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|---|---|
| **Project title:** | Watercress: predicting the effect of agronomic production factors on the flavour acceptability to consumers |
| **Project number:** | FV 255 |
| **Project leader:** | Dr Richard Stanley<br>Campden & Chorleywood Food Research Association<br>Chipping Campden<br>Gloucestershire GL55 6LD |
| **Report:** | Final report, September 2004 |
| **Previous reports:** | None |
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| **Location:** | Commercial crops in Hampshire and Dorset and Florida USA evaluated at CCFRA Gloucestershire |
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| **Key words:** | Watercress, agronomy, sensory quality, consumer, chemical analysis, flavour |

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

**AUTHENTICATION**

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr Richard Stanley

Campden & Chorleywood Food Research Association

Signature ..... Date .....

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**CONTENTS**

# Growers Summary

## Headlines

- Sensory attributes relating to consumer preference have been identified
- Consumers appear to prefer; crisp and chewy textures, hot flavour, grassy/green flavour, sweetness and bitterness
- Chemical volatile composition and the profile of sensory attributes have been linked to provide a means to predict the sensory properties of watercress from a laboratory test. This includes the anti-carcinogen phenethylisothiocyanate (PEITC)
- Further work in 2005 will attempt to optimise watercress flavour by manipulating crop agronomy

## Background

A study was carried out to determine which sensory attributes are potential drivers of consumer acceptance and liking of watercress and to identify chemical volatile compounds, including the proposed anti-carcinogen phenethylisothiocyanate (PEITC), whose concentrations are correlated to the intensity of those attributes. The objective of the study was to increase understanding of consumer preferences in relation to watercress and to develop methodologies capable of monitoring the impact of changing agronomic procedures and predicting the effect on consumer liking. This represents Phase 1 of a 3 phase study into the sensory quality of watercress and how it may be manipulated.

## Approach

Six samples of watercress were obtained in May, 2004; the samples were selected to represent a diverse range of sensory characters. Samples were evaluated by a consumer panel, who scored each on the basis of liking. Additional sensory assessment was carried out by a trained sensory panel, in order to obtain objective information regarding the sensory attributes of the products. Samples were also analysed by headspace solid phase microextraction (SPME) and gas chromatography/mass spectrometry (GC/MS) to obtain a profile of chemical volatile composition.

Data from all tests were analysed individually and in combination, using univariate and multivariate statistical methods. This presented a novel approach to the understanding of consumer acceptance in terms of both sensory profile and chemical composition.

## Summary of results

The data from this study indicate that the most probable drivers of consumer liking for watercress are texture, hot flavour, grassy/green flavour, sweetness and bitterness. The limitations of the sample set used in this study meant that it was not possible to determine which of these sensory attributes (or combination of attributes) are the key drivers of liking.

It is likely that each attribute must be optimised, rather than maximised or minimised, in order to achieve the highest level of overall consumer liking. This was illustrated by the relationship between overall liking and hot flavour, in which a peak of overall liking was found to be somewhere in the middle of the range of hotness values. The data was insufficient to draw definitive conclusions with respect to the relationship between specific sensory attributes and consumer liking, but potentially important trends were identified for further investigation in subsequent phases of the study.

Important relationships were identified between chemical volatile composition and the profile of sensory attributes. These are significant as they provide a means to predict the sensory properties of watercress from the results of chemical analysis.

Some attributes were found to be strongly correlated to the concentration of individual chemical components. For example, grassy/green flavour showed strong positive correlation with 2,4-nonadienal, and hot flavour showed significant correlation with a number of components, including phenethylisothiocyanate (PEITC). Thus, the intensity of these flavour attributes may be predicted from the abundance of these indicator compounds.

Other attributes did not exhibit significant correlation with individual chemical components. For these attributes, predictions may be made from chemical volatile composition using multivariate regression methods. However, it may be necessary for additional analyses to be carried out in order to make more confident predictions of the intensity of some attributes (e.g. bitterness) which are predominated by the influence of non-volatile compounds.

Overall, the work reported in this document has provided valuable information regarding the likely drivers of consumer liking for watercress, as well as the basis for an analytical approach to monitor these sensory attributes. Thus, the objectives of the work were achieved and the results provide a suitable platform for subsequent stages of the study.

## Further work

Phase 2 of this study will investigate the influence of various agronomic factors on the sensory attribute found to be potentially significant to consumer preference. These are believed to be crisp and chewy textures, and hot, sweet and grassy/green flavours. The study will focus on flavour attributes, with the univariate and multivariate regression methods, developed in the first phase of the study, being used to predict sensory perception from chemical volatile composition.

The results of phase 2 will provide vital information on how the sensory properties of watercress can be manipulated. Thus, for phase 3 of the study, consumers will be presented with the range of watercress samples necessary to develop a more definitive understanding of consumer preference.

# Science Section

## Introduction

Consumption of watercress has been linked positively to certain forms of treatment or prevention of cancer, and there is an expectation that these positive health connotations could be useful in the promotion of watercress to consumers. However, consumer demand for watercress could be affected by the unpredictability of flavour quality. It is suggested that volatile compounds responsible for flavour are influenced significantly by the growing conditions. The overall objective of this study was to obtain a greater understanding of the influence of growing conditions on watercress sensory quality so that a more consistent product can be developed.

The aim of this initial stage of the investigation was to determine the sensory attributes that are potential drivers of consumer acceptance and liking of watercress and to identify chemical volatile compounds whose concentrations are correlated to the intensity of those attributes. Subsequent stages of the investigation will determine the influence of agronomic factors on sensory quality, as indicated by the concentrations of chemical volatile compounds identified in the first stage. Finally, the findings will be confirmed using consumer panels to assess liking of watercress grown under selected conditions.

Six samples of watercress were obtained in May 2004. The samples were selected to represent a diverse range of sensory character. Samples were evaluated by a consumer panel, who scored each on the basis of liking. Additional sensory assessment was carried out by a trained sensory panel in order to obtain objective information regarding the sensory attributes of the products. Samples were also analysed by headspace solid phase microextraction (SPME) and gas chromatography/mass spectrometry (GC/MS) to obtain a profile of chemical volatile composition.

Data from all tests were analysed individually and in combination using univariate and multivariate statistical methods. This presented a novel approach to the understanding of consumer acceptance in terms of both sensory profile and chemical composition.

## MATERIALS AND METHODS

### Sample Details

| Sample Name | Sample Description |
|---|---|
| Top Stubble | Cut from the top end of an over-wintered crop in the UK |
| Bottom Stubble | Cut from the bottom end of an over-wintered crop in the UK |
| Top Seedling | Cut from the top end of a spring sown crop in the UK |
| Bottom Seedling | Cut from the bottom end of a spring sown crop in the UK |
| USA Organic | Supplied from a grower in Florida, USA, this is a UK type grown organically |
| USA Polyploid | Supplied from a grower in Florida, USA, this is a true American polyploid, similar to old brown cress |

All samples were vacuum cooled after harvest, packed in ice in polystyrene boxes for transport to CCFRA for assessment.

### Sample Preparation

Prior to the assessment the samples were washed thoroughly and the young centre stalks removed for assessment. The Stubble samples appeared more mature with thicker stalks and significant sprouting and flowering. The flowering/thick stalks were considered unsuitable to present to the consumers, therefore to standardise the method, only the young centre stalks were used, for all samples. For both the sensory and the consumer assessment, each assessor was presented with several sprigs of watercress on a coded plate. Water and cream crackers were given as palate cleansers.

### Sensory Assessment

The sensory characteristics (appearance, taste, flavour, texture and aftertaste) of the six samples of watercress were determined using a trained sensory panel by means of Quantitative Descriptive Analysis (QDA) (Test TES-S-009).

Attribute Generation Sessions

Several training sessions took place in which each assessor was asked to describe each sample in his/her own terminology (appearance, taste, flavour, texture and aftertaste). After these sessions, the panel leader compiled the common language terms and developed descriptors for each term, which were subsequently agreed by the entire panel. The final attribute list is shown in Appendix 1.

Attribute Scoring Sessions

These sessions were carried out as part of the training sessions. The panel was asked to score selected attributes on a 0-9 fixed scale. The results from the sessions allowed the panel leader to promote a standardised scoring system for use by the entire panel.

Assessment Sessions

A computer-driven acquisition system was used for all assessments using the FIZZ software package (version 2.0). All assessors were highly trained and experienced in using the system. Ten trained assessors carried out the quantitative assessment over four sessions on 26th and 27th May 2004.

Each sample was assessed by each assessor in three replicates. A Latin-square design (software-generated) was used in order to minimise any carry-over and order effects. Due to the carry-over effect and lingering aftertaste three samples were assessed in each session with two sessions per replication.

For each attribute, each assessor used a mouse to score on a 0-100 continuous line scale, anchored at the extremes. The description (or 'help' message) for each attribute was accessible to each assessor at all times. Sessions were conducted in sensory booths under white lighting.

**Consumer Panel**

The test products were assessed using a central location test approach. All respondents were pre-recruited.

A total of 106 respondents were recruited, 28 respondents were from a combination of internal staff at CCFRA and local residents from the area and 78 from the Redditch area in the West Midlands. Each respondent was asked to assess six samples of watercress.

Respondents were asked to evaluate each of the trial products and complete a questionnaire (shown in Appendix 4). Due to the nature of the product, in order to combat palate fatigue, respondents were forced to take a five minute break after evaluating the first three products, before continuing to evaluate the last three products.

Degree of liking was measured for overall, appearance, flavour, texture and aftertaste. Consumer satisfaction (Just about Right) was also measured for bitterness, hotness of flavour and strength of aftertaste. The consumer data were analysed to identify the most and least acceptable samples. Alongside this, the samples were characterised by a trained sensory panel. The sensory data collected determined the appearance, flavour, texture and aftertaste characteristics of the watercress samples.

A 9-point hedonic scale was used to capture respondents degree of liking of the products characteristics. A 5-point "Just about Right" (JAR) scale was used for specific attributes.

**Hedonic Scale**

| | |
|---|---|
| Like extremely | 9 |
| Like very much | 8 |
| Like moderately | 7 |
| Like slightly | 6 |
| Neither like or dislike | 5 |
| Dislike slightly | 4 |
| Dislike moderately | 3 |
| Dislike very much | 2 |
| Dislike extremely | 1 |

**Just about Right (JAR)**

| | |
|---|---|
| 5 | Much too strong/too much |
| 4 | A little too strong/too much |
| 3 | Just about right |
| 2 | A little too weak/not enough |
| 1 | Much too weak/not enough |

**Chemical Analysis**

Samples were prepared by blending sample (50g) with liquid nitrogen and mixing with sodium chloride (20g) and an aqueous solution of phenol-$d_6$ (200ppb; 50ml).

Prepared sample (10g) was placed into a 20ml vial, and sealed. The vial was equilibrated at 75°C for 15 minutes with agitation. The headspace of the vial was then sampled for 15

minutes at 75°C (with agitation) using a carboxen / polydimethylsiloxane coated SPME fibre. The volatiles adsorbed onto the fibre were analysed by thermal desorption at 250°C in the injector port of a GC/MS.

Analyses were carried out on a Varian 3800 gas chromatograph (GC) and Varian Saturn 2000 ion trap mass spectrometer (MS) via a CTC Combi-Pal autosampler.

GC/MS conditions were as follows:

| | |
|---|---|
| Column: | 25m x 0.25mm fused silica with ZB-624 stationary phase |
| Helium carrier gas flow rate: | 1ml. $Min^{-1}$ |
| Desorption temperature: | 250°C |
| Column temperature: | 2 mins at 50°C; then 5°C. $min^{-1}$ to 250°C |
| MS analysis mode: | SCAN 29-350 *m/z* |

Peaks were tentatively identified by spectral matching with the Wiley library of mass spectral data.

**Data Analysis**

Sensory Assessments

The data were analysed by a number of methods, which are described below. The statistical package used was S-Plus.

*Analysis of Variance*

A two-way analysis of variance (ANOVA) was used to test if there was a significant difference between the means of samples (products) for each variable (attribute). The Newman-Keuls (NK) multiple comparison test was used to determine whether the samples were significantly different for each attribute at the specified 5% level of significance. Samples with the same letters were not significantly different from each other.

*Principal Components Analysis (PCA)*

Principal components analysis (PCA) is a data reduction technique that attempts to summarise multivariate information, normally using 2-4 dimensions. PCA allows products and attributes to be represented together on a multivariate space, summarising the similarities and differences between products, and showing how the attributes are related to the products and each other.

Consumer Panel

The data were analysed by a number of methods, which are described below. The statistical packages used were S-Plus, SPSS and Minitab.

The recruitment data were tabulated and cross-tabulated as appropriate. The data were tabulated to indicate the count and percentage of responses for each of the scores per sample, for both the hedonic and JAR questions. Summary statistics were provided on each sample.

*ANOVA*

The hedonic data were then analysed using analysis of variance (ANOVA) to determine if there were significant differences between the samples with respect to acceptability. Following ANOVA, a Newman-Keuls multiple comparison test was undertaken to establish which samples were different at the 5% level of significance. Samples with the same letters are not significantly different from each other.

*T-test*

A t-test was performed on the JAR attributes; bitter, hotness of flavour, strength of aftertaste, to establish if each sample was significantly different from the "just about right" score of 3 (Hypothesis = 3).

Combined Data Sets

Relationships between the three data sets (sensory assessment, consumer panel and chemical analysis) were identified using Partial Least Squares (PLS) regression. PLS regression is a statistical modelling technique that links a block of response variables (y data set) to a block of explanatory variables (x data set). The main advantage of PLS is that it identifies sources of variance in the explanatory variables that are most relevant to the response variables (e.g. it creates a "consumer-relevant" sensory map).

The statistical package used was The Unscrambler.

# RESULTS

## Sensory Assessment

The statistical results are detailed in terms of a summary table showing significant differences and means (Appendix 2). The letters in the table indicate where the samples are significantly different. Means sharing the same letter are not significantly different, whereas means that have different letters are significantly different to each other. Mean graphs follow the summary table in Appendix 3.

As can be seen in the ANOVA results, 16 out of the 17 attributes selected were found to describe significant differences between samples. The non-significant attribute was acid taste.

### Bottom Stubble

*Appearance*

The Bottom Stubble sample was significantly darker than all the other samples and was significantly less bright than the Top and Bottom Seedling samples. It was also the most mature/aged, being significantly more mature than USA Organic, Top and Bottom Seedling samples.

*Flavour*

Bottom Stubble was the most bitter, being significantly more bitter in flavour and aftertaste than USA Organic, Top and Bottom Seedling samples. The Bottom Stubble sample was significantly stronger in flavour, had more iron and cabbage flavour, and was hotter in flavour and aftertaste than all other samples except Top Stubble, which was the strongest in all these characteristics. Bottom Stubble was the least grassy/green, being significantly less than all other samples, except Top Stubble. It was the least sweet, being significantly less sweet than the USA Organic, Top and Bottom Seedling samples.

*Texture*

Bottom Stubble was significantly more chewy and significantly less crisp than all the other samples, except Top Stubble.

Top Stubble

*Appearance*

The Top Stubble sample was significantly paler than the Bottom Stubble sample, which was the darkest sample, but was significantly darker than all the remaining samples. Similar to Bottom Stubble, was more mature/aged, with both stubble samples being significantly more mature than USA Organic, Top and Bottom Seedling samples. Top Stubble had the thinnest stems, being significantly thinner than all other samples except Bottom Stubble. This is however misleading as both Stubble samples had unacceptably thick mature stems and due to this only the young top stems could be used.

*Flavour*

Top Stubble was the strongest in flavour, had the most iron and cabbage flavour, and was the hottest in flavour and aftertaste, being significantly more so than all other samples, except Bottom Stubble. Similar to Bottom Stubble, it was significantly more bitter in flavour and aftertaste and significantly less sweet than USA Organic, Top and Bottom Seedling samples.

*Texture*

Top Stubble was significantly more chewy and less crisp than all other samples, except Bottom Stubble.

Bottom Seedling

*Appearance*

The Bottom Seedling sample was significantly darker than USA Polyploid, but significantly lighter than Top Seedling and Bottom and Top Stubble. Similar to Top Seedling, it was significantly brighter than the Bottom Stubble and USA Polyploid samples. Bottom Seedling was the least blemished being significantly less blemished than USA Polyploid and Top Seedling. It was the least mature being significantly less mature than all the other samples.

*Flavour*

Bottom Seedling was the sweetest and the least bitter for flavour and aftertaste, being significantly different from the USA Polyploid, Top and Bottom Stubble samples. Similar to Top Seedling and USA Polyploid, it was significantly less hot in flavour than USA Organic and the Top and Bottom Stubble samples.

