 11 coffee samples (PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers)

Table 19: Means[1] and least significant difference (LSD) values for the descriptive sensory analysis of coffee mouthfeel and flavour

Attributes	CID_Y	CB_{X1}	CB_{X2}	$CBdec_X$	CB_{Y1}	CB_{Y2}	CB_{Y3}	PC_Y	PC_Z	PC_X	$PCdec_X$	LSD	p-value
Bitter taste 0 = not bitter, 100 = intense bitter	38.0^{ab}	79.3^{c}	43.5^{ab}	48.8^{ab}	37.5^{a}	47.6^{ab}	53.4^{c}	79.4^{c}	79.8^{c}	72.0^{c}	70.1^{c}	**6.01**	**<0.001**
Roasted 0 = lightly roasted, 100 = burnt	38.1^{ab}	79.8^{c}	53.4^{b}	50.6^{b}	29.8^{a}	46.7^{b}	49.5^{b}	79.1^{c}	80.9^{c}	70.9^{c}	74.7^{c}	**6.10**	**<0.001**
Acidic taste 0 =no acidic 100 = intensely acidic	52.1^{abc}	68.3^{c}	35.7^{a}	51.9^{abc}	51.7^{abc}	52.0^{abc}	54.4^{bc}	56.0^{bc}	63.8^{c}	44.3^{ab}	50.5^{abc}	**5.69**	**<0.001**
Sweetness 0 = no sweet 100 = molasses sweet	58.7^{d}	25.1^{ab}	48.1^{d}	45.7^{d}	53.0^{d}	41.4^{bcd}	43.3^{cd}	25.6^{ab}	25.9^{abc}	23.0^{a}	25.9^{abc}	**5.96**	**<0.001**
Malty flavour 0 =no maltiness, 100 = intense malty	33.4	26.5	37.2	37.6	37.3	41.0	37.3	33.7	38.9	34.3	35.8	**17.61**	**0.233**
Nutty flavour 0 = no nuttiness, 100 = intense nuttiness	28.2^{db}	33.5^{d}	26.9^{b}	37.0^{cd}	27.9^{bd}	31.5^{cd}	35.1^{cd}	42.3^{a}	37.4^{acd}	36.9^{cd}	42.9^{a}	**5.55**	**0.05**
Earthy flavour 0 = least earthy, 100 = most earthy	2.1	32.1	32.6	37.7	31.6	35.8	28.5	35.8	26.9	37.2	35.7	**18.93**	**0.076**

1 Means in a row with the same letters (abcde) are not significantly different ($p>0.05$)
2 PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

Table 19: Means[1] and least significant difference (LSD) values for the descriptive sensory analysis of coffee mouthfeel and flavour (continued)

Attributes	CID_Y	CB_{X1}	CB_{X2}	$CBdec_X$	CB_{Y1}	CB_{Y2}	CB_{Y3}	PC_Y	PC_Z	PC_X	$PCdec_X$	LSD	p-value
Astringency 0 = not astringent, 100 = strong astringency	33.3^{a}	64.7^{d}	35.3^{ab}	44.6^{abc}	30.9^{a}	52.9^{cd}	46.6^{abcd}	60.5^{cd}	63.5^{d}	54.5^{cd}	58.0^{cd}	**6.05**	**<0.001**
Body 0 = watery 100 = full bodied	44.2^{ab}	62.5^{cd}	44.4^{ab}	44.1^{ab}	34.7^{a}	40.8^{a}	47.3^{abc}	62.9^{cd}	65.5^{d}	62.4^{cd}	59.3^{bcd}	**5.78**	**<0.001**

1 Means in a row with the same letters (abcde) are not significantly different ($p>0.05$)
2 PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

Table 20: Caffeine content[1] of 11 coffee samples[2] measured by means of capillary electrophoresis

Sample	Caffeine content (mg/g)
CID_Y	0.3^{a}
CB_{X1}	15.9^{e}
CB_{X2}	7.2^{d}
$CBdec_X$	1.8^{ab}
CB_{Y1}	7.2^{d}
CB_{Y2}	5.2^{c}
CB_{Y3}	6.5^{cd}
PC_Y	20.1^{f}
PC_Z	22.9^{g}
PC_X	34.7^{h}
$PCdec_X$	2.3^{b}
LSD	**1.80**
p-value	**<0.001**

[1] Means with the same letters (abcdefg) are not significantly different ($p>0.05$)

[2]PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

7.4 Analysis of the demographic and psychographic profiles of the consumers that participated in the coffee study

Ninety-nine percent of the evaluation sheets were completed and returned within 14 days. The demographic and psychographic profiles of the consumers that participated in the study are summarised in Table 21. Twice as many females compared to males participated in the study and the majority of the consumers were white. No comments can be made on the income distribution of the respondents as the majority did not indicate their income level. Sixty percent of the consumers drank two to three cups of coffee a day, 65% drank their coffee with milk and sugar and coffee was predominantly enjoyed at home and work. The participating consumers purchased instant coffee regularly and 39% indicated that they currently bought CB_{x2} and 19% purchased PC_x. In general it seemed as if the majority of consumers that categorised themselves as power seekers bought PC_x or pure coffees more often, whilst the freedom and friendship seekers rather purchased CB_{x2}, CB_{y3} or equivalent instant coffee blends (Table 21).

Table 21: Demographic and psychographic profiles of consumers that participated in the consumer evaluation of the 11 coffee samples

Age distribution of consumer panel	
Not completed	3%
15-19	4%
20-24	27%
25-29	25%
30-39	12%
40+	20%

Income distribution (ZAR) of consumer panel	
Not completed	60%
<R24000	13%
R24000-R47999	5%
R48000-R71999	7%
R72000-R95999	6%
>R96000	10%

South African ethnic group distribution of consumer panel	
Not completed	2%
Black	38%
White	55%
Coloured	2%
Asian	2%

Consumption of coffee per day	
1 Cup	13%
2 Cups	34%
3 Cups	26%
4 Cups	15%
5+ Cups	21%

Place where coffee is most often consumed	
Home	76%
Work	32%
Friends	19%
Restaurant	16%

Coffee types regularly consumed	
Instant Coffee	82%
Filter Coffee	18%
Flavoured Coffee	7%
Iced Coffee	4%