*Texture*

Bottom Seedling was the most crisp and the least chewy, being significantly different from the Top and Bottom Stubble samples.

Top Seedling

*Appearance*

Top Seedling was significantly darker than Bottom Seedling, USA Organic and USA Polyploid, but significantly paler than Bottom and Top Stubble. Similar to Bottom Seedling, it was significantly brighter than the Bottom Stubble and USA Polyploid samples. It was significantly less mature than the Bottom and Top Stubble samples, but significantly more mature than the Bottom Seedling, which was the least mature.

*Flavour*

Similar to Bottom Seedling and USA Organic, Top Seedling was significantly sweeter than the Bottom and Top Stubble samples. Similar to Bottom Seedling and USA Organic, it was significantly more Grassy/Green than the Bottom Stubble sample. Similar to Bottom Seedling, it was significantly less hot in flavour than USA Organic and the Bottom and Top Stubble samples. Similar to Bottom Seedling, it was significantly less bitter for flavour and aftertaste than the USA Polyploid and the Top and Bottom Stubble samples.

*Aftertaste*

Similar to Bottom Seedling and USA Organic, Top Seedling was significantly less hot than the two Stubble samples for aftertaste, but significantly hotter than USA Polyploid, which was significantly the least hot.

USA Organic

*Appearance*

USA Organic was significantly darker than the USA Polyploid sample (which was the palest), but was significantly paler than the Top Seedling and Bottom and Top Stubble samples. It was significantly more mature than the Bottom Seedling sample, but significantly less mature than the Bottom and Top Stubble samples.

*Flavour*

USA Organic was significantly hotter than USA Polyploid, Bottom and Top Seedlings, but less hot than the Top and Bottom Stubble samples. Similar to Bottom and Top Seedling, it was significantly more Grassy/Green than the Bottom Stubble sample. Similar to Bottom and Top Seedling, USA Organic was significantly sweeter, less cabbagy and weaker in overall strength and iron flavour than the Top and Bottom Stubble samples. USA Organic was significantly less bitter than the Top and Bottom Stubble.

*Aftertaste*

USA Organic was significantly less bitter for aftertaste than the USA Polyploid, Top and Bottom Stubble samples. It was significantly hotter in aftertaste than USA Polyploid, but significantly less hot than the Top and Bottom samples.

USA Polyploid

*Appearance*

USA Polyploid was the palest and most blemished, being significantly different to all the other samples. It was the least bright being significantly less bright than the Bottom and Top Seedling samples.

*Flavour*

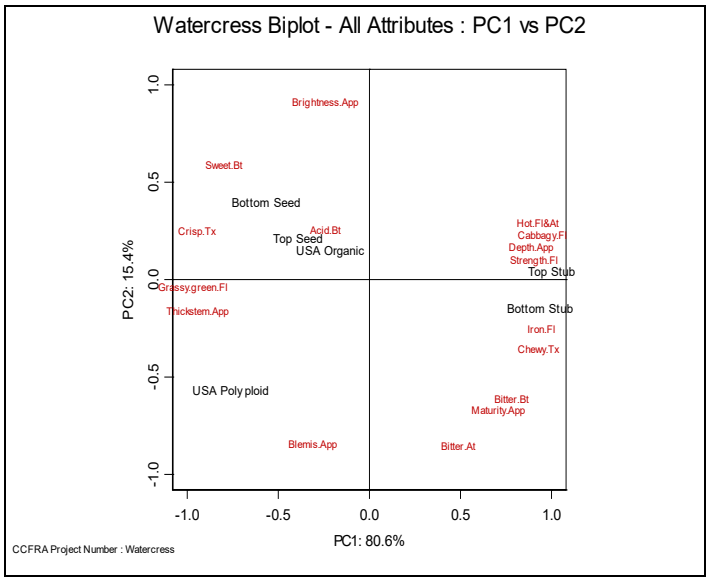
USA Polyploid was significantly more bitter than the Top and Bottom Seedling samples, but significantly less bitter than the Top and Bottom Stubble samples. It was the most grassy/green, being significantly more than the Top and Bottom Stubble samples. It was the least cabbagy and weakest flavour, being significantly less than the Top and Bottom Stubble samples. It was the least hot, being significantly less than the USA Organic, Top and Bottom Stubble.

*Aftertaste*

USA Polyploid was the least hot, being significantly less than all the other samples. Similar to the Top and Bottom Stubble samples, was more bitter, than USA Organic and the two Seedling samples.

**Principal Component Biplot**

The Top and Bottom Stubble samples were similarly perceived, being darker, more mature, stronger in cabbage, iron, bitter and overall strength of flavour (Figure 1). The USA Organic sample was fairly similar to the two Seedling samples, being sweeter, less mature, less iron flavour, less bitter and less chewy. The USA Polyploid was the palest, least bright, most blemished, most grassy/green, least cabbagy, least hot and weakest flavour.



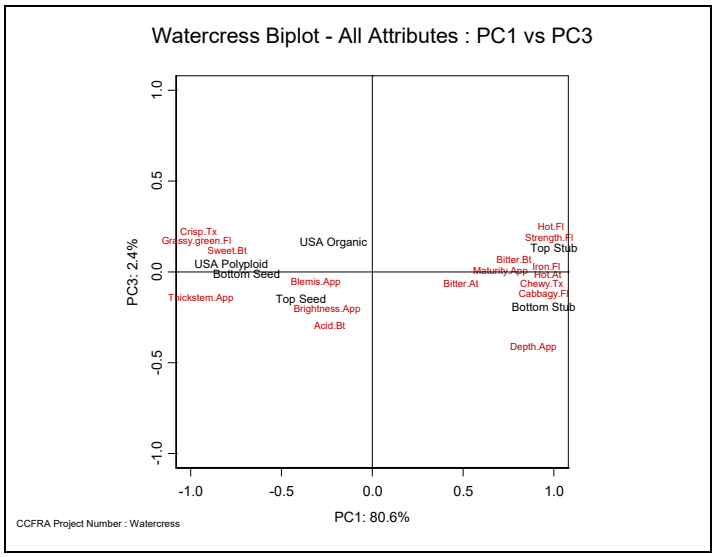




**Figure 1: Principal Component Biplot of Responses from the Sensory Panel**

## Consumer Panel

A total of 106 consumer respondents were recruited, 28 respondents were from a combination of internal staff at CCFRA and local residents from the area and 78 from the Redditch area in the West Midlands. The test was a pre-recruited central location test. All respondents had eaten watercress within the last 12 months and all indicated that they would eat watercress in the future.

The majority of respondents were female, represented by 72% against 28% for male. The social class were evenly split between A/B/C1 (49%) and C2/D/E (51%). Age ranged from 18 – 64 with the majority being fairly evenly split across the ages 18-54, with a lower percentage accounting for 55-64, representing 10%. The full demographic results are shown in Appendix 6.

The statistical results are detailed in terms of a summary table showing significant differences and means (Appendix 5). The letters in the table indicate where the samples are significantly different. Means sharing the same letter are not significantly different, whereas means that have different letters are significantly different to each other. Mean graphs follow the summary table in Appendix 5. The hedonic and JAR full and summarised tabulations (count & %) are shown in Appendix 6. Summarised hedonic tabulations are shown in Figure 2, while summarised JAR tabulations are shown in Figure 3.

Overall the Bottom Seedling sample recorded the highest levels of liking, recording mean values between 6.2-6.8, with liking to some degree being expressed between 70-82% of respondents for all hedonic attributes except the aftertaste which accrued a mean score of 5.7, with liking being expressed to some degree by 53% of respondents. The Bottom Seedling was significantly liked more than the USA Polyploid and Top Stubble samples for overall liking, from the USA Polyploid, Bottom and Top Stubble samples for appearance, and from the Bottom and Top Stubble samples for flavour and texture.

The Top Seedling and USA Organic samples recorded similar liking levels to the Bottom Seedling sample. The USA Organic sample recorded mean values between 6.1-6.6, with liking to some degree being expressed between 66-77%, of respondents, except the aftertaste which accrued a mean score of 5.9, with liking being expressed to some degree by 66% of respondents. The USA Organic sample was significantly liked more than the Top Stubble sample for overall liking and from the Top and Bottom Stubble samples for Flavour and Texture.

The Top Seedling recorded mean values of between 5.8-6.6, with liking to some degree being expressed between 60-78%, of respondents, except the aftertaste which accrued a mean score of 5.6, with liking being expressed to some degree by 57% of respondents. The Top Seedling sample was significantly preferred to the Top and Bottom Stubble samples for Texture.

The USA Polyploid sample recorded mean values between 5.6-6.1, with liking to some degree being expressed between 56-69%, of respondents, except the aftertaste which accrued a mean score of 5.5, with liking being expressed to some degree by 49% of respondents.

The Bottom Stubble sample recorded fairly low levels of liking for the hedonic attributes, overall, flavour and aftertaste, recording mean values between 5.2-5.7, with liking to some degree being expressed between 49-58%, of respondents. For Bottom Stubble, 71% of respondents liked the appearance, recording a mean of 6.1, with 63% liking the texture recording a mean of 5.9. The Top Stubble sample recorded fairly low levels of liking for all the hedonic attributes, recording mean values between 5.2-5.8, with liking to some degree being expressed between 48-56%, of respondents.

For all samples poor levels of consumer satisfaction were recorded for all of the JAR attributes, ranging from 38-59% of respondents indicating just about right. The Top and Bottom Stubble samples received the strongest criticism, with consumer satisfaction being recorded by between only 38-48% of respondents. Both samples were indicated as being significantly too bitter, too hot and aftertaste too strong.

For Top Stubble, 49% of respondents indicated the sample to be too bitter, 50% indicated the product too hot and 55% indicated too strong. For Bottom Stubble, 50% of respondents indicated the sample to be too bitter, 40% indicated it to be too hot and 53% indicated it to too strong. For Top Seedling, 31% of respondents indicated the sample to be too bitter with 59% indicating consumer satisfaction, 25% indicated it to be too hot with 56% indicating consumer satisfaction and 35% indicated it to be too strong, with 50% indicating consumer satisfaction.

For Bottom Seedling, 50% of respondents indicated consumer satisfaction for bitterness with the remaining respondents being split, 28% indicating too bitter and 22% not bitter enough. For hotness 48% indicated it to be too hot with 31% indicating it not hot enough. For aftertaste 49% of respondents indicated consumer satisfaction, with the remaining respondents being split 24% indicating too strong and 26% not strong enough.

For USA Polyploid, 39% of respondents indicated the sample to be too bitter with 46% indicating consumer satisfaction, 41% indicated it to be not hot enough. For aftertaste 50% of respondents indicated consumer satisfaction, with the remaining respondents being split 28% indicating too strong and 21% not strong enough.

For USA Organic, 36% of respondents indicated the sample to be too bitter with 53% indicating consumer satisfaction. For hotness 53% of respondents indicated consumer satisfaction, with the remaining respondents being split 26% indicating too hot and 22% not hot enough. For aftertaste 32% of respondents indicated it to be too strong with 53% indicating “just about right”.

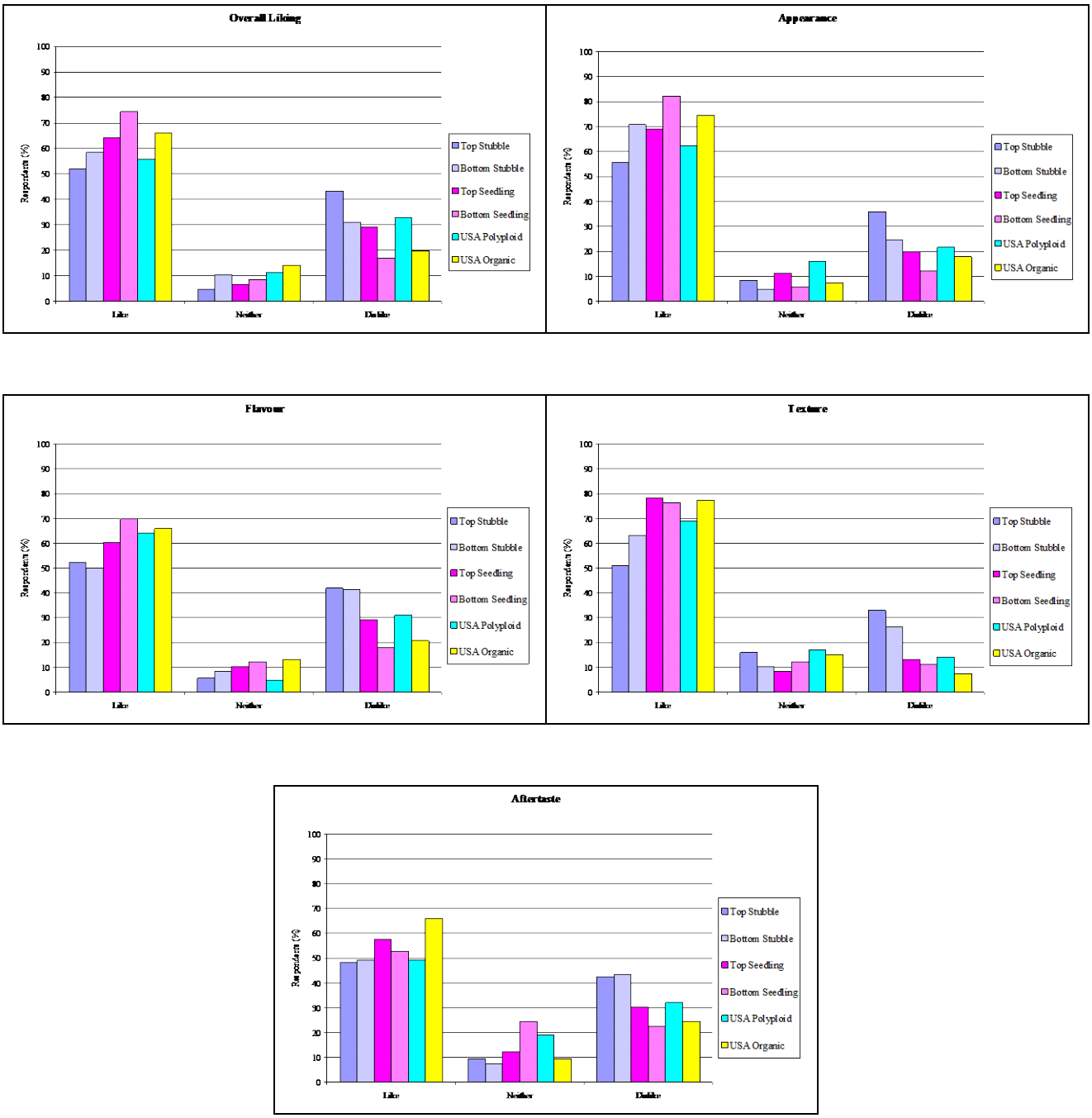



**Figure 2: Graphs of Summarised Percentages (Hedonic)**

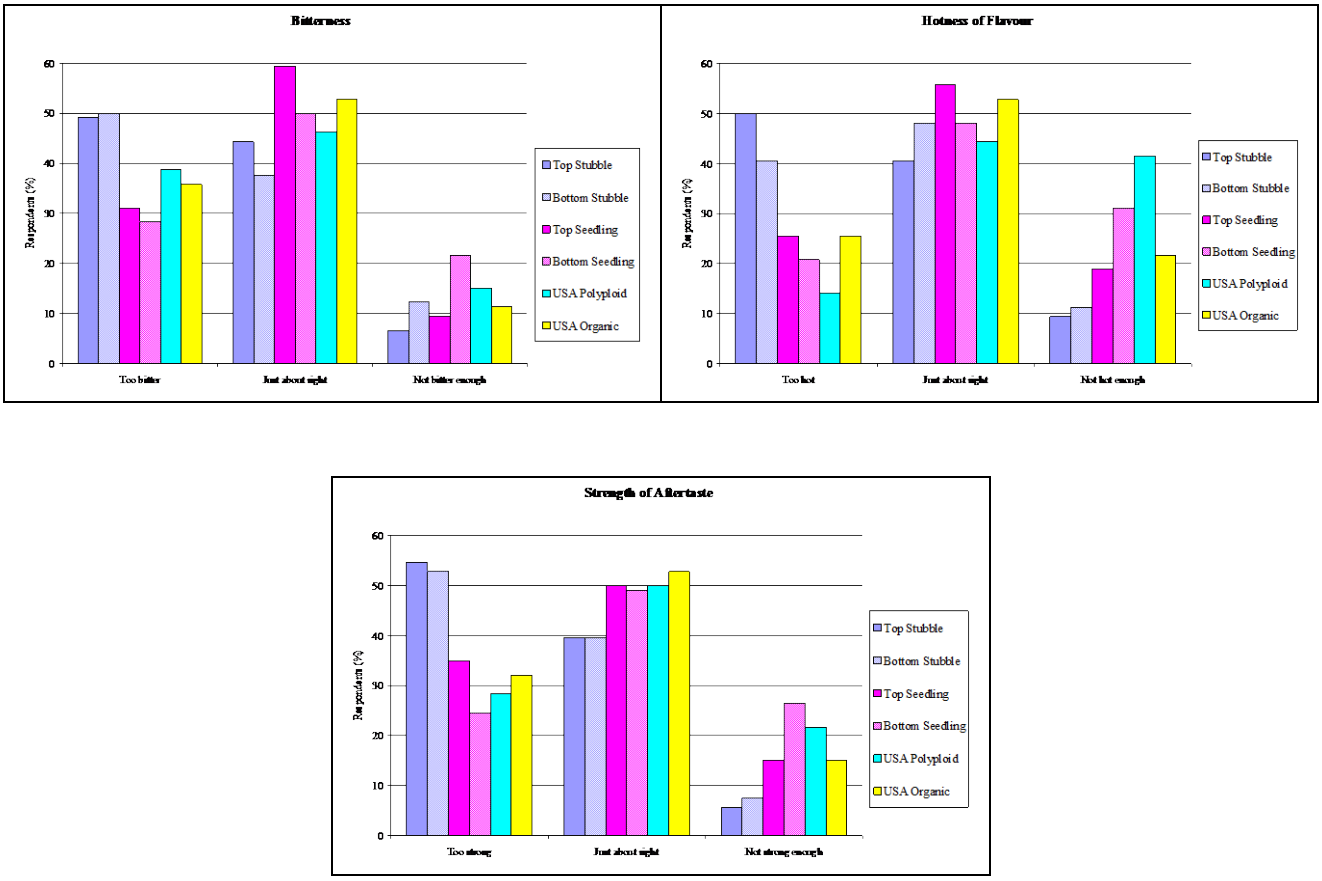



**Figure 3: Graphs of Summarised Percentages (Just about Right)**

Cross tabulations showed a trend for the males giving a slighter higher preference overall to the USA Organic, Bottom Seedling and Bottom Stubble samples. The females indicated a slighter higher preference to the seedling samples, with a lower preference to the stubble samples, particularly for overall, flavour and aftertaste. (Appendix 6).

## DISCUSSION

Relationships between consumer panel data, sensory assessment data and chemical analysis data were investigated using Partial Least Squares (PLS) regression. This statistical approach allows the analyst to identify how the variance in one data set is related to the variance in another data set. An understanding of this relationship can be used to develop predictive tools. For example, by understanding the relationship between data associated with sensory attributes and data associated with chemical composition, it may be possible to predict the change in certain sensory attributes brought about by an increase in one or more chemical volatile compound.

PLS2 regression was used to identify relationships between the responses of trained sensory assessors (x data set) and the consumer panel (y data set). The score plot (Figure 4) illustrates a differentiation between the top stubble and bottom stubble samples and the other four samples along PC1, which represented 74% of the variance in consumer panel data.

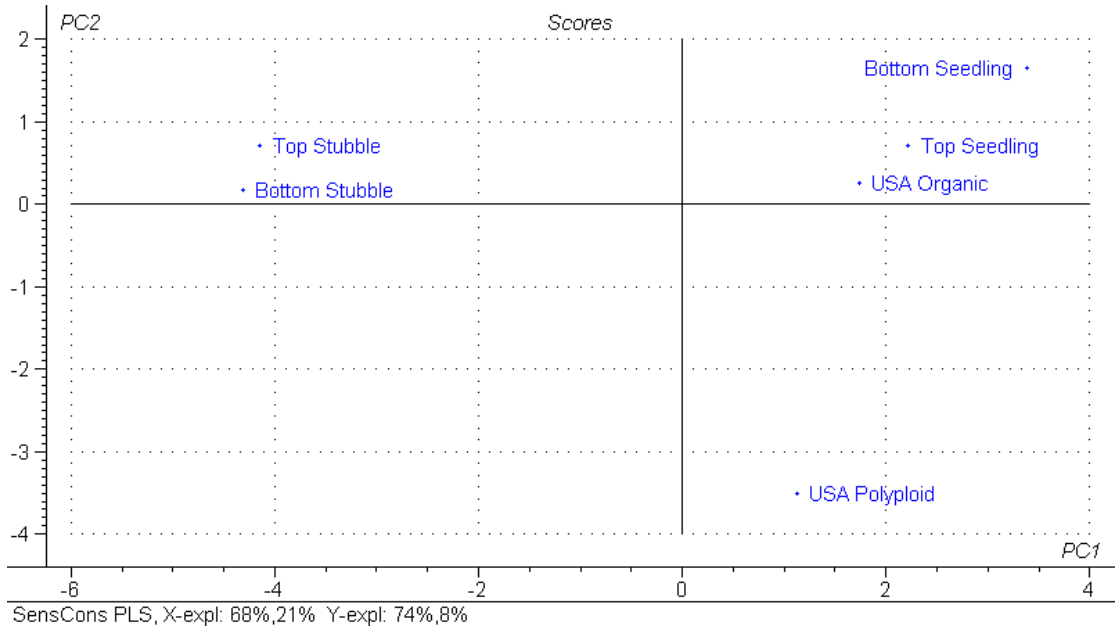



**Figure 4: PLS Score Plot for Sensory Panel (x Data Set) and Consumer Panel (y Data Set) Data**

PC2 was used to separate USA Polyploid from the other samples, although this dimension represented only 8% of the variance in consumer panel responses, which demonstrates that there were only small differences between these samples in terms of consumer preference. Greater differentiation of these samples was provided by the responses of the trained sensory panel, for which PC2 represents 21% of the data variance.

The correlation loadings plot for this regression showed that all responses from the consumer panel (i.e. representing different aspects of acceptance and liking) were positioned in close proximity to each other (Figure 5). This illustrates that consumers tended to either like or dislike all aspects of each watercress type, including flavour and texture attributes. This reduced the consumer panel data to a rather more univariate consideration of whether each consumer liked or disliked a sample *per se*, rather than resolving whether the consumer liked a certain aspect in particular.

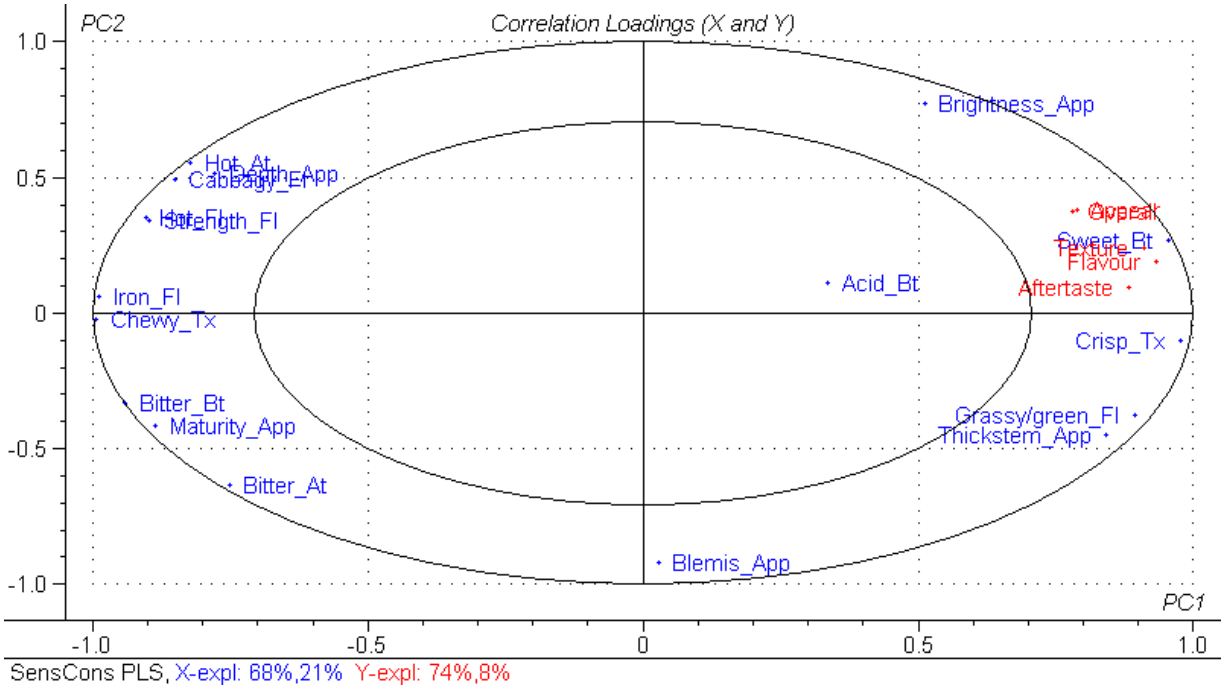



**Figure 5: PLS Correlation Loadings Plot for Sensory Panel (x Data Set) and Consumer Panel (y Data Set) Data**

The correlation loadings plot also provides information on how the different sensory attributes appear to relate to the consumer preference scores. In general, preference appears to be positively correlated to sweet and grassy/green attributes, and negatively correlated to many other flavour attributes, including hot.

The observation of a negative correlation between hot flavour and consumer liking is one worthy of further consideration. The correlation may be interpreted in one of two ways. The first possibility is that some samples were mild and others were hot, and that the consumers preferred the mild samples. This would lead to the conclusion that the consumer tends to dislike a hot flavour in watercress. Alternatively, it may be that some of the samples were hot

and others were extremely hot. This raises the possibility that the negative correlation was a consequence of the fact that some samples tested were unpalatably hot.

Whichever conclusion prevails, it would be intuitive to suggest that a certain level of hot flavour would be desirable to the consumer, as a hot flavour is a key characteristic of watercress, but that a very high intensity of hot flavour would be considered a negative characteristic. This is supported by the relationship between hot flavour and consumer overall liking for these samples, in which overall liking peaked at an intermediate level of hotness (Figure 6). One of the objectives of further stages of this study must be to establish the range of 'hotness values' that are considered to be desirable by the consumer.

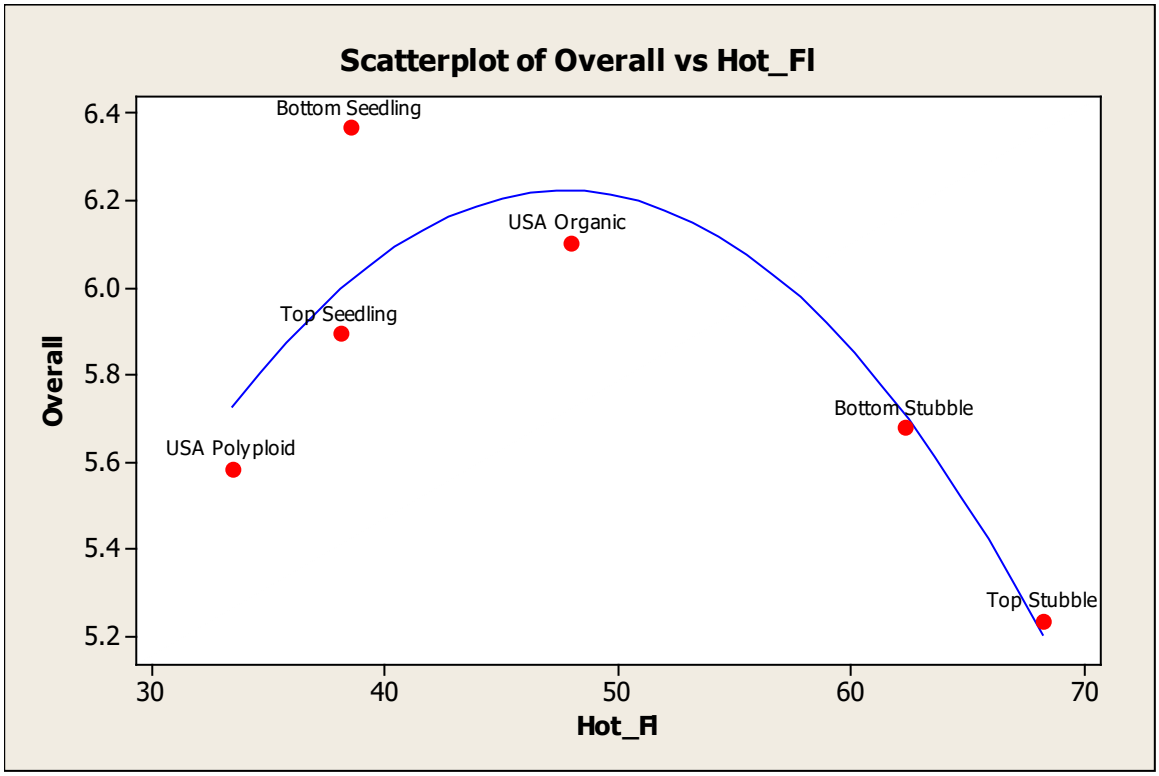



**Figure 6: Relationship Between Overall Liking and Hot Flavour**

The differences between samples as depicted in the score plot are reflective of the information given in the correlation loadings plot. Therefore, samples towards the right side of the score plot (e.g. Top Seedling) are more associated with those attributes on the right side of the correlation loadings plot (e.g. Flavour preference and Sweet_Bt).

By studying the results of the PLS analysis in terms of textural qualities, it is also apparent that consumers preferred watercress with a crisp texture over those with a chewy texture. It is

assumed that the degree of crispness or chewiness in watercress is due more to post-harvest factors (e.g. storage conditions), rather than factors related to variety or agronomic conditions. Therefore, it is proposed that this observation is noted as a general preference of the consumer, but not considered further in this study.

The observation that consumer preference was driven by flavour and texture parameters leaves some uncertainty surrounding the interpretation of the relationship between sensory profile and consumer preference. Among the samples of watercress that were assessed, all samples that were sweeter and more grassy/green were crisp, while the hotter samples were chewy. This limitation makes it impossible to predict the response of the consumer should they be presented with a sample of watercress that is crisp and hot or chewy and sweet. Thus, it is not possible to state whether texture or flavour is the predominant driver of consumer preference.

In the context of the overall investigation, this is not an insurmountable problem. Phase 2 of the research will identify approaches to control the types of flavour formed in a particular batch of watercress. This will provide the possibility to produce grassy/green or hot samples on demand for phase 3, which will involve consultation with consumers once again. Assuming that knowledge exists on how to control the texture of watercress, it will be possible to present the consumer with samples of watercress covering all permutations of texture and flavour combinations. Thus a more definitive understanding of consumer preference will be acquired.

A PLS2 regression was used to develop understanding of how data from chemical analysis (x data set) was related to data from sensory assessment using the trained panel (flavour attributes only; y data set). Once again, the score plot showed that the samples were separated into two groups, with Top Stubble and Bottom Stubble showing large differences from the rest of the samples (Figure 7). The correlation loadings plot from this regression analysis shows how each individual chemical volatile compound was seen to relate to each flavour attribute (Figure 8).