Other beverages consumed	
Other hot beverages e.g tea	72%
Alcoholic beverages	24%
Carbonated/still soft drinks	19%
Fruit Juice	60%
Other e.g. mineral water	11%

Gender distribution of consumer panel	
Not completed	3%
Male	30%
Female	67%

Occupation distribution of consumer panel	
Not completed	4%
Student	40%
Domestic	20%
Education	20%
Administration	6%
Professional e.g. doctor	14%
Self employed	4%
Trade	3%
Pension	2%

City distribution of consumer panel	
Johannesburg	50%
Pretoria	50%

Manner of consumption	
Black	7%
Black & sugar	15%
With milk/cream	10%
With milk/cream & sugar	65%
Black & artificial sweetener	1%
Milk/cream & artificial sweetener	3%

Coffee brands currently purchased	
CB_{X2}	39%
$CBdec_{X2}$	6%
CB_{Y3}	12%
CB_{Y1} & CB_{Y2}	8%
PC_X	19%
$PCdec_X$	2%
PC_Z	2%
CB_{X1}	3%
Other coffee brands	5%
Not completed	7%

Personality types	
Aggressive (Power seekers)	20%
Compliant (Friendship seekers)	42%
Detached (Freedom seekers)	33%

7.5 Cluster analysis of hedonic ratings of the 11 coffee samples

Four distinct clusters of consumers could be identified based on the hedonic ratings of the 11 coffee samples (Table 22 & Fig. 19).

Cluster 1 called **pure coffee lovers** represented 23% of the study population. This cluster predominantly included consumers that preferred pure coffees. These consumers rated PC_Z the highest with a highest cluster mean of 6.7 and rated CB_{y1} as the least acceptable with a cluster mean of 3.0 (Table 22). Coffee samples that also scored well within this cluster included PC_Y, PC_z, $PCdec_x$ and CB_{x1}.

Cluster 2, the **coffee blend lovers** included 30% of the study population. These consumers indicated a preference for coffee blends and rated the majority of the coffee blends (CB_{y3}, CB_{Y1}, CB_{Y2}) and chicory drink (CID_Y) high (cluster means between 6.2 and 7). The exception was CB_{X1} (mean score of 3.9) which was more acceptable to the pure coffee drinkers (cluster 1). The pure coffees were given lower mean scores (cluster means between 4.3 and 5.5) with PC_X rated the highest of this group with a cluster mean of 5.5 (Table 22).

Cluster 3: Only 9 % of the consumers that participated in the study grouped together in cluster 3, the **not serious coffee drinkers**. In general the cluster means for this group were lower than all of the other clusters. Mean scores started as low as 1.8 for PC_z to 6.8 for CB_{y1} (Table 22). These consumers seemed not to be serious coffee drinkers.

Cluster 4: The largest percentage (37%) of the population was represented in this cluster and called **general coffee drinkers**. There was not a large preference difference between the coffees. Cluster means were all in the range of 5.9 to 7.1 (Table 22). No specific brand dominated in particular. PC_X, $CBdec_X$ and PC_Z obtained the highest mean score of 7.1, whilst CID_Y only scored 5.9. These consumers seemed to generally like coffee and would drink any brand.

Table 22: Mean hedonic scores[1] for each of the identified consumer clusters for the 11 coffee samples (the highlighted scores are the highest and lowest scores within each cluster)

Coffee samples	Cluster 1 Pure coffee lovers	Cluster 2 Coffee blend lovers	Cluster 3 Not serious coffee drinkers	Cluster 4 General coffee drinkers
CID_Y	4.3	6.9	4.6	5.9
CB_{X1}	5.7	**3.9**	2.8	6.7
CB_{X2}	5.5	**7.0**	5.2	6.9
$CBdec_X$	5.5	6.2	5.7	7.0
CB_{Y1}	**3.0**	6.9	**6.8**	6.4
CB_{Y2}	4.1	**7.0**	3.4	6.3
CB_{Y3}	3.8	6.7	4.5	**6.0**
PC_Y	6.4	4.3	2.8	6.4
PC_Z	**6.7**	4.3	**1.8**	**7.1**
PC_X	6.1	5.5	4.3	7.0
$PCdec_X$	6.1	4.7	2.9	6.8

[1] 1=Dislike extremely, 9 = Like extremely

PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

Based on the Pearson Chi-square test it was possible to test for differences amongst the clusters with regard to consumers' demographic and psychographic characteristics at an alpha level of 0.05 (Table 23). Factors that differentiated the clusters significantly were age, ethnic group, city, coffee consumption at noon, regular consumption of filter coffee and brands regularly purchased (Table 23). A General trend seemed to be that the consumers in clusters 1,2 and 4 were mostly in the 20-29 year age group or older than 40 years, whilst cluster 3 had more consumers between 15-19 years (Table 24). Cluster 1 and 4 had more white consumers whilst clusters 2 and 3 had more black consumers. Clusters 1,2 and 4 included a small percentage of coloured and asian consumers (Table 24). A higher percentage of consumers of clusters 2 and 3 lived in Pretoria, whilst the majority of consumers in Cluster 1 lived in Johannesburg (Table 24).