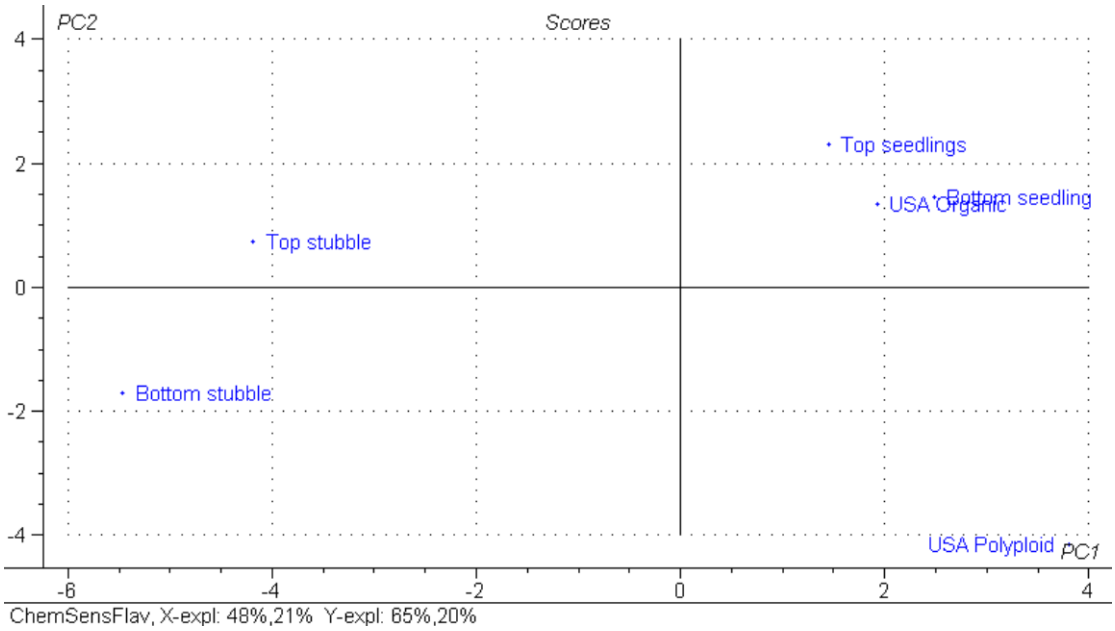



**Figure 7: PLS Score Plot for Chemical Analysis (x Data Set) and Sensory Panel Flavour Attributes (y Data Set) Data**

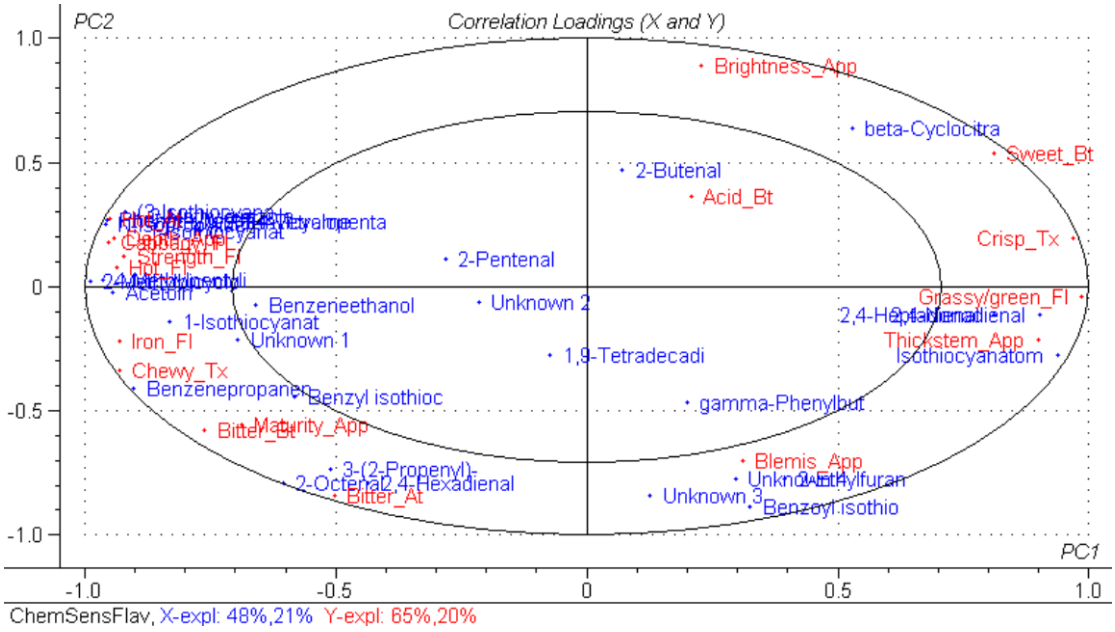



**Figure 8: PLS Correlation Loadings Plot for Chemical Analysis (x Data Set) and Sensory Panel Flavour Attributes (y Data Set) Data**

A number of compounds known to contribute hotness are positioned in close proximity to the hot flavour attribute in the correlations loadings plot; this suggests that their concentration

provides a good indication of the perceived level of hotness. Most notably in light of its suggested anticancer properties, a high correlation was observed between the concentration of phenethylisothiocyanate and hot flavour (Figure 9). This observation is in accordance with the known sensory characteristics of phenethylisothiocyanate.

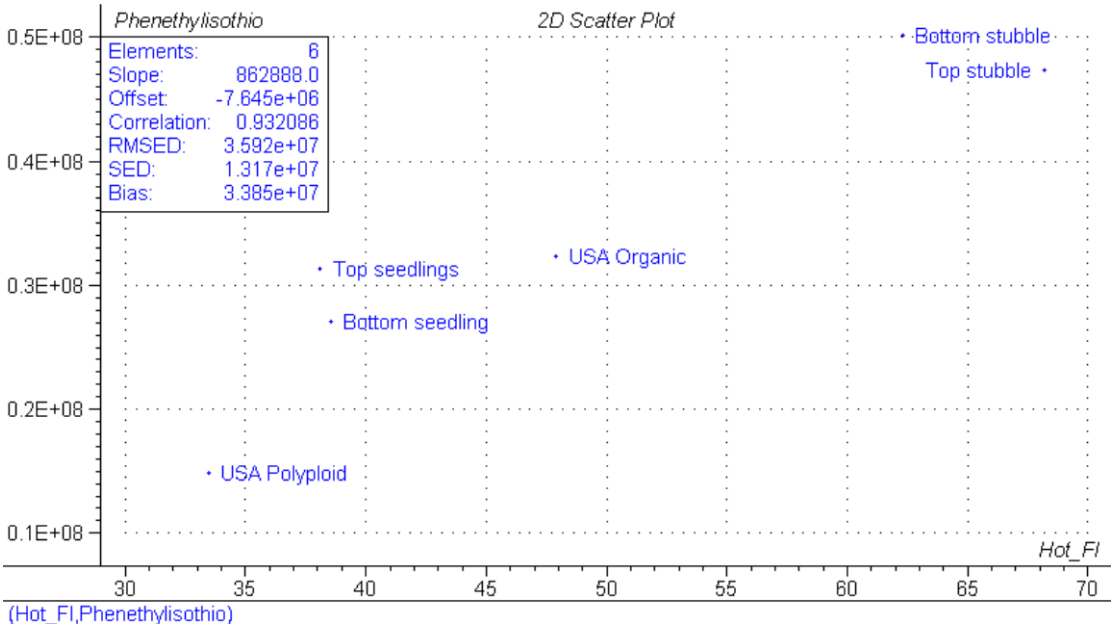



**Figure 9: Correlation between N-isopropylidene Concentration and Hot Flavour Sensory Attribute**

Both 2,4-heptadienal and 2,4-nonadienal are positioned in close proximity to the grassy/green sensory attribute on the correlation loadings plot. This is intuitive, as these compounds typically have grassy/green odour character. Their suitability as indicators of the intensity of grassy/green is illustrated by the high correlation between 2,4-nonadienal and grassy/green flavour (Figure 10).

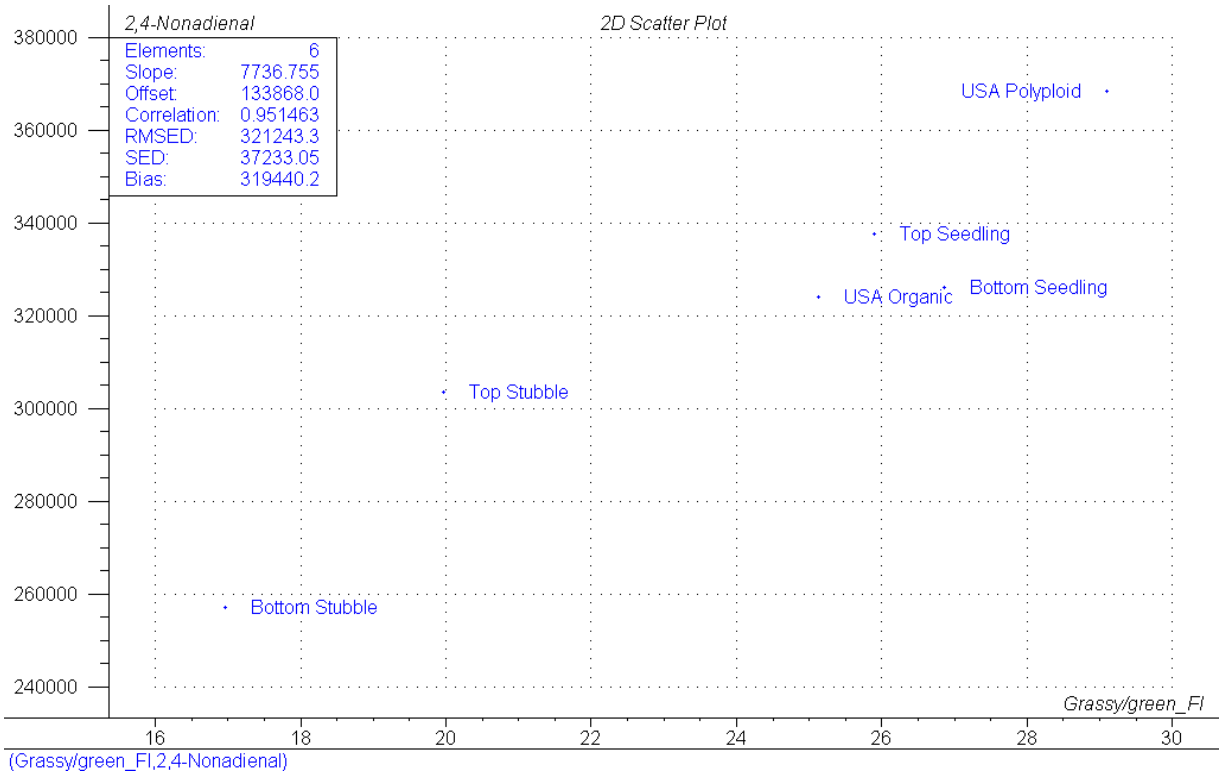



**Figure 10: Correlation between 2,4-Nonadienal Concentration and Grassy/Green Sensory Attribute**

The correlation loadings plot suggests that the concentration of beta-cyclocitral may be related to the Sweet_Bt sensory attribute. However, the correlation coefficient for these variables is only 0.7, indicating that there is not a particularly strong bivariate relationship.

It would be expected that sweetness is most closely related to the concentration of sugars, whose concentration cannot be determined using this analytical method. However, the volatile composition of a sample can give much information on the overall composition of the sample, including non-volatile components. For example, sugar composition may be indirectly determined by measuring the concentration of volatile compounds formed through the breakdown or reaction of sugars.

Alternatively, the perception of sweetness may be predominantly influenced by the presence of volatile components that synergise or antagonise the sweetness of sugars. Thus, the concentration of sugars may stay fairly constant across all samples, with the perception of sweetness being heavily influenced by the presence of certain volatile components.

For either scenario, the relationship between volatile composition and the perception of a sweet flavour is likely to be complex, requiring a consideration of the concentration of many

different chemical volatile compounds. One of the strengths of multivariate regression is that it provides a means to understand these types of complex relationships and to use them for prediction. Therefore, it may be reasonable to use multivariate PLS regression as a tool to predict the perceived sweetness of a sample on the basis of the concentration of many different volatile components. This makes no impact in analytical terms, as all volatile analytes can be quantified from a single analysis. Similar approaches can also be applied to the prediction of other attributes that may be significant to consumer liking, such as bitterness, using data from the same analyses.

A plot of predicted sweetness against measured sweetness for all samples shows that the correlation coefficient for the PLS2 regression (0.82) is higher than the univariate regression using only the concentration of beta-cyclocitral (0.7). Correlation using a PLS1 regression (x data set: chemical data; y data set: sweet flavour) is substantially higher (0.97) if the outlier USA Polyploid sample is omitted from the regression.

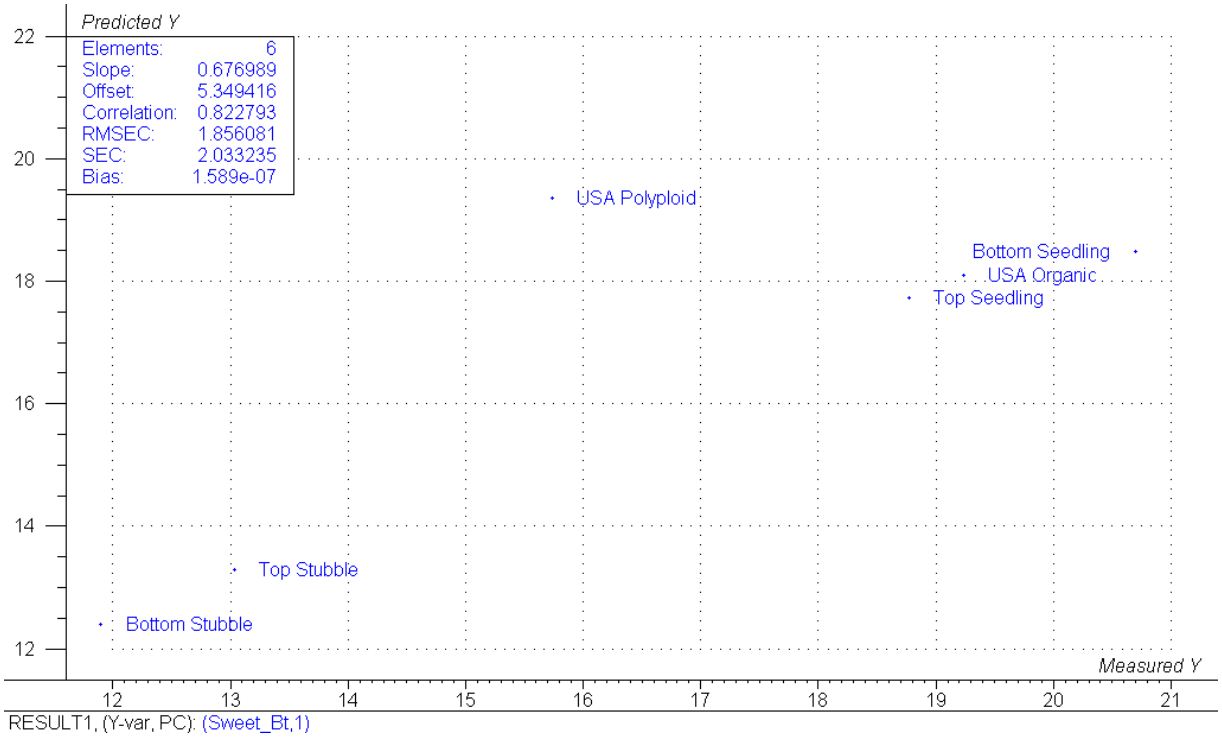



**Figure 11: Prediction of Sweetness using PLS Regression of all Chemical Data**

No linear relationship was evident between chemical volatile profile and bitterness using univariate or PLS regression methods if all samples were included in the regression. In all cases, it appeared that the USA Polyploid sample was not compliant with any trends observed

for the other five samples. A PLS1 regression of chemical composition against bitterness for all samples excluding USA Polyploid gave a correlation between predicted and measured values of 0.96.

This regression provides an approach to tentatively predict bitterness from volatile composition. The non-compliance of one out of the six samples suggests that the regression is far from robust and any predictions of bitterness made using this approach must be qualified by the understand of these limitations. Alternatively, a more reliable approach to predicting bitterness would be to quantify levels of key glucosinolates using HPLC.

## SUMMARY

The data from this study indicate that the most probable drivers of consumer liking for watercress are texture, hot flavour, grassy/green flavour, sweetness and bitterness. The limitations of the sample set used in this study meant that it was not possible to determine which of these sensory attributes (or combination of attributes) are the most important drivers of liking.

It is likely that each attribute must be optimised, rather than maximised or minimised, in order to achieve the highest level of overall consumer liking. This was illustrated by the relationship between overall liking and hot flavour, in which a peak of overall liking was found to be somewhere in the middle of the range of hotness values. The data was insufficient to draw definitive conclusions with respect to the relationship between specific sensory attributes and consumer liking, but potentially important trends were identified for further investigation in subsequent phases of the study.

Important relationships were identified between chemical volatile composition and the profile of sensory attributes. These are significant as they provide a means to predict the sensory properties of watercress from the results of chemical analysis.

Some attributes were found to be strongly correlated to the concentration of individual chemical components. For example, grassy/green flavour showed strong positive correlation with 2,4-nonadienal, and hot flavour showed significant correlation with a number of components, including N-isopropylidene and phenethylisothiocyanate. Thus, the intensity of these flavour attributes may be predicted from the intensity of these indicator compounds.

Other attributes did not exhibit significant correlation with individual chemical components. For these attributes, predictions may be made from chemical volatile composition using multivariate regression methods. However, it may be necessary for additional analyses to be carried out in order to make more confident predictions of the intensity of some attributes (e.g. bitterness) which are predominated by the influence of non-volatile compounds.

Overall, the work reported in this document has provided valuable information regarding the likely drivers of consumer liking for watercress, as well as the basis for an analytical approach to monitor these sensory attributes. Thus, the objectives of the work were achieved and the results provide a suitable platform for subsequent stages of the study.

## FUTURE WORK

In Phase 2 of this study it is proposed to investigate the influence of various agronomic factors on the sensory attribute found to be potentially significant to consumer preference. These are believed to be crisp and chewy textures, and hot, sweet and grassy/green flavours. The study will focus on flavour attributes, with the univariate and multivariate regression methods, developed in the first phase of the study, being used to predict sensory perception from chemical volatile composition.

The results of phase 2 will provide vital information on how the sensory properties of watercress can be manipulated. Thus, for phase 3 of the study, consumers will be presented with the range of watercress samples necessary to develop a more definitive understanding of consumer preference.

# APPENDIX I

## SENSORY DESCRIPTIVE ATTRIBUTES

## ATTRIBUTES AND DEFINITIONS

| Attribute Group | Attribute | Abbreviated Term | Definition |
|---|---|---|---|
| Appearance | Depth of colour | Depth | Depth of overall colour, ranging from pale to dark |
| | Brightness | Brightness | Reflecting light, shiny |
| | Thickness of stem | Thick stem | Thickness of stem |
| | Amount of blemish | Blemish | Amount of blemishes/insect damage present on sample |
| | Maturity | Maturity | Sample having an over-mature/aged appearance |
| Flavour | Overall strength | Strength | Overall strength of flavour |
| | Iron | Iron | Reminiscent of spinach |
| | Cabbagy | Cabbagy | Reminiscent of raw white cabbage |
| | Grassy/green | Grassy/green | Reminiscent of stalks of grass |
| | Hot | Hot | Reminiscent of mustard |
| Basic tastes | Sweet | Sweet | Associated with sucrose |
| | Acid | Acid | Associated with citric acid |
| | Bitter | Bitter | Associated with quinine |
| Texture | Crisp | Crisp | Having a fresh, crisp bite |
| | Chewy/fibrous | Chewy | Tough, requiring more effort to break down |
| Aftertaste | Bitter | Bitter | Intensity of bitterness perceived after swallowing |
| | Hot | Hot | Intensity of hotness perceived after swallowing |

# APPENDIX II

## SENSORY SAMPLE MEANS, INCLUDING ANALYSIS OF VARIANCE

## ANALYSIS OF VARIANCE

| Attribute Group | Attribute | Sample | N | Mean | P Value | Significance | NK Groups |
|---|---|---|---|---|---|---|---|
| Appearance | Depth of colour | Bottom Stubble | 30 | 63.3 | <0.001 | 0.1% | A |
| | | Top Stubble | 30 | 57.9 | | | B |
| | | Top Seedling | 30 | 53.1 | | | C |
| | | Bottom Seedling | 30 | 48.5 | | | D |
| | | USA Organic | 30 | 46.4 | | | D |
| | | USA Polyploid | 30 | 41.4 | | | E |
| | Brightness | Bottom Seedling | 30 | 55.5 | <0.001 | 0.1% | A |
| | | Top Seedling | 30 | 55.3 | | | A |
| | | Top Stubble | 30 | 51.1 | | | A B |
| | | USA Organic | 30 | 50.5 | | | A B |
| | | Bottom Stubble | 30 | 47.3 | | | B |
| | | USA Polyploid | 30 | 46.0 | | | B |
| | Thickness of stem | USA Polyploid | 30 | 41.8 | 0.001 | 0.1% | A |
| | | Bottom Seedling | 30 | 39.9 | | | A |
| | | Top Seedling | 30 | 39.6 | | | A |
| | | USA Organic | 30 | 39.4 | | | A |
| | | Bottom Stubble | 30 | 36.3 | | | A B |
| | | Top Stubble | 30 | 33.1 | | | B |
| | Amount of blemish | USA Polyploid | 30 | 29.7 | <0.001 | 0.1% | A |
| | | Top Seedling | 30 | 22.7 | | | B |
| | | USA Organic | 30 | 22.1 | | | B C |
| | | Bottom Stubble | 30 | 21.5 | | | B C |
| | | Top Stubble | 30 | 18.5 | | | B C |
| | | Bottom Seedling | 30 | 14.7 | | | C |
| | Maturity | Bottom Stubble | 30 | 55.0 | <0.001 | 0.1% | A |
| | | Top Stubble | 30 | 54.5 | | | A |
| | | USA Polyploid | 30 | 51.6 | | | A B |
| | | USA Organic | 30 | 46.7 | | | B |
| | | Top Seedling | 30 | 46.3 | | | B |
| | | Bottom Seedling | 30 | 39.7 | | | C |

| Attribute Group | Attribute | Sample | N | Mean | P Value | Significance | NK Groups |
|---|---|---|---|---|---|---|---|
| Flavour | Overall strength | Top Stubble | 30 | 60.1 | <0.001 | 0.1% | A |
| | | Bottom Stubble | 30 | 55.4 | | | A |
| | | USA Organic | 30 | 49.3 | | | B |
| | | Top Seedling | 30 | 46.1 | | | B |
| | | Bottom Seedling | 30 | 44.2 | | | B |
| | | USA Polyploid | 30 | 42.7 | | | B |
| | Iron | Top Stubble | 30 | 28.6 | <0.001 | 0.1% | A |
| | | Bottom Stubble | 30 | 26.9 | | | A |
| | | USA Polyploid | 30 | 19.2 | | | B |
| | | Top Seedling | 30 | 18.3 | | | B |
| | | USA Organic | 30 | 17.9 | | | B |
| | | Bottom Seedling | 30 | 16.8 | | | B |
| | Cabbagy | Top Stubble | 30 | 28.4 | <0.001 | 0.1% | A |
| | | Bottom Stubble | 30 | 26.0 | | | A |
| | | Top Seedling | 30 | 18.1 | | | B |
| | | Bottom Seedling | 30 | 18.1 | | | B |
| | | USA Organic | 30 | 15.7 | | | B |
| | | USA Polyploid | 30 | 12.7 | | | B |
| | Grassy/ green | USA Polyploid | 30 | 29.1 | 0.001 | 0.1% | A |
| | | Bottom Seedling | 30 | 26.9 | | | A B |
| | | Top Seedling | 30 | 25.9 | | | A B |
| | | USA Organic | 30 | 25.1 | | | A B |
| | | Top Stubble | 30 | 20.0 | | | B C |
| | | Bottom Stubble | 30 | 17.0 | | | C |
| | Hot | Top Stubble | 30 | 68.2 | <0.001 | 0.1% | A |
| | | Bottom Stubble | 30 | 62.3 | | | A |
| | | USA Organic | 30 | 47.9 | | | B |
| | | Bottom Seedling | 30 | 38.5 | | | C |
| | | Top Seedling | 30 | 38.1 | | | C |
| | | USA Polyploid | 30 | 33.5 | | | C |

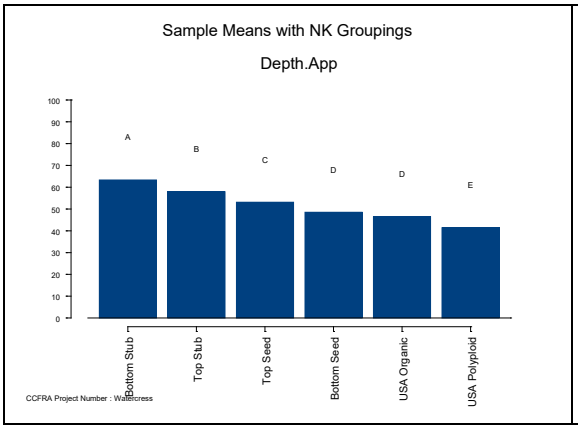
| Attribute Group | Attribute | Sample | N | Mean | P Value | Significance | NK Groups |
|---|---|---|---|---|---|---|---|
| Basic tastes | Sweet | Bottom Seedling | 30 | 20.7 | <0.001 | 0.1% | A |
| | | USA Organic | 30 | 19.2 | | | A B |
| | | Top Seedling | 30 | 18.8 | | | A B |
| | | USA Polyploid | 30 | 15.7 | | | B C |
| | | Top Stubble | 30 | 13.0 | | | C |
| | | Bottom Stubble | 30 | 11.9 | | | C |
| | Acid | Top Seedling | 30 | 25.2 | 0.774 | NS | |
| | | USA Organic | 30 | 24.9 | | | |
| | | Bottom Stubble | 30 | 23.9 | | | |
| | | USA Polyploid | 30 | 23.2 | | | |
| | | Bottom Seedling | 30 | 22.9 | | | |
| | | Top Stubble | 30 | 22.5 | | | |
| | Bitter | Bottom Stubble | 30 | 38.4 | <0.001 | 0.1% | A |
| | | Top Stubble | 30 | 37.5 | | | A |
| | | USA Polyploid | 30 | 32.5 | | | A B |
| | | USA Organic | 30 | 26.9 | | | B C |
| | | Top Seedling | 30 | 23.9 | | | C |
| | | Bottom Seedling | 30 | 21.8 | | | C |
| Texture | Crisp | Bottom Seedling | 30 | 50.7 | <0.001 | 0.1% | A |
| | | USA Polyploid | 30 | 48.2 | | | A |
| | | USA Organic | 30 | 47.9 | | | A |
| | | Top Seedling | 30 | 47.0 | | | A |
| | | Top Stubble | 30 | 39.7 | | | B |
| | | Bottom Stubble | 30 | 37.1 | | | B |
| | Chewy/ fibrous | Bottom Stubble | 30 | 55.8 | <0.001 | 0.1% | A |
| | | Top Stubble | 30 | 52.8 | | | A |
| | | USA Polyploid | 30 | 43.1 | | | B |
| | | USA Organic | 30 | 41.7 | | | B |
| | | Top Seedling | 30 | 40.6 | | | B |
| | | Bottom Seedling | 30 | 38.0 | | | B |

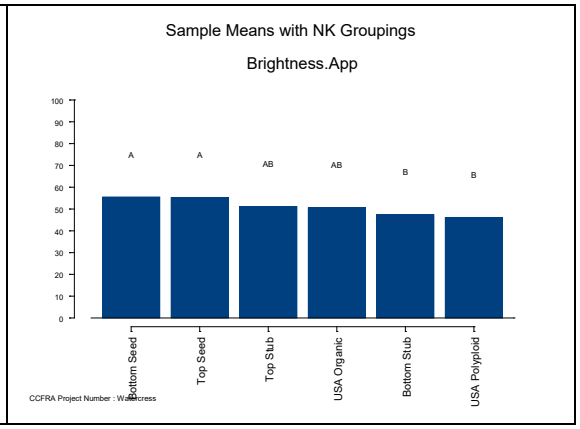
| Attribute Group | Attribute | Sample | N | Mean | P Value | Significance | NK Groups |
|---|---|---|---|---|---|---|---|
| Aftertaste | Bitter | Bottom Stubble | 30 | 42.2 | <0.001 | 0.1% | A |
| | | USA Polyploid | 30 | 41.7 | | | A |
| | | Top Stubble | 30 | 37.6 | | | A |
| | | USA Organic | 30 | 27.8 | | | B |
| | | Top Seedling | 30 | 26.8 | | | B |
| | | Bottom Seedling | 30 | 24.7 | | | B |
| | Hot | Top Stubble | 30 | 81.6 | <0.001 | 0.1% | A |
| | | Bottom Stubble | 30 | 79.8 | | | A |
| | | USA Organic | 30 | 59.7 | | | B |
| | | Top Seedling | 30 | 56.5 | | | B |
| | | Bottom Seedling | 30 | 53.5 | | | B |
| | | USA Polyploid | 30 | 37.9 | | | C |

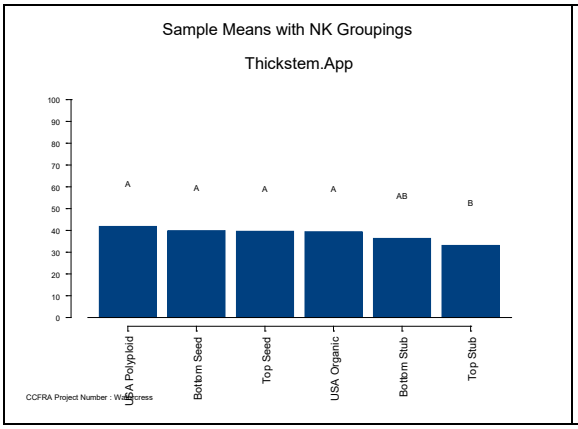
| P Value | | Significance Level |
|---|---|---|
| ≤ 0.001 | 0.1% | Significant at 0.1% level of significance |
| ≤ 0.010 | 1% | Significant at 1% level of significance |
| ≤ 0.050 | 5% | Significant at 5% level of significance |
| > 0.050 | NS | Not significant |