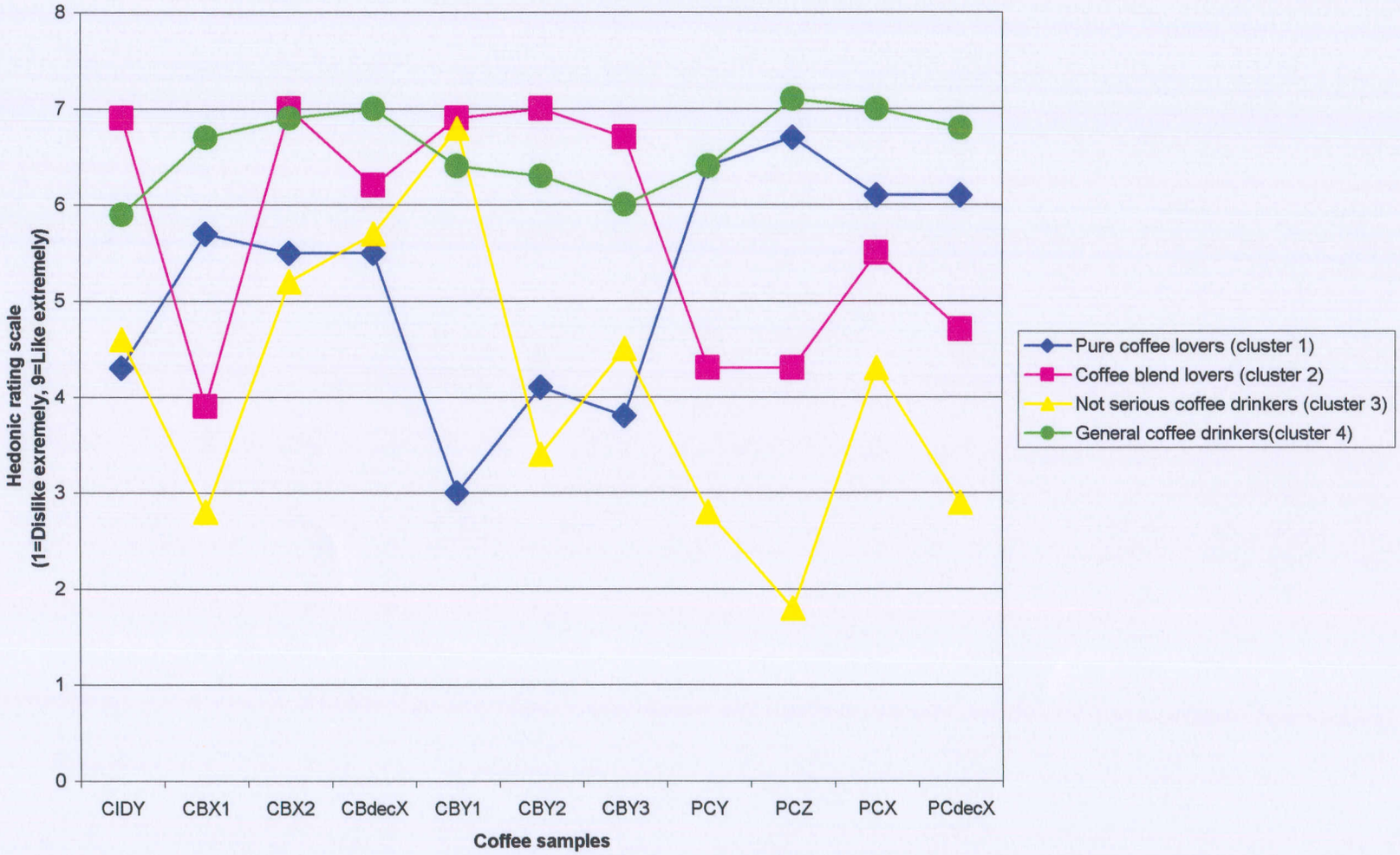

Fig 19: Cluster analysis of consumer data showing differences in the mean hedonic ratings for the 11 coffee samples (n = 199 consumers) (PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers)

The majority of the consumers regularly consumed instant coffee, although a higher percentage of pure coffee lovers, not serious coffee drinkers and general coffee drinkers enjoyed filter coffee. Consumers of cluster 3, the not serious coffee drinkers seemed to enjoyed other variations of coffee such as flavoured and iced coffee more regularly (Table 24). It seemed as if coffee was more often consumed in the morning, but consumers in the pure coffee lovers and general coffee drinkers clusters enjoyed drinking coffee at noon (Table 24). In general coffee sample CB_{Y3} seemed to be a popular choice amongst all the consumers (Cluster 1, 2, 3 and 4). Coffee sample CB_{Y1} rated well amongst coffee blend lovers and not serious coffee drinkers and CB_{Y2} scored well in the coffee blend lovers and general coffee drinkers clusters. Coffee sample PC_X was liked by pure coffee lovers, not serious coffee drinkers and general coffee drinkers (Table 24).

7.6 Internal preference mapping

PCA was performed on consumer liking scores. The factor scores and component matrix data was plotted to obtain internal preference maps of the consumers and coffee samples (Fig 20 and Fig 21). The total variance explained by the first three dimensions of the Internal Preference Map was 50% (Table 25). The four consumer clusters could clearly be identified. All the coffees plotted on the right side of Fig 21, which confirmed that the consumers plotted on this right side (in Fig 20) were coffee lovers, i.e. pure coffee lovers (cluster 1) and general coffee drinkers (cluster 4). Cluster 1 consumers preferred the pure coffees namely PC_X, PC_Y, PC_Z, $PCdec_X$ and also the coffee blend CB_{X1}. The majority of coffee blend samples were grouped at the bottom right of Fig 21, at the side of the coffee blend lovers (cluster 2) (Fig 20) which included all the consumers that rated coffee blends higher.

Table 23: Results of Pearson chi-square test to identify demographic characteristics that significantly differentiated between clusters

Demographic & psychographic characteristics	Pearson X^2	Significance ($p \leq 0.05$)
Age	27.1	0.03
Gender	6.7	NS
Job description	34.6	NS
Ethnic group	31.2	<0.001
City	30.7	<0.001
How do you drink your coffee?	17.4	NS
How many cups of coffee do you drink per day?	16.1	NS
Drink coffee at breakfast	0.6	NS
Drink coffee in the morning	7.2	NS
Drink coffee at noon	9.2	0.03
Drink coffee at dinner	2.3	NS
Drink coffee in the evening	0.8	NS
Drink coffee at bedtime	0.3	NS
Drink other hot beverages	7.5	NS
Drink alcoholic beverages	1.0	NS
Drink still and carbonated drinks	4.9	NS
Drink fruit juices	1.5	NS
Drink other drinks	0.5	NS
Drink coffee at home	3.4	NS
Drink coffee at work	7.2	NS
Drink coffee with friends	2.5	NS
Drink coffee at restaurants	2.6	NS
Regularly drink instant coffee	8.4	NS
Regularly drink filter coffee	17.1	0.05
Regularly drink flavoured coffee	15.8	NS
Regularly drink iced coffee	16.0	NS
Brand currently purchased	50.7	0.01

NS = Not significantly different ($p>0.05$)

Table 24: Breakdown (%) of demographic and psychographic characteristics, which were significantly different among the four consumer clusters

Characteristics	Cluster 1 Pure coffee lovers	Cluster 2 Coffee blend lovers	Cluster 3 Not serious coffee drinkers	Cluster 4 General coffee drinkers
Age				
Not completed	9	6	5	7
15-19 years	4	5	21	6
20-24 years	20	14	47	38
25-29 years	22	53	5	12
30-39 years	13	8	11	15
40+ years	32	14	11	22
Ethnic group				
Black	11	57	53	36
White	85	38	42	56
Coloured	2	2	5	1
Asian	2	2	0	3
City				
Not completed	0	0	0	0
Johannesburg	80	30	37	51
Pretoria	20	70	63	49
Time of coffee consumption				
Breakfast	43	48	53	49
Morning	72	57	47	73
Noon	54	38	16	36
Dinner	24	18	11	25
Evening	57	57	58	64
Bedtime	20	20	21	23
Coffee types regularly consumed				
Instant	83	80	74	86
Filter	24	5	21	25
Flavoured	4	8	21	3
Iced	0	0	11	7
Coffee brands purchased				
CB_{X2}	4	5	0	11
CB_{Y3}	37	42	53	36
CB_{Y1}	2	23	16	8
CB_{Y2}	0	10	5	12
$CBdec_X$	4	2	0	0
PC_X	30	8	16	22
Speciality coffees	7	2	0	7
CB_{X1}	9	2	5	0
House Brands	2	3	5	1
PC_Y	4	2	0	0
PC_Z	0	2	16	3

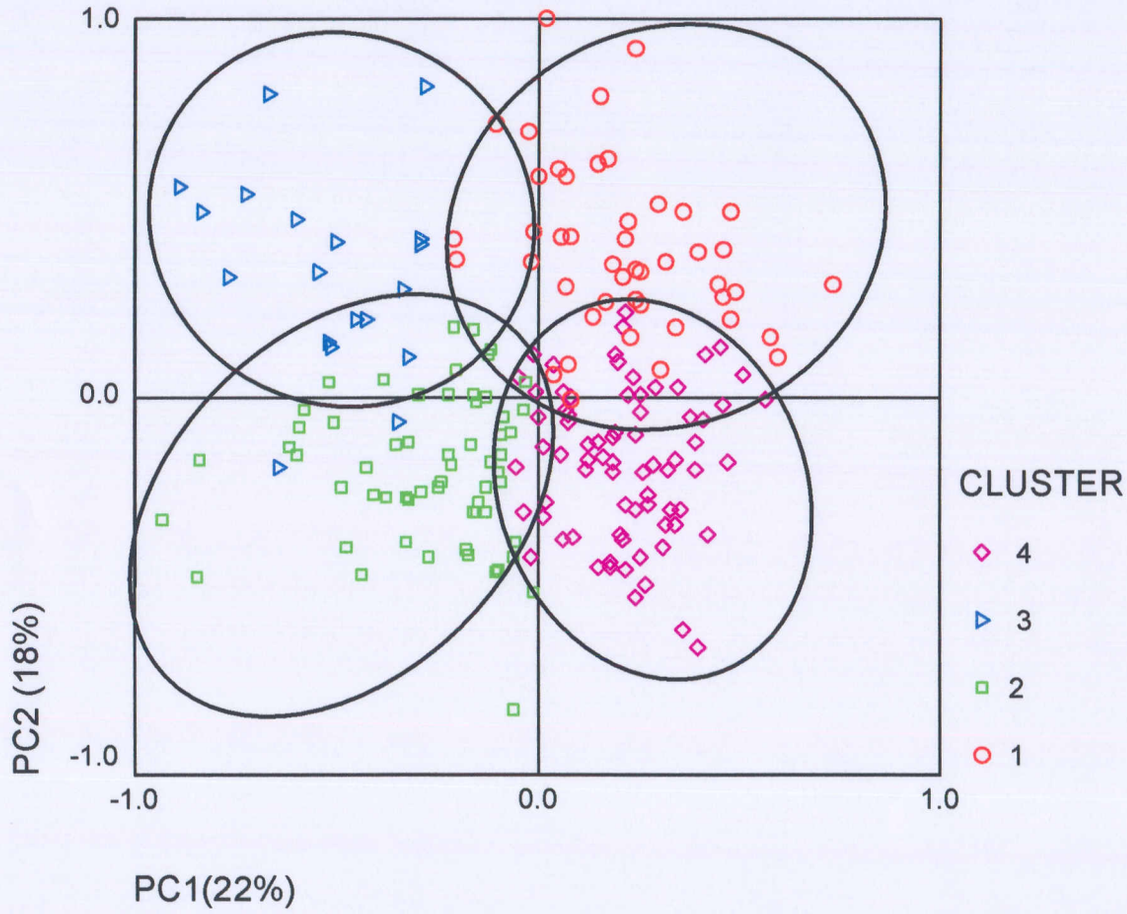

Fig 20: Internal preference mapping of coffee samples indicating the positions of the consumers (n = 199 consumers)

Cluster1 = Pure coffee lovers, Cluster 2 = Coffee blend lovers, Cluster 3 = Not serious coffee drinkers, Cluster 4 = General coffee drinkers