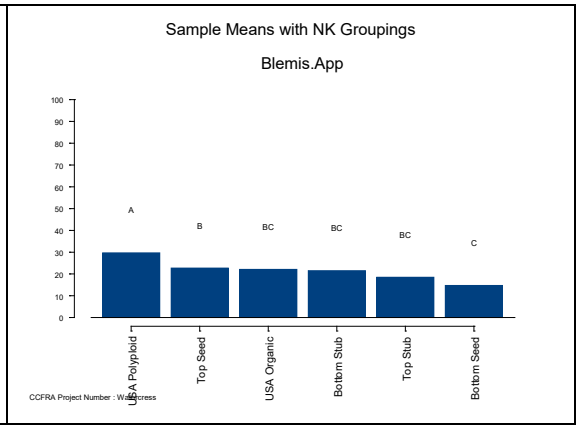
# APPENDIX III

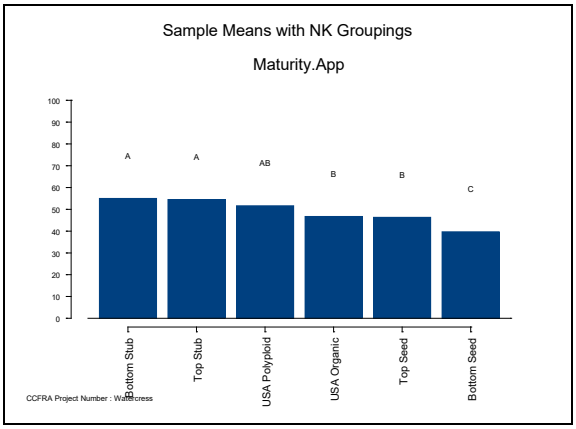
## SENSORY SAMPLE MEAN GRAPHS, INCLUDING NEWMAN-KEULS (NK) GROUPINGS

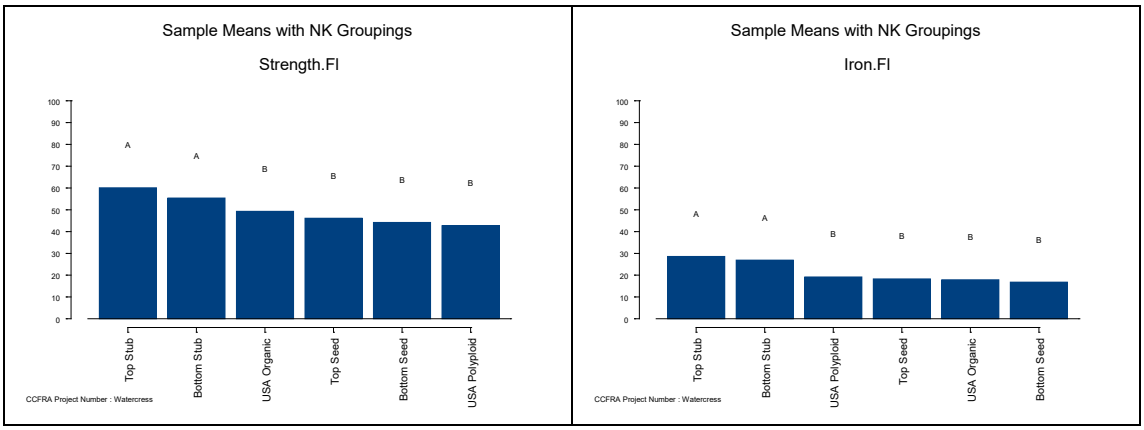


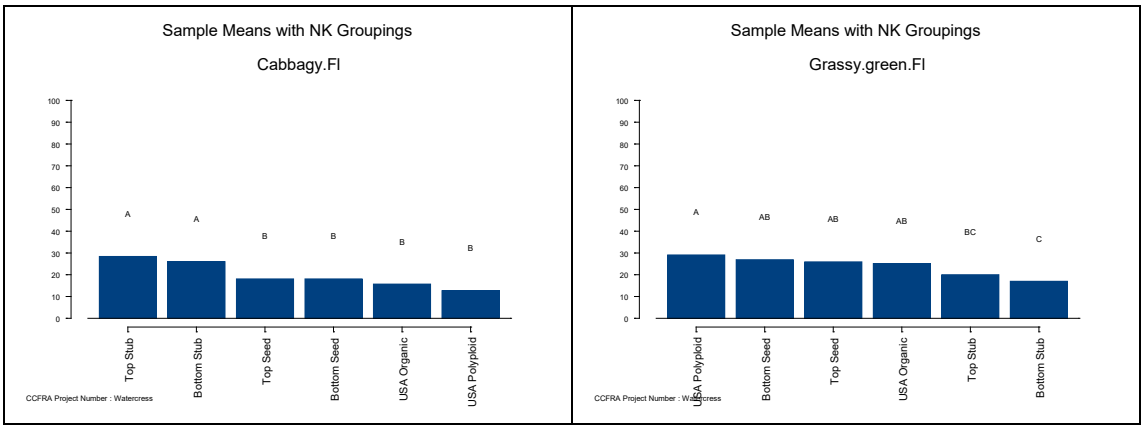



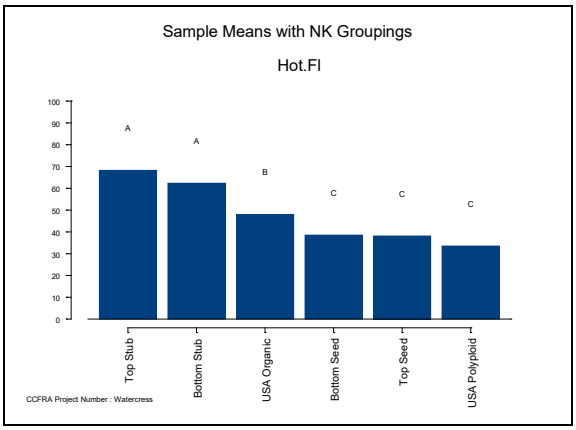



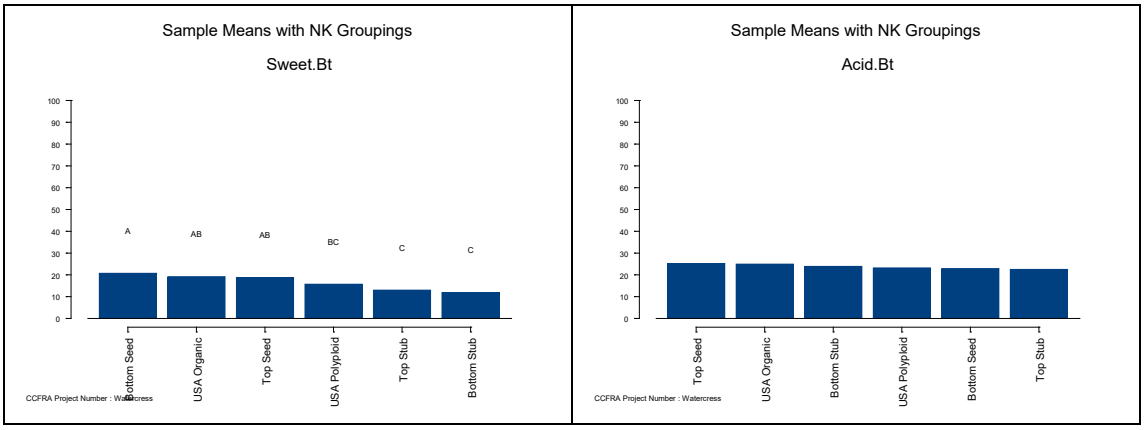



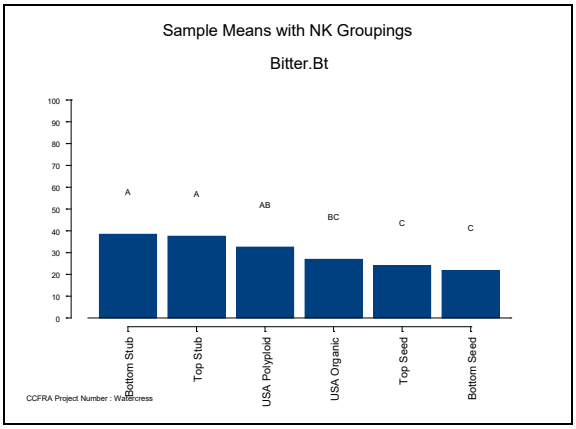



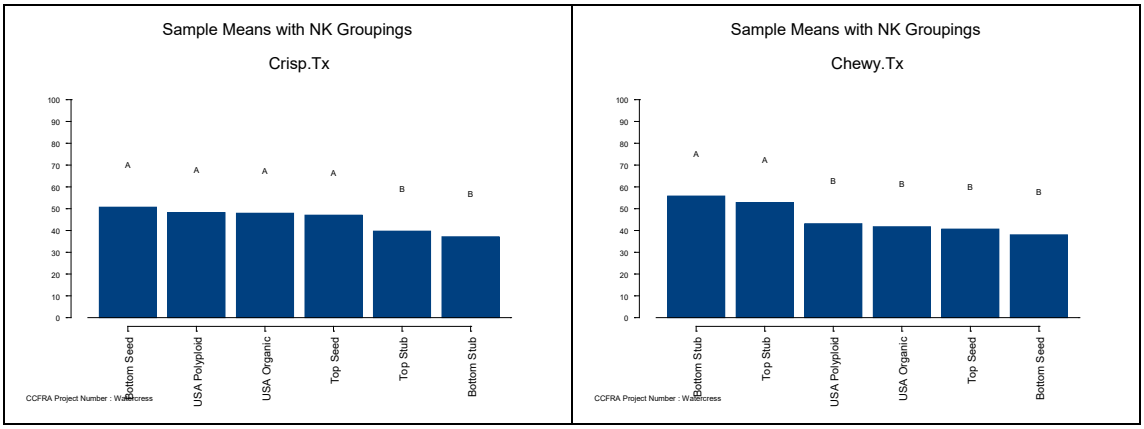


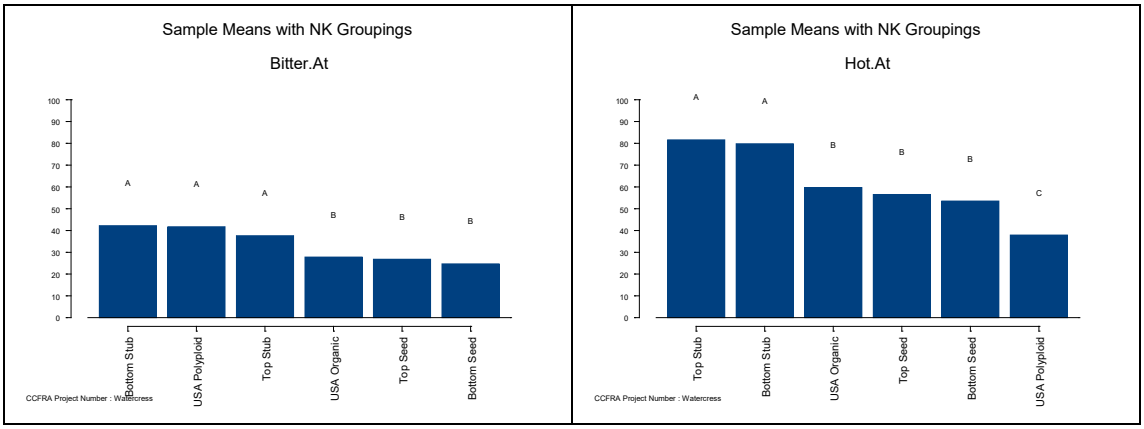







# APPENDIX IV

## CONSUMER QUESTIONNAIRES

**Recruitment Questionnaire**
**Test Questionnaire**

**INSTRUCTIONS:**
Please use a blue or black pen
Please fill in the box like this ☒
or like this ☒

# RECRUITMENT QUESTIONNAIRE P.78452

Campden & Chorleywood Food Research Association Group
*Chipping Campden*
*Glos. GL55 6LD*
*Tel: 01386 842000*

Time: _____

Respondent ID ☐☐☐

Good Morning/Afternoon,
I am conducting a survey on behalf of Campden & Chorleywood Food Research Association, an independent market research company. We are carrying out a survey in this area. May I ask you some questions?

Name (of respondent) _____

Address _____

_____

_____

Telephone Number _____

**INTERVIEWERS DECLARATION**

I declare that the interview was carried out in accordance with the written instructions with the person named here, who was previously unknown to me.

Interviewer's name _____

Date of interview __ __/__ __/__ __

Signed _____

**SOCIAL GRADE**

Occupation of Chief Wage Earner _____

Job Title _____

Industry _____

**SocioEco**
A/B/C1 ☐
C2/D/E ☐
} **NO QUOTA**

**Gender**
Male ☐
Female ☐
} **NO QUOTA**

**Age**
18 - 24 ☐
25 - 34 ☐
35 - 44 ☐
45 - 54 ☐
55 - 64 ☐
} **REFER TO QUOTA**

**Do you have any food allergies or adverse reactions to food?**
Yes ☐ **DO NOT RECRUIT**
No ☐

36322

**INSTRUCTIONS:**
**Please use a blue or black pen**
**Please fill in the box like this** ☒
**or like this** ☒

# RECRUITMENT QUESTIONNAIRE P.78452

**Campden & Chorleywood Food Research Association Group**
*Chipping Campden*
*Glos. GL55 6LD*
*Tel: 01386 842000*

**Respondent ID** ☐☐☐

1) Do you, or any of your family or close friends work in any of the industries shown on this card?
**(SHOW CARD A)**

| | |
|---|---|
| Media | Market Research |
| Journalism | Advertising |
| Marketing | Public Relations |
| Food Industry (manufacture or sales) | |

**IF YES THANK AND CLOSE INTERVIEW**

2) Are you or could you be pregnant? **(FEMALES ONLY)**

| | | |
|---|---|---|
| Yes | ☐ | **DO NOT RECRUIT** |
| No | ☐ | **GO TO Q3** |
| Declined to answer | ☐ | **DO NOT RECRUIT** |

3) Have you participated in any market research on salads in the last 12 months?

**IF YES THANK AND CLOSE INTERVIEW**

4) Have you eaten any of the following types of fresh uncooked salad leaves in the last 12 months, either on their own or as part of a meal, salad or snack? **(SHOW CARD B)**

| | | |
|---|---|---|
| Lettuce | ☐ | |
| Spinach | ☐ | |
| Watercress | ☐ | **MUST BE CODED** |
| Rocket | ☐ | |
| Mustard and cress | ☐ | |

5) Which of the following types of fresh uncooked salad leaves would you be willing to eat in the future? **(SHOW CARD B)**

| | | |
|---|---|---|
| Lettuce | ☐ | |
| Spinach | ☐ | |
| Watercress | ☐ | **MUST BE CODED** |
| Rocket | ☐ | |
| Mustard and cress | ☐ | |

**Interviewer Notes**
a) Check respondent qualifies for test
b) Invite to attend the hall test
c) Explain duration and nature of test - respondent will be tasting 6 samples of watercress

36322

**INSTRUCTIONS:**
**Please use a blue or black pen**
**Please fill in the box like this ■**
**or like this ☒**

**Sample Questionnaire**
**Watercress -P78452**

**Campden & Chorleywood Food Research Association Group**
*Chipping Campden*
*Glos. GL55 6LD*
*Tel: 01386 842000*

**Respondent ID** ☐ **Sample ID** ☐

**PLEASE TASTE THIS SAMPLE OF WATERCRESS AND ANSWER THE FOLLOWING QUESTIONS**

1) How much do you like this watercress **overall?**

Like extremely ☐
Like very much ☐
Like moderately ☐
Like slightly ☐
Neither like nor dislike ☐
Dislike slightly ☐
Dislike moderately ☐
Dislike very much ☐
Dislike extremely ☐

2) How much do you like the **appearance** of this watercress?

Like extremely ☐
Like very much ☐
Like moderately ☐
Like slightly ☐
Neither like nor dislike ☐
Dislike slightly ☐
Dislike moderately ☐
Dislike very much ☐
Dislike extremely ☐

3) How much do you like the **flavour** of this watercress?

Like extremely ☐
Like very much ☐
Like moderately ☐
Like slightly ☐
Neither like nor dislike ☐
Dislike slightly ☐
Dislike moderately ☐
Dislike very much ☐
Dislike extremely ☐

4) What is your opinion of the **bitterness** of this watercress?

Much too bitter ☐
A little too bitter ☐
Just about right ☐
Not quite bitter enough ☐
Not at all bitter enough ☐

5) What is your opinion of the **hotness of the flavour** of this watercress?

Much too hot ☐
A little too hot ☐
Just about right ☐
Not quite hot enough ☐
Not at all hot enough ☐



2789

**INSTRUCTIONS:**
**Please use a blue or black pen**
**Please fill in the box like this** ■
**or like this** ☒

**Sample Questionnaire**
**Watercress -P78452**

**Campden & Chorleywood Food Research Association Group**
*Chipping Campden*
*Glos. GL55 6LD*
*Tel: 01386 842000*

**Respondent ID** ☐ **Sample ID** ☐

6) How much do you like the **texture** of this watercress?

Like extremely ☐
Like very much ☐
Like moderately ☐
Like slightly ☐
Neither like nor dislike ☐
Dislike slightly ☐
Dislike moderately ☐
Dislike very much ☐
Dislike extremely ☐

7) How much do you like the **aftertaste** *(5 seconds after swallowing)* of this watercress ?

Like extremely ☐
Like very much ☐
Like moderately ☐
Like slightly ☐
Neither like nor dislike ☐
Dislike slightly ☐
Dislike moderately ☐
Dislike very much ☐
Dislike extremely ☐

8) What is your opinion of the strength of the **aftertaste** of this watercress?

Much too strong ☐
A little too strong ☐
Just about right ☐
Not quite strong enough ☐
Not at all strong enough ☐

**********



2789

# APPENDIX V

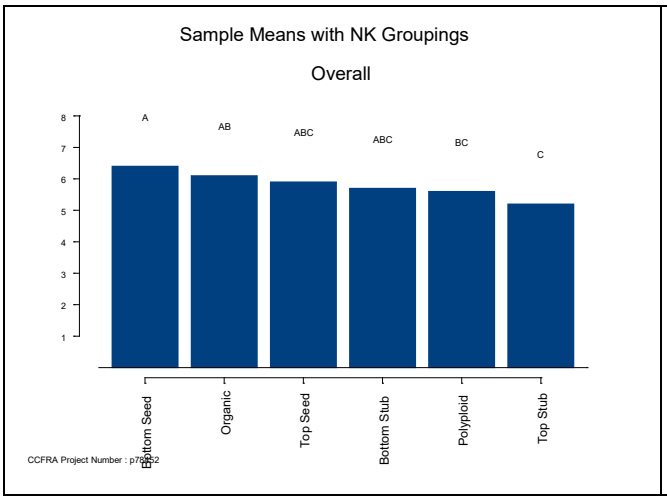
## CONSUMER HEDONIC SUMMARY STATISTICS AND MEAN GRAPHS

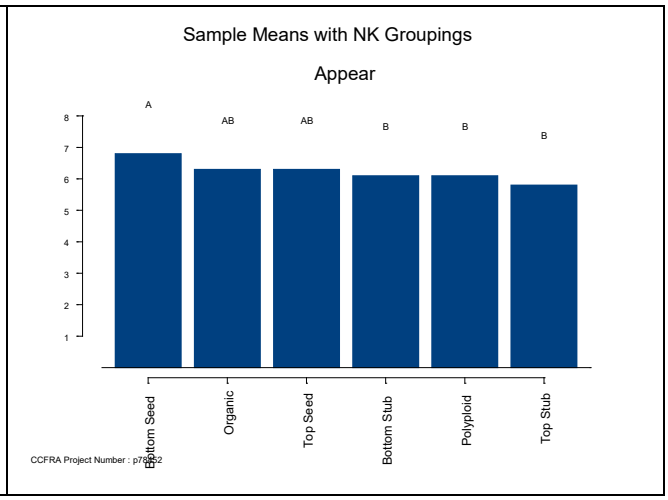
## HEDONIC – SUMMARY STATISTICS, INCLUDING ONE WAY ANOVA, WITH NEWMAN-KEULS CALCULATED MULTIPLE COMPARISON