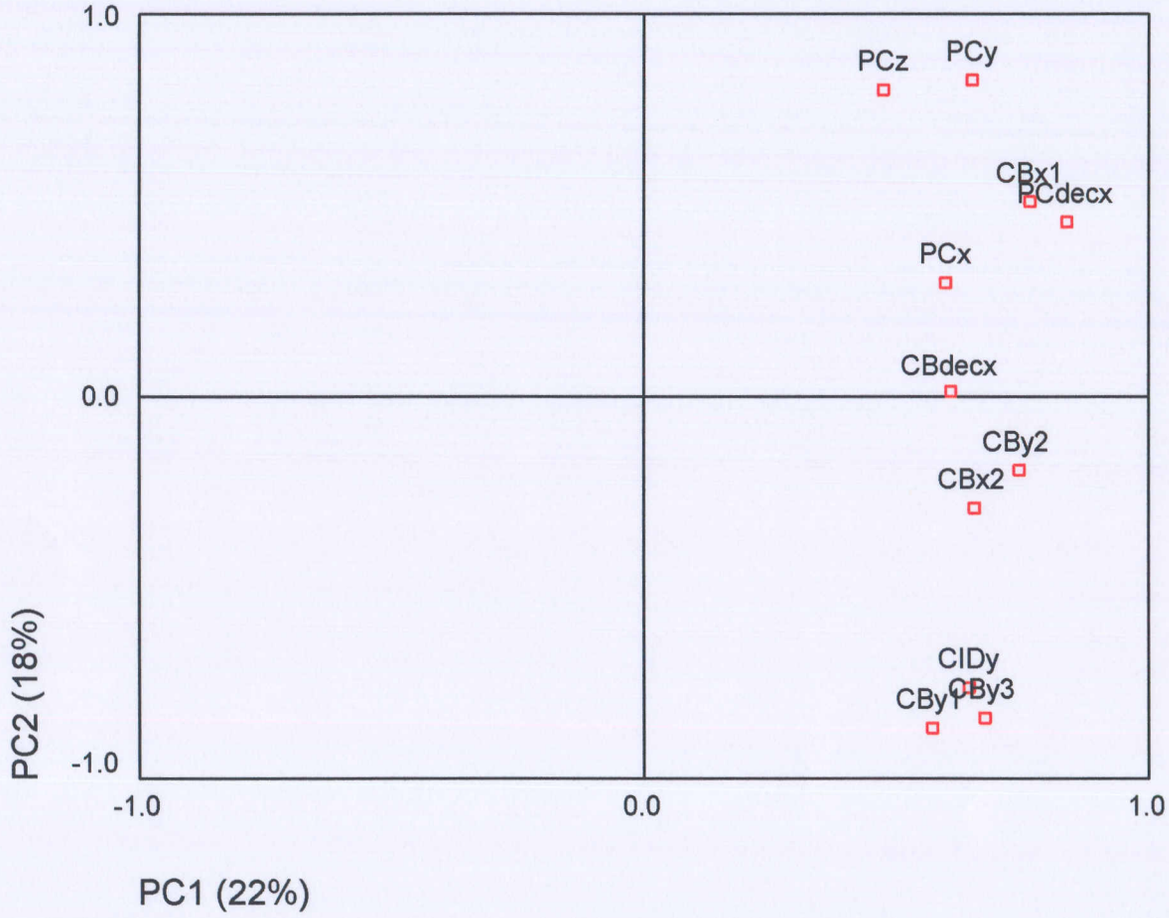

Fig 21: Internal preference mapping of coffee samples indicating the positions of the 11 coffees (n = 199 consumers)

(PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturer.)

Table 25: Percentage variance explained by the first 3 principal components of the internal preference map for the 11 coffee samples (n = 199 consumers)

Principal Components	Variance (%)	Cumulative variance (%)
1	21.6	21.6
2	18.1	39.7
3	10.9	50.6

7.7 Extended internal preference mapping

The cluster ratings obtained by cluster analysis of the individual consumer scores for liking of coffee samples were fitted onto the sensory space by regressing the cluster means onto the external data obtained by principal component analysis of the descriptive sensory data (Fig. 22). The vectors in Fig 22 indicate the direction of liking of the four identified consumer clusters. From this it was possible to identify the attributes of the coffee samples that drove consumer liking. The attributes of coffee blends differed from pure coffees. The coffee blends (samples CB_{Y2}, CB_{Y3}, CID_{Y}, CB_{Y1}, CB_{X2} and $CBdec_{X}$), on the right hand side of Fig 22, were preferred by the coffee blend lovers (cluster 2) and not so serious coffee drinkers (cluster 3). These consumers preferred coffee granules that were denser, gave higher ratings for brewed coffees that were darker in colour and more cloudy. Flavour characteristics that positively described the coffee preferences for these groups were astringency, bitterness, acidic, root and leather-like aromas. The pure coffee lovers (cluster 1) and general coffee drinkers (cluster 4) preferred the sensory characteristics of coffee samples represented by the pure coffees (PC_{Y}, PC_{Z}, PC_{X} and $PCdec_{X}$) as well as CB_{X1} as shown on the left of Fig 22. The preferred sensory characteristics for these groups were described as more roasted, nutty, malty and toasted aroma and flavour characteristics. These consumers also preferred more coarse coffee granules.

When evaluating the second principal component, PC_{X}, CB_{X2}, $CBdec_{X}$ and CB_{Y1} (at the bottom of Fig 22) were separated from the remaining samples and seemed to have more characteristics that increased consumers liking. These samples were described as having dense and symmetric coffee granules. The coffees in cup were described as having more intense malty, nutty, cocoa aromas and were perceived as full bodied and cloudy with a roasted flavour and some acidic and astringent characteristics. The remainder of the samples were grouped at the top of Fig 22 and were described as having fishy, earthy and roasted aromas and sweet taste.

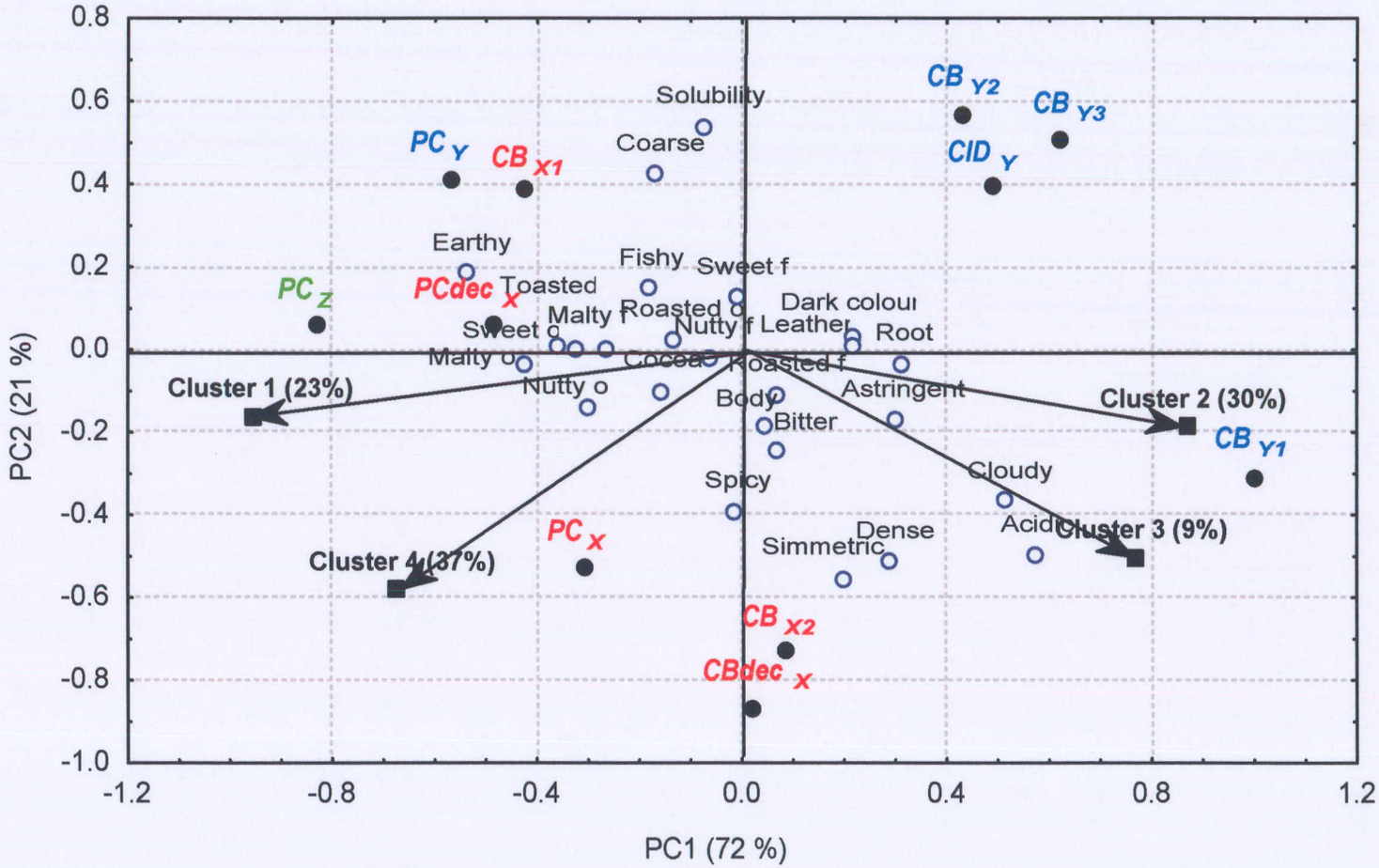

Fig 22: Extended internal preference mapping of the consumer clusters and descriptive sensory analysis of the 11 coffee samples. The vectors represent the direction of liking for the consumer clusters (1 = pure coffee lovers, 2= coffee blend lovers, 3 = not serious coffee drinkers, 4 = general coffee drinkers). PC = pure coffees, CB = coffee blends, CID = chicory instant drink; dec = decaffeinated, XYZ refers to three coffee manufacturers.

8. DISCUSSION

This study was conducted on eleven commercially available instant coffees consisting of pure coffees, coffee blends and a chicory drink. The aim was to establish which intrinsic factors were responsible for making an instant pure coffee, instant coffee blend and chicory drink acceptable? The intention was also to identify possible extrinsic influences, but not including brand name, price and marketing information, that could contribute to the perception consumers have of instant coffees and instant coffee blends. Sensory evaluation is a valuable tool that was used to measure product acceptability and to identify the inherent properties of the coffee brands used for this study. Preference mapping was used to connect consumers preferences (hedonic evaluation) with the product attributes (identified by a trained sensory panel) and thereby drawing a clearer picture on what make specific coffee brands more acceptable to the end user.

Intrinsic characteristics of the samples were identified using Quantitative Descriptive Analysis, where human subjects were used as measuring instruments, as consumers find it difficult at times to articulate why they like a specific brand. This resulted in an objective description of the evaluated products in terms of perceived sensory attributes (Calvino, Zamora & Sarch, 1996). To select a suitable sensory panel from a large group of candidates, a range of tests consisting of the recognition of the four basic tastes, identification and matching of odours, taste intensity evaluation and perception of small differences in taste proved fruitful just as reported by Zamora and Calvino (1996). As stated by Moskowitz (1993), descriptive procedures must be aimed at solving the description of sensory characteristics of any food in a reliable fashion therefore people selected for this panel could distinguish small differences and also had the ability to translate what they tasted into terms that could be easily understood. The panel used came to consensus on 29 attributes, but after quantifying the attributes for each coffee sample, six attributes (mushroom aroma, fenugreek aroma, malty taste, earhy aroma, earthy taste, acidic/sour aroma) were eliminated due to the fact that these attributes did not contribute significantly to differences amongst the coffee samples. It was then possible to identify pertinent information from the large set of descriptive analysis data of instant coffee, by using principal component analysis to construct a product map. In terms of dry appearance, aroma and flavour the first two components explained 83% of the variance in the data which compare well with a reported value of 70.4% for the aroma profile of 15 coffee varieties tested by Liardon, Ott & Daget (1987).

The coffee samples differed from each other but it was especially the differences between pure coffees and coffee blends that stood out. Coffee is a complex product with many properties that make up its intrinsic qualities (Sivetz & Desrosier, 1979). The blend of coffee beans and how the coffee beans was processed all play a part in how the coffee is perceived and described (Liardon *et al.*, 1987). Very little literature could be found where instant coffee blends were sensorically described or evaluated and many additional ingredients are added to make up the final instant coffee blend product, that could have major influences on these products' sensory characteristics.

The trained panel evaluated each sample in terms of its visual appearance, aroma properties, flavour and mouthfeel qualities, as was done by Calvino *et al.* (1996). But Calvino *et al.* (1995) only focussed on the aroma and flavour properties whilst with this study the visual appearance of the dry coffee granules were the first characteristics on which the trained panel distinguished between the samples. The results indicated that these properties were of equal importance in the formation of the quality perception of an instant coffee product. As suggested by Sivetz & Desrosier (1979), these visual attributes create an expectation with the final coffee consumer and must be deemed as important. In terms of appearance all the pure coffees had a coarse texture whilst some coffee blends had fine granules (CB_{Y1}, CB_{Y3} and CID_Y). Six of the samples were dark in colour while CB_{X2}, $CBdec_{X,}$, CB_{Y3}, CID_Y and PC_Z had a light colour. In terms of denseness the coffee samples with a fine texture were perceived as dense, the other samples were more coarse and perforated in appearance with the exception of PC_Z that was also coarse but had a dense appearance and the coffee granules of this sample also solubilised slower than all of the other test samples. It was clear that samples from manufacturer X (CB_{X1}, CB_{X2}, $CBdec_X$, PC_X, $Pcdec_X$) all had a coarse perforated appearance whilst manufacturer Y (CB_{Y1}, CB_{Y2}, CB_{Y3}, CID_Y, PC_Y) included coarse as well as fine coffees in their product catalogue. Validated by a low but significant Pearson correlation, coffee samples with higher a-values as in the case of PC_Z, were perceived by the panel as lighter in colour. Sivetz & Desrosier (1979) reported that the appearance characteristics were very much dictated by the manufacturer and the process used. Pomeranz & Meloan (1994) suggested that physical characteristics of the surface like gloss, texture, relative opacity and surface uniformity have a role to play in terms of colour measurements and human perception. PC_Z coffee granules had a smoother visual appearance, which reflected light and resulted in the sample being perceived as being lighter in colour. This was in contrast to CB_{X2} and