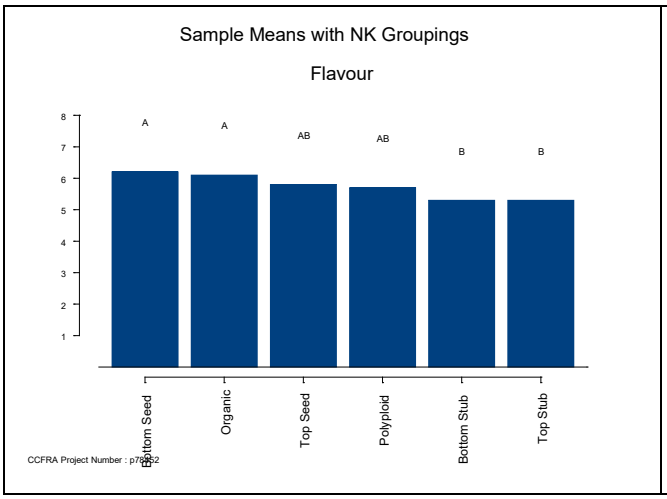
| Variable | Sample | N | Mean | Median | St. Dev. | P Value | Significance | NK 5% |
|---|---|---|---|---|---|---|---|---|
| Overall | 486 Bottom Seedling | 106 | 6.4 | 7.0 | 1.83 | 0.001 | 0.1% | A |
| | 802 USA Organic | 106 | 6.1 | 7.0 | 1.95 | | | AB |
| | 364 Top Seedling | 106 | 5.9 | 6.5 | 2.05 | | | ABC |
| | 269 Bottom Stubble | 106 | 5.7 | 6.0 | 2.19 | | | ABC |
| | 537 USA Polyploid | 106 | 5.6 | 6.0 | 2.09 | | | BC |
| | 156 Top Stubble | 106 | 5.2 | 6.0 | 2.22 | | | C |
| Appearance | 486 Bottom Seedling | 106 | 6.8 | 7.0 | 1.78 | 0.002 | 1% | A |
| | 802 USA Organic | 106 | 6.3 | 7.0 | 1.74 | | | AB |
| | 364 Top Seedling | 106 | 6.3 | 7.0 | 1.93 | | | AB |
| | 269 Bottom Stubble | 106 | 6.1 | 7.0 | 1.99 | | | B |
| | 537 USA Polyploid | 106 | 6.1 | 6.0 | 1.77 | | | B |
| | 156 Top Stubble | 106 | 5.8 | 6.0 | 1.93 | | | B |
| Flavour | 486 Bottom Seedling | 106 | 6.2 | 7.0 | 1.94 | 0.003 | 1% | A |
| | 802 USA Organic | 106 | 6.1 | 6.0 | 1.95 | | | A |
| | 364 Top Seedling | 106 | 5.8 | 6.0 | 2.07 | | | AB |
| | 537 USA Polyploid | 106 | 5.7 | 6.0 | 2.07 | | | AB |
| | 269 Bottom Stubble | 106 | 5.3 | 5.5 | 2.19 | | | B |
| | 156 Top Stubble | 105 | 5.3 | 6.0 | 2.28 | | | B |
| Texture | 802 USA Organic | 106 | 6.6 | 7.0 | 1.48 | <0.001 | 0.1% | A |
| | 364 Top Seedling | 106 | 6.6 | 7.0 | 1.64 | | | A |
| | 486 Bottom Seedling | 106 | 6.6 | 7.0 | 1.71 | | | A |
| | 537 USA Polyploid | 106 | 6.1 | 6.0 | 1.71 | | | AB |
| | 269 Bottom Stubble | 106 | 5.9 | 6.0 | 1.95 | | | B |
| | 156 Top Stubble | 106 | 5.6 | 6.0 | 1.86 | | | B |
| Aftertaste | 802 USA Organic | 106 | 5.9 | 6.0 | 1.96 | 0.043 | 5% | A |
| | 486 Bottom Seedling | 106 | 5.7 | 6.0 | 1.91 | | | A |
| | 364 Top Seedling | 106 | 5.6 | 6.0 | 1.98 | | | A |
| | 537 USA Polyploid | 106 | 5.5 | 5.0 | 1.89 | | | A |
| | 269 Bottom Stubble | 106 | 5.2 | 5.0 | 2.18 | | | A |
| | 156 Top Stubble | 106 | 5.2 | 5.0 | 2.13 | | | A |

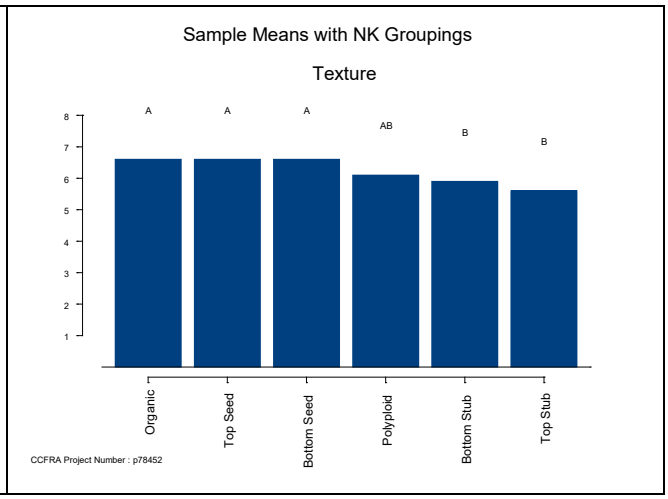
### Table of Significance

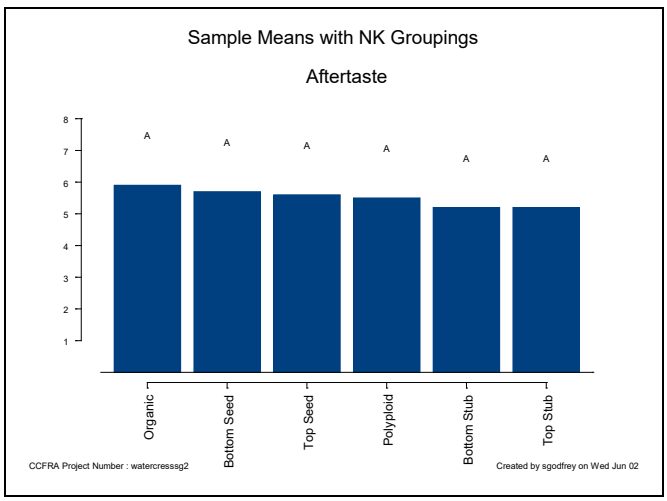
| P Value | | Significant Level |
|---|---|---|
| <0.001 | 0.1% | Significant at 0.1% level of significance |
| <0.010 | 1% | Significant at 1% level of significance |
| <0.050 | 5% | Significant at 5% level of significance |
| > 0.050 | NS | Not significant |



# APPENDIX VI

## FULL TABULATIONS

- **Demographic Tabulations**
- **Sample Assessment Tabulations Hedonic (Summary)**
- **Sample Assessment Tabulations Hedonic (Full Tabulations)**
- **Sample Assessment Tabulations JAR (Summary)**
- **Sample Assessment Tabulations JAR (Full Tabulations)**
- **Cross Tabulations**

## DEMOGRAPHIC TABULATIONS

| Gender | Count | Age | | | | | |
|---|---|---|---|---|---|---|---|
| | | 18-24 | 25-34 | 35-44 | 45-54 | 55-64 | Total |
| Male | Count | 5 | 9 | 6 | 7 | 3 | 30 |
| | % of Total | 4.7 | 8.5 | 5.7 | 6.6 | 2.8 | 28.3 |
| Female | Count | 23 | 16 | 12 | 17 | 8 | 76 |
| | % of Total | 21.7 | 15.1 | 11.3 | 16.0 | 7.5 | 71.7 |
| Total | Count | 28 | 25 | 18 | 24 | 11 | 106 |
| | % of Total | 26.4 | 23.6 | 17.0 | 22.6 | 10.4 | 100 |

| Social Class | Count | Age | | | | | |
|---|---|---|---|---|---|---|---|
| | | 18-24 | 25-34 | 35-44 | 45-54 | 55-64 | Total |
| A/B/C1 | Count | 12 | 12 | 11 | 11 | 6 | 52 |
| | % of Total | 11.3 | 11.3 | 10.4 | 10.4 | 5.7 | 49.1 |
| C2/D/E | Count | 16 | 13 | 7 | 13 | 5 | 54 |
| | % of Total | 15.1 | 12.3 | 6.6 | 12.3 | 4.7 | 50.9 |
| Total | Count | 28 | 25 | 18 | 24 | 11 | 106 |
| | % of Total | 26.4 | 23.6 | 17.0 | 22.6 | 10.4 | 100 |

| Gender | Count | Social Class | | |
|---|---|---|---|---|
| | | A/B/C1 | C2/D/E | Total |
| Male | Count | 14 | 16 | 30 |
| | % of Total | 13.2 | 15.1 | 28.3 |
| Female | Count | 38 | 38 | 76 |
| | % of Total | 35.8 | 35.8 | 71.7 |
| Total | Count | 52 | 54 | 106 |
| | % of Total | 49.1 | 50.9 | 100 |

**Purchase – Counts**

Have you eaten any of the following types of fresh uncooked salad leaves in the last 12 months?

| Salad Leaves | Count | % |
|---|---|---|
| Lettuce | 105 | 99.1 |
| Spinach | 59 | 55.7 |
| Watercress | 106 | 100.0 |
| Rocket | 70 | 66.0 |
| Mustard and cress | 75 | 70.8 |

Which of the following types of fresh uncooked salad leaves would you be willing to eat in the future?

| Salad Leaves | Count | % |
|---|---|---|
| Lettuce | 105 | 99.1 |
| Spinach | 73 | 68.9 |
| Watercress | 106 | 100.0 |
| Rocket | 82 | 77.4 |
| Mustard and cress | 91 | 85.8 |

## SUMMARISED HEDONIC COUNTS & PERCENTAGES

| Overall | | Count Like | Count Neither | Count Dislike | Mean | % Like | % Neither | % Dislike |
|---|---|---|---|---|---|---|---|---|
| 156 | Top Stubble | 55 | 5 | 46 | 5.2 | 51.9 | 4.7 | 43.4 |
| 269 | Bottom Stubble | 62 | 11 | 33 | 5.7 | 58.5 | 10.4 | 31.1 |
| 364 | Top Seedling | 68 | 7 | 31 | 5.9 | 64.2 | 6.6 | 29.2 |
| 486 | Bottom Seedling | 79 | 9 | 18 | 6.4 | 74.5 | 8.5 | 17.0 |
| 537 | USA Polyploid | 59 | 12 | 35 | 5.6 | 55.7 | 11.3 | 33.0 |
| 802 | USA Organic | 70 | 15 | 21 | 6.1 | 66.0 | 14.2 | 19.8 |

| Appearance | | Count Like | Count Neither | Count Dislike | Mean | % Like | % Neither | % Dislike |
|---|---|---|---|---|---|---|---|---|
| 156 | Top Stubble | 59 | 9 | 38 | 5.8 | 55.7 | 8.5 | 35.8 |
| 269 | Bottom Stubble | 75 | 5 | 26 | 6.1 | 70.8 | 4.7 | 24.5 |
| 364 | Top Seedling | 73 | 12 | 21 | 6.3 | 68.9 | 11.3 | 19.8 |
| 486 | Bottom Seedling | 87 | 6 | 13 | 6.8 | 82.1 | 5.7 | 12.3 |
| 537 | USA Polyploid | 66 | 17 | 23 | 6.1 | 62.3 | 16.0 | 21.7 |
| 802 | USA Organic | 79 | 8 | 19 | 6.3 | 74.5 | 7.5 | 17.9 |

| Flavour | | Count Like | Count Neither | Count Dislike | Mean | % Like | % Neither | % Dislike |
|---|---|---|---|---|---|---|---|---|
| 156 | Top Stubble | 55 | 6 | 44 | 5.3 | 52.4 | 5.7 | 41.9 |
| 269 | Bottom Stubble | 53 | 9 | 44 | 5.3 | 50.0 | 8.5 | 41.5 |
| 364 | Top Seedling | 64 | 11 | 31 | 5.8 | 60.4 | 10.4 | 29.2 |
| 486 | Bottom Seedling | 74 | 13 | 19 | 6.2 | 69.8 | 12.3 | 17.9 |
| 537 | USA Polyploid | 68 | 5 | 33 | 5.7 | 64.2 | 4.7 | 31.1 |
| 802 | USA Organic | 70 | 14 | 22 | 6.1 | 66.0 | 13.2 | 20.8 |

| Texture | | Count Like | Count Neither | Count Dislike | Mean | % Like | % Neither | % Dislike |
|---|---|---|---|---|---|---|---|---|
| 156 | Top Stubble | 54 | 17 | 35 | 5.6 | 50.9 | 16.0 | 33.0 |
| 269 | Bottom Stubble | 67 | 11 | 28 | 5.9 | 63.2 | 10.4 | 26.4 |
| 364 | Top Seedling | 83 | 9 | 14 | 6.6 | 78.3 | 8.5 | 13.2 |
| 486 | Bottom Seedling | 81 | 13 | 12 | 6.6 | 76.4 | 12.3 | 11.3 |
| 537 | USA Polyploid | 73 | 18 | 15 | 6.1 | 68.9 | 17.0 | 14.2 |
| 802 | USA Organic | 82 | 16 | 8 | 6.6 | 77.4 | 15.1 | 7.5 |

| Aftertaste | | Count Like | Count Neither | Count Dislike | Mean | % Like | % Neither | % Dislike |
|---|---|---|---|---|---|---|---|---|
| 156 | Top Stubble | 51 | 10 | 45 | 5.2 | 48.1 | 9.4 | 42.5 |
| 269 | Bottom Stubble | 52 | 8 | 46 | 5.2 | 49.1 | 7.5 | 43.4 |
| 364 | Top Seedling | 61 | 13 | 32 | 5.6 | 57.5 | 12.3 | 30.2 |
| 486 | Bottom Seedling | 56 | 26 | 24 | 5.7 | 52.8 | 24.5 | 22.6 |
| 537 | USA Polyploid | 52 | 20 | 34 | 5.5 | 49.1 | 18.9 | 32.1 |
| 802 | USA Organic | 70 | 10 | 26 | 5.9 | 66.0 | 9.4 | 24.5 |

## SAMPLE ASSESSMENT TABULATIONS – FULL TABULATIONS

### Hedonic – Full Counts

| Overall | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 0 | 3 | 3 | 8 | 5 | 5 |
| Like very much | 22 | 22 | 25 | 25 | 15 | 25 |
| Like moderately | 18 | 27 | 25 | 25 | 26 | 25 |
| Like slightly | 15 | 10 | 15 | 21 | 13 | 15 |
| Neither like or dislike | 5 | 11 | 7 | 9 | 12 | 15 |
| Dislike slightly | 22 | 14 | 16 | 9 | 14 | 8 |
| Dislike moderately | 7 | 6 | 7 | 4 | 11 | 6 |
| Dislike very much | 12 | 8 | 5 | 4 | 8 | 5 |
| Dislike extremely | 5 | 5 | 3 | 1 | 2 | 2 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| Appearance | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 4 | 3 | 2 | 11 | 5 | 5 |
| Like very much | 22 | 32 | 39 | 37 | 19 | 25 |
| Like moderately | 24 | 22 | 22 | 27 | 28 | 30 |
| Like slightly | 9 | 18 | 10 | 12 | 14 | 19 |
| Neither like or dislike | 9 | 5 | 12 | 6 | 17 | 8 |
| Dislike slightly | 28 | 11 | 10 | 7 | 16 | 11 |
| Dislike moderately | 6 | 8 | 6 | 2 | 3 | 5 |
| Dislike very much | 3 | 6 | 3 | 2 | 3 | 2 |
| Dislike extremely | 1 | 1 | 2 | 2 | 1 | 1 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| Flavour | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 2 | 2 | 3 | 6 | 4 | 5 |
| Like very much | 20 | 20 | 24 | 25 | 18 | 27 |
| Like moderately | 18 | 18 | 22 | 23 | 19 | 20 |
| Like slightly | 15 | 13 | 15 | 20 | 27 | 18 |
| Neither like or dislike | 6 | 9 | 11 | 13 | 5 | 14 |
| Dislike slightly | 19 | 21 | 15 | 6 | 13 | 10 |
| Dislike moderately | 9 | 8 | 5 | 5 | 10 | 5 |
| Dislike very much | 9 | 11 | 9 | 7 | 7 | 5 |
| Dislike extremely | 7 | 4 | 2 | 1 | 3 | 2 |
| Total | 105 | 106 | 106 | 106 | 106 | 106 |

| **Texture** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 4 | 5 | 2 | 7 | 5 | 6 |
| Like very much | 16 | 21 | 39 | 32 | 20 | 27 |
| Like moderately | 14 | 21 | 25 | 26 | 19 | 29 |
| Like slightly | 20 | 20 | 17 | 16 | 29 | 20 |
| Neither like or dislike | 17 | 11 | 9 | 13 | 18 | 16 |
| Dislike slightly | 26 | 18 | 9 | 6 | 7 | 5 |
| Dislike moderately | 3 | 4 | 2 | 1 | 4 | 1 |
| Dislike very much | 3 | 2 | 2 | 5 | 2 | 2 |
| Dislike extremely | 3 | 4 | 1 | 0 | 2 | 0 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| **Aftertaste** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 1 | 2 | 1 | 1 | 4 | 3 |
| Like very much | 17 | 18 | 17 | 23 | 14 | 22 |
| Like moderately | 18 | 16 | 25 | 18 | 18 | 25 |
| Like slightly | 15 | 16 | 18 | 14 | 16 | 20 |
| Neither like or dislike | 10 | 8 | 13 | 26 | 20 | 10 |
| Dislike slightly | 22 | 21 | 16 | 12 | 20 | 13 |
| Dislike moderately | 8 | 9 | 6 | 4 | 7 | 6 |
| Dislike very much | 10 | 12 | 6 | 4 | 5 | 3 |
| Dislike extremely | 5 | 4 | 4 | 4 | 2 | 4 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