$CBdec_X$, which had a coarse texture and thus absorbed more of the light and had more shadowed areas on the surfaces which resulted in these samples being considered darker in colour by the human eye. When describing coffee characteristics Calvino *et al.* (1995) included the extent of gas bubbles disposed in the border surface of coffee infusion as well as the magnitude of the perceived oil-like film on the surface of the coffee infusion, but reported that no consensus could be reached by the participating panel due to the inconsistent presence of the above-mentioned attributes.

When instant coffee is reconstituted, hundreds of volatiles are released (Hodgins, 1997), which creates a flavour promise for the coffee consumer. It is frequently stated that coffee contains more than 800 flavour components (Grosch, 1998), but such statements give limited information on intrinsic attributes. A clear distinction was found between the aroma of pure coffees that included PC_X, $PCdec_X$, PC_Y, PC_Z and coffee blends namely CB_{X2}, $CBdec_X$, CB_{Y1}, CB_{Y2}, and CB_{Y3}. The pure coffees were predominantly described by the trained panel using terms like *"malty", "nutty", "roasted", "toasted cereal", "spicy" and "chocolate-like"*. The chicory drink (CID_Y) tended to be grouped with the coffee blends and were generally perceived as having an *"earthy"* and *"leather"* aroma by the trained nose that was not surprising as chicory has its origin from the chicory plant's roots which are sliced, kiln-dried, roasted and then ground to be used by itself or in coffee blends (Maier, 1987). CB_{X1} was stronger associated with the pure coffee category which could mean that this sample's composition was different from the other coffee blends, which was confirmed by the label description which indicated that this product only consisted of coffee and chicory. Ingredients, like chicory and maltodextrin, were added to coffee blends mainly for economical reasons (Maier, 1987). These ingredients dilute and even hide pure coffee characteristics and incorporate properties such as sweetness and root-like aroma into coffee blends (Maier, 1987).

In terms of taste and mouthfeel of the evaluated coffee samples a definite difference existed between pure coffees and coffee blends. Pure coffees were described as being full-bodied with a stronger roasted flavour and being more bitter, whilst the coffee blends were generally perceived as watery, sweeter and less bitter. Coffee sample CB_{x1} was described by the panel as less sweet and significantly more bitter than the remaining coffee blends and therefore was grouped closer to the pure coffees. Once again this confirmed that CB_{X1} contained no maltodextrin in its composition.

Bitterness is a distinct attribute found in coffee (Calvino *et al.,* 1995) and the less it is diluted by maltodextrin or chicory in coffee blends, the stronger bitterness is perceived to be. The sweetness identified especially in coffee blends was due to carbohydrates (maltodextrin) added as filler to coffee blends.

Consumers of coffee include a wide selection of people, with different backgrounds, lifestyles, personalities and values. Consumers' lifestyles mainly dictate their coffee consumption habits (Hawkins *et al.,*1992). Coffee is mainly consumed at home and at work, early morning as a wake-me-up remedy, with breakfast and in the evenings to relax at home or with friends and as Cristovan, Russell, Paterson, Reid (2000) suggested, seen in a social environment as a healthy alternative to alcohol. But some coffee lovers consume coffee all day in every situation, which can be a good indication of the physiological effect coffee has on the human body (Macrae, 1985). The majority of consumers that participated in this study consumed any form of coffee, as the opportunity arises or as part of their behavioural pattern, even though they may prefer a specific brand from a flavour perspective. This proves that preference positively rests mainly in the affective domain and stands separate from consumption (Randall & Sanjur, 1981). When the consumer preference map was regressed onto the product map there was a clear distinction made between those consumers that preferred pure coffees and those that preferred coffee blends. Four clusters of consumers were identified that included "coffee blend lovers", "pure coffee lovers", "general coffee lovers" and "not serious coffee drinkers". The overall preference of the general coffee drinkers was strongly associated with CB_{X2} which was also the brand currently purchased by this single largest grouping (39%) of the participants. Consumers were thus familiar with the sensory properties of CB_{X2} and many of this sample's qualities were stored in their sensory information bank ("taste memory") which explained the favourable ratings it received. CB_{X1}, CB_{X2} and $CBdec_{X2}$ were rated well by general coffee drinkers (Cluster 4) and pure coffee drinkers (Cluster 1) alike. This indicated the familiarity of CB_{X2} and $CBdec_{X2}$ to most coffee drinkers. CB_{X1} was mapped between the attributes strongly related to pure coffees and this strong relationship made it more appealing to consumers with a preference for pure coffees whilst it alienated coffee blend drinkers who generally scored it lower than any of the other coffee blends (mean cluster score of 3.6).

For the pure coffee drinkers group PC_z had particular appeal that could be accredited to its lighter symmetric dense appearance, roasted and nutty aroma, its full-bodied mouthfeel with a bitter and slight astringent mouthfeel. CID_Y, CB_{Y1}, CB_{Y2} and CB_{y3} were rated most positive by the coffee blend consumers (Cluster 2) and the less serious coffee consumers (Cluster 3). These consumers' preferences were dictated by attributes such as sweetness, colour, acidity and bitterness. Thus the serious coffee drinkers rated all the coffees highly liked/acceptable, which indicates that these consumers had no specific preference or bias for specific attributes and drank coffee (in any form) for the enjoyment thereof. On the other hand a small group of consumers (9%) was identified, as not very serious coffee consumers as they scored the entire coffee sample set with low acceptability ratings. Indications were that these consumers would drink other hot drinks such as tea, milo and hot chocolate more often (though not significantly more than other clusters) than coffee and also seemed to include younger (15-24 years) coffee consumers, who were most probably still building up a reference in their memory of what attributes they prefer in a coffee product. The pure coffee drinking group rated all the pure coffee samples high, whilst rejecting the coffee blends. This group of consumers was predominantly white and an older more established group of consumers, which could explain their clear preferences for pure coffee, which are usually higher priced products. Then there were the coffee blend drinkers, characterised as possibly having limited income (mostly students and domestic workers) and thus would be more price sensitive when purchasing coffee and coffee blends are usually lower priced.

The majority of consumers (80.6%) regularly consumed instant coffee and from the purchasing data 86% consumers indicated that they purchased coffee blends regularly. Of the 19.4 % of the consumers that indicated that they regularly consumed pure coffee in the form of filter coffee only 30.6% mirrored this consumption preference when ask to indicated their taste preferences blind, 50% of the filter coffee drinkers generally liked any type of coffee and the remaining 19.4% of the consumers actually preferred the taste profile of coffee blends or was not serious coffee drinkers. As suggested by McEwan (1996a), and confirmed by this study, the majority (83.4%) of the participating coffee consumers indicated that they were mainly driven by 'taste' (intrinsic factor) in their purchasing decision. But it seems, as generally predicted by Khan (1981), Cristovan *et al.* (2000) and Heidema & de Jong (1998), that there certainly were other external cues involved such as biological factors (age), cultural factors (ethnic group and neighbourhood), tradition (consumption and purchasing habits) that played a significant role in the participating consumers' choices of a coffee product.

There are several laboratory tests mentioned that could be done on coffee and only a few of these tests were selected to support the results gathered from the sensory panel. It was however evident that human senses take more into consideration when evaluating a product. An electronic nose instrument was used to measure the aroma profiles of each coffee sample. In many instances the electronic nose is recommended for quality control but it must be kept in mind that the quality of a product is not only dependant on the products' volatile aroma but also by sensory factors like non-volatile flavour compounds (taste), mouthfeel and appearance. This results in differences between the observations obtained by a human sensory panel and an electronic nose. Even though the electronic nose segmented the coffees into similar product groups to the descriptive panel, that is, pure coffees, coffee blends, chicory drink and CB_{X2} and $CBdec_X$, this instrument could not take into account the other sensory stimuli that also contributed to the whole coffee drinking experience or even verbalise the aromas into terms that humans understand (Hodgins, 1997). The lack of multifunctionality and articulation of the electronic nose still put this technology some steps behind the human being and can therefore not be exclusively used (Mielle, 1996). The L a b colour measurements gave a measurable indication of how the consumer perceived colour in terms of lightness and in the case of coffee the different colour tones. Samples with higher a-value were perceived by the human eye as lighter in colour and samples with higher b-value darker in colour, even though the chromometer did not indicate significant differences in L values amongst the samples. But as Wall & Bosland (1998) suggested there are factors like size of sample, type of light source, background colour and angle at which the sample is viewed influence human observaion. The caffeine measurements at first appeared to have some kind of link to bitter perception, but no significant correlation could be made between caffeine content and bitterness. Macrea (1985) reported that caffeine is not the only contributor to bitterness and only contributed approximately 10% to bitterness. In most instances the coffee samples perceived as more bitter by the panel also had higher caffeine content. The pure coffee samples had between 40.2mg and 69.4mg caffeine per serving. The exceptions was the chicory and decaffeinated coffee samples which still were perceived as very bitter even though these samples only contained between 1.5mg and 9.0mg caffeine per serving. Clifford (1985) suggested that chlorogenic acids (especially dicaffeoylquinic acids) present in coffee also add to the bitterness perception of coffee which could explain why decaffeinated coffees were still perceived as being bitter even though the caffeine levels were significantly lower. Thus by additionally testing the dicaffeoylquinic acid content of coffee a

more accurate measurement of bitterness could be made. Caffeine measurements also indicated that CB_{X1} contained more caffeine than any of the other coffee blends which supports the label claim that this coffee blend contain more pure coffee in its composition and therefore placed it closer to pure coffee from a taste perspective.

9. CONCLUSIONS

There are many methods to evaluate the sensory attributes of a product but by using a multivariate statistical technique like preference mapping, a possible connection can be made between what the consumers prefer and what intrinsic and extrinsic factors influence their preferences.

Eleven commercial coffee samples were evaluated by the trained sensory panel in terms of dry granule appearance and aroma, ready to drink aroma, mouthfeel and flavour. There is a clear separation between coffee blends and pure coffees. The aroma profiles of the coffee blends are described as "root-like", "leather" and "earthy". The flavour of coffee blends is perceived to be sweeter. The pure coffees, on the other hand, are described as "malty", "toasted", "roasted" and having "chocolate-like" aromas. They are also significantly more bitter than most of the coffee blends. Coffee blend, CB_{X1} seems to group closer to the pure coffee category and even had more caffeine than other coffee blends, whilst the chicory drink (CID_Y) grouped with the coffee blends, even though it does not contain any coffee.

Consumers evaluated all the coffee samples in their normal home environment and four clusters of coffee consumers were identified. Cluster 1 preferred the taste of pure coffee with "nutty", "malty", "roasted" and "chocolate-like" notes with more bitterness, Cluster 2 liked coffee blends sweeter "earthy" and "root-like" characteristics, Cluster 3 did not consume as much coffee as the other groups and did not distinguish clearly between coffees and lastly cluster 4 enjoyed coffee in any form and also did not have a clearly developed coffee profile preference as they gave high ratings to all eleven test samples.

Instrumental measurements indicated similar patterns to the trained panel. The electronic nose, grouped the coffee samples in a similar manner to that of the trained sensory panel and made a clear distinction between pure coffees and coffee blends. The caffeine content measured by means of capillary electrophoresis did not correlate significantly with bitterness perception. The L a b colour measurements gave a measurable indication of how the consumer perceived colour in terms of lightness and in the case of coffee the different colour tones.

From a demographic and psychographic perspective, age, job description, ethnicity, coffee consumption, time of coffee consumption and brands purchased regularly significantly distinguished the consumer clusters. All the consumers seem to be well acquainted with the taste of CB_{X2} and $CBdec_X$. CB_{X2} are most regularly purchased by the majority of participating consumers.

There appear to be more factors like price and culture that influence consumers' purchasing decisions for coffee, but this has to be further investigated. Ultimately it is all a matter of the individual consumers' sensory preferences that dictate which coffee product best meet the specifications set in each consumer's "sensory memory". This 'sensory memory' for coffee is developed by regular consumption of coffee and each individual's lifestyle.