**Hedonic – Full Percentages**

| Overall | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | - | 2.8 | 2.8 | 7.5 | 4.7 | 4.7 |
| Like very much | 20.8 | 20.8 | 23.6 | 23.6 | 14.2 | 23.6 |
| Like moderately | 17.0 | 25.5 | 23.6 | 23.6 | 24.5 | 23.6 |
| Like slightly | 14.2 | 9.4 | 14.2 | 19.8 | 12.3 | 14.2 |
| Neither like or dislike | 4.7 | 10.4 | 6.6 | 8.5 | 11.3 | 14.2 |
| Dislike slightly | 20.8 | 13.2 | 15.1 | 8.5 | 13.2 | 7.5 |
| Dislike moderately | 6.6 | 5.7 | 6.6 | 3.8 | 10.4 | 5.7 |
| Dislike very much | 11.3 | 7.5 | 4.7 | 3.8 | 7.5 | 4.7 |
| Dislike extremely | 4.7 | 4.7 | 2.8 | 0.9 | 1.9 | 1.9 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Appearance | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 3.8 | 2.8 | 1.9 | 10.4 | 4.7 | 4.7 |
| Like very much | 20.8 | 30.2 | 36.8 | 34.9 | 17.9 | 23.6 |
| Like moderately | 22.6 | 20.8 | 20.8 | 25.5 | 26.4 | 28.3 |
| Like slightly | 8.5 | 17.0 | 9.4 | 11.3 | 13.2 | 17.9 |
| Neither like or dislike | 8.5 | 4.7 | 11.3 | 5.7 | 16.0 | 7.5 |
| Dislike slightly | 26.4 | 10.4 | 9.4 | 6.6 | 15.1 | 10.4 |
| Dislike moderately | 5.7 | 7.5 | 5.7 | 1.9 | 2.8 | 4.7 |
| Dislike very much | 2.8 | 5.7 | 2.8 | 1.9 | 2.8 | 1.9 |
| Dislike extremely | 0.9 | 0.9 | 1.9 | 1.9 | 0.9 | 0.9 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Flavour | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 1.9 | 1.9 | 2.8 | 5.7 | 3.8 | 4.7 |
| Like very much | 19.0 | 18.9 | 22.6 | 23.6 | 17.0 | 25.5 |
| Like moderately | 17.1 | 17.0 | 20.8 | 21.7 | 17.9 | 18.9 |
| Like slightly | 14.3 | 12.3 | 14.2 | 18.9 | 25.5 | 17.0 |
| Neither like or dislike | 5.7 | 8.5 | 10.4 | 12.3 | 4.7 | 13.2 |
| Dislike slightly | 18.1 | 19.8 | 14.2 | 5.7 | 12.3 | 9.4 |
| Dislike moderately | 8.6 | 7.5 | 4.7 | 4.7 | 9.4 | 4.7 |
| Dislike very much | 8.6 | 10.4 | 8.5 | 6.6 | 6.6 | 4.7 |
| Dislike extremely | 6.7 | 3.8 | 1.9 | 0.9 | 2.8 | 1.9 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Texture | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 3.8 | 4.7 | 1.9 | 6.6 | 4.7 | 5.7 |
| Like very much | 15.1 | 19.8 | 36.8 | 30.2 | 18.9 | 25.5 |
| Like moderately | 13.2 | 19.8 | 23.6 | 24.5 | 17.9 | 27.4 |
| Like slightly | 18.9 | 18.9 | 16.0 | 15.1 | 27.4 | 18.9 |
| Neither like or dislike | 16.0 | 10.4 | 8.5 | 12.3 | 17.0 | 15.1 |
| Dislike slightly | 24.5 | 17.0 | 8.5 | 5.7 | 6.6 | 4.7 |
| Dislike moderately | 2.8 | 3.8 | 1.9 | 0.9 | 3.8 | 0.9 |
| Dislike very much | 2.8 | 1.9 | 1.9 | 4.7 | 1.9 | 1.9 |
| Dislike extremely | 2.8 | 3.8 | 0.9 | - | 1.9 | - |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Aftertaste | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Like extremely | 0.9 | 1.9 | 0.9 | 0.9 | 3.8 | 2.8 |
| Like very much | 16.0 | 17.0 | 16.0 | 21.7 | 13.2 | 20.8 |
| Like moderately | 17.0 | 15.1 | 23.6 | 17.0 | 17.0 | 23.6 |
| Like slightly | 14.2 | 15.1 | 17.0 | 13.2 | 15.1 | 18.9 |
| Neither like or dislike | 9.4 | 7.5 | 12.3 | 24.5 | 18.9 | 9.4 |
| Dislike slightly | 20.8 | 19.8 | 15.1 | 11.3 | 18.9 | 12.3 |
| Dislike moderately | 7.5 | 8.5 | 5.7 | 3.8 | 6.6 | 5.7 |
| Dislike very much | 9.4 | 11.3 | 5.7 | 3.8 | 4.7 | 2.8 |
| Dislike extremely | 4.7 | 3.8 | 3.8 | 3.8 | 1.9 | 3.8 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

## JUST ABOUT RIGHT SUMMARY STATISTICS, INCLUDING T-TEST (3)

| Variable | Sample | N | Mean | Median | St. Dev. | P Value | Significance |
|---|---|---|---|---|---|---|---|
| Bitterness | 156 Top Stubble | 106 | 3.6 | 3.0 | 0.89 | 0.000 | 0.1% |
| | 269 Bottom Stubble | 106 | 3.5 | 3.5 | 0.90 | 0.000 | 0.1% |
| | 802 USA Organic | 106 | 3.3 | 3.0 | 0.84 | 0.001 | 0.1% |
| | 537 USA Polyploid | 106 | 3.3 | 3.0 | 0.99 | 0.003 | 1% |
| | 364 Top Seedling | 106 | 3.3 | 3.0 | 0.84 | 0.001 | 0.1% |
| | 486 Bottom Seedling | 106 | 3.1 | 3.0 | 0.89 | 0.326 | NS |
| Hotness of flavour | 156 Top Stubble | 106 | 3.5 | 3.5 | 0.91 | 0.000 | 0.1% |
| | 269 Bottom Stubble | 106 | 3.4 | 3.0 | 0.91 | 0.000 | 0.1% |
| | 364 Top Seedling | 106 | 3.1 | 3.0 | 0.85 | 0.307 | NS |
| | 802 USA Organic | 106 | 3.0 | 3.0 | 0.86 | 0.910 | NS |
| | 486 Bottom Seedling | 106 | 2.9 | 3.0 | 0.99 | 0.281 | NS |
| | 537 USA Polyploid | 106 | 2.6 | 3.0 | 0.94 | 0.000 | 0.1% |
| Strength of aftertaste | 156 Top Stubble | 106 | 3.7 | 4.0 | 0.92 | 0.000 | 0.1% |
| | 269 Bottom Stubble | 106 | 3.6 | 4.0 | 0.84 | 0.000 | 0.1% |
| | 364 Top Seedling | 106 | 3.2 | 3.0 | 0.92 | 0.010 | 1% |
| | 802 USA Organic | 106 | 3.2 | 3.0 | 0.85 | 0.025 | 5% |
| | 537 USA Polyploid | 106 | 3.0 | 3.0 | 1.00 | 0.846 | NS |
| | 486 Bottom Seedling | 106 | 3.0 | 3.0 | 1.03 | 0.777 | NS |

### Table of Significance

| P Value | | Significant Level |
|---|---|---|
| <0.001 | 0.1% | Significant at 0.1% level of significance |
| <0.010 | 1% | Significant at 1% level of significance |
| <0.050 | 5% | Significant at 5% level of significance |
| > 0.050 | NS | Not significant |

## JUST ABOUT RIGHT – SUMMARISED COUNTS & PERCENTAGES

### Summarised Counts

| **Bitterness** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too bitter | 52 | 53 | 33 | 30 | 41 | 38 |
| Just about right | 47 | 40 | 63 | 53 | 49 | 56 |
| Not bitter enough | 7 | 13 | 10 | 23 | 16 | 12 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| **Hotness of Flavour** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too hot | 53 | 43 | 27 | 22 | 15 | 27 |
| Just about right | 43 | 51 | 59 | 51 | 47 | 56 |
| Not hot enough | 10 | 12 | 20 | 33 | 44 | 23 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| **Strength of Aftertaste** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too strong | 58 | 56 | 37 | 26 | 30 | 34 |
| Just about right | 42 | 42 | 53 | 52 | 53 | 56 |
| Not strong enough | 6 | 8 | 16 | 28 | 23 | 16 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

### Summarised Percentages

| **Bitterness** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too bitter | 49.1 | 50.0 | 31.1 | 28.3 | 38.7 | 35.8 |
| Just about right | 44.3 | 37.7 | 59.4 | 50.0 | 46.2 | 52.8 |
| Not bitter enough | 6.6 | 12.3 | 9.4 | 21.7 | 15.1 | 11.3 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| **Hotness of Flavour** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too hot | 50.0 | 40.6 | 25.5 | 20.8 | 14.2 | 25.5 |
| Just about right | 40.6 | 48.1 | 55.7 | 48.1 | 44.3 | 52.8 |
| Not hot enough | 9.4 | 11.3 | 18.9 | 31.1 | 41.5 | 21.7 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| **Strength of Aftertaste** | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Too strong | 54.7 | 52.8 | 34.9 | 24.5 | 28.3 | 32.1 |
| Just about right | 39.6 | 39.6 | 50.0 | 49.1 | 50.0 | 52.8 |
| Not strong enough | 5.7 | 7.5 | 15.1 | 26.4 | 21.7 | 15.1 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

## JUST ABOUT RIGHT – FULL TABULATIONS

### Full Counts

| Bitterness | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too bitter | 22 | 16 | 10 | 6 | 12 | 8 |
| A little too bitter | 30 | 37 | 23 | 24 | 29 | 30 |
| Just about right | 47 | 40 | 63 | 53 | 49 | 56 |
| Not quite bitter enough | 7 | 13 | 7 | 19 | 10 | 9 |
| Not at all bitter enough | 0 | 0 | 3 | 4 | 6 | 3 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| Hotness of Flavour | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too hot | 16 | 13 | 6 | 8 | 3 | 3 |
| A little too hot | 37 | 30 | 21 | 14 | 12 | 24 |
| Just about right | 43 | 51 | 59 | 51 | 47 | 56 |
| Not quite hot enough | 8 | 9 | 16 | 25 | 31 | 17 |
| Not at all hot enough | 2 | 3 | 4 | 8 | 13 | 6 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

| Strength of Aftertaste | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too strong | 26 | 16 | 9 | 9 | 6 | 6 |
| A little too strong | 32 | 40 | 28 | 17 | 24 | 28 |
| Just about right | 42 | 42 | 53 | 52 | 53 | 56 |
| A little too mild | 5 | 8 | 11 | 18 | 12 | 12 |
| Much too mild | 1 | 0 | 5 | 10 | 11 | 4 |
| Total | 106 | 106 | 106 | 106 | 106 | 106 |

**Full Percentages**

| Bitterness | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too bitter | 20.8 | 15.1 | 9.4 | 5.7 | 11.3 | 7.5 |
| A little too bitter | 28.3 | 34.9 | 21.7 | 22.6 | 27.4 | 28.3 |
| Just about right | 44.3 | 37.7 | 59.4 | 50.0 | 46.2 | 52.8 |
| Not quite bitter enough | 6.6 | 12.3 | 6.6 | 17.9 | 9.4 | 8.5 |
| Not at all bitter enough | - | - | 2.8 | 3.8 | 5.7 | 2.8 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Hotness of Flavour | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too hot | 15.1 | 12.3 | 5.7 | 7.5 | 2.8 | 2.8 |
| A little too hot | 34.9 | 28.3 | 19.8 | 13.2 | 11.3 | 22.6 |
| Just about right | 40.6 | 48.1 | 55.7 | 48.1 | 44.3 | 52.8 |
| Not quite hot enough | 7.5 | 8.5 | 15.1 | 23.6 | 29.2 | 16.0 |
| Not at all hot enough | 1.9 | 2.8 | 3.8 | 7.5 | 12.3 | 5.7 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

| Strength of Aftertaste | 156 Top Stubble | 269 Bottom Stubble | 364 Top Seedling | 486 Bottom Seedling | 537 USA Polyploid | 802 USA Organic |
|---|---|---|---|---|---|---|
| Much too strong | 24.5 | 15.1 | 8.5 | 8.5 | 5.7 | 5.7 |
| A little too strong | 30.2 | 37.7 | 26.4 | 16.0 | 22.6 | 26.4 |
| Just about right | 39.6 | 39.6 | 50.0 | 49.1 | 50.0 | 52.8 |
| A little too mild | 4.7 | 7.5 | 10.4 | 17.0 | 11.3 | 11.3 |
| Much too mild | 0.9 | - | 4.7 | 9.4 | 10.4 | 3.8 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |

## CROSS TABULATIONS

### Demographics Versus Hedonic Acceptability

| Attribute | Sample | Social Grade | | | | Gender | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A/B/C1 | | C2/D/E | | Male | | Female | |
| | | Mean | Median | Mean | Median | Mean | Median | Mean | Median |
| Overall | 156 Top Stubble | 5.4 | 6.0 | 5.1 | 5.0 | 5.6 | 6.0 | 5.1 | 5.5 |
| | 269 Bottom Stubble | 5.8 | 7.0 | 5.6 | 6.0 | 6.2 | 7.0 | 5.5 | 6.0 |
| | 364 Top Seedling | 6.4 | 7.0 | 5.4 | 6.0 | 5.5 | 6.0 | 6.1 | 7.0 |
| | 486 Bottom Seedling | 6.6 | 7.0 | 6.1 | 7.0 | 6.6 | 7.0 | 6.3 | 7.0 |
| | 537 USA Polyploid | 5.7 | 6.0 | 5.5 | 6.0 | 5.6 | 6.0 | 5.6 | 6.0 |
| | 802 USA Organic | 6.3 | 7.0 | 6.0 | 7.0 | 6.5 | 7.0 | 5.9 | 6.0 |
| Appearance | 156 Top Stubble | 5.8 | 6.0 | 5.9 | 6.0 | 5.5 | 4.5 | 5.9 | 7.0 |
| | 269 Bottom Stubble | 5.9 | 7.0 | 6.3 | 7.0 | 5.8 | 6.0 | 6.3 | 7.0 |
| | 364 Top Seedling | 6.7 | 7.0 | 5.9 | 7.0 | 6.2 | 7.0 | 6.4 | 7.0 |
| | 486 Bottom Seedling | 7.3 | 8.0 | 6.4 | 7.0 | 7.1 | 7.0 | 6.8 | 7.0 |
| | 537 USA Polyploid | 5.9 | 6.0 | 6.2 | 7.0 | 6.0 | 7.0 | 6.1 | 6.0 |
| | 802 USA Organic | 6.4 | 7.0 | 6.3 | 7.0 | 6.4 | 7.0 | 6.3 | 7.0 |

| Attribute | Sample | Social Grade | | | | Gender | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A/B/C1 | | C2/D/E | | Male | | Female | |
| | | Mean | Median | Mean | Median | Mean | Median | Mean | Median |
| Flavour | 156 Top Stubble | 5.4 | 6.0 | 5.1 | 5.0 | 5.6 | 6.0 | 5.1 | 6.0 |
| | 269 Bottom Stubble | 5.7 | 6.0 | 4.9 | 5.0 | 5.5 | 6.0 | 5.2 | 5.0 |
| | 364 Top Seedling | 6.2 | 7.0 | 5.4 | 6.0 | 5.6 | 6.0 | 5.8 | 6.0 |
| | 486 Bottom Seedling | 6.3 | 6.5 | 6.0 | 7.0 | 6.7 | 7.0 | 6.0 | 6.0 |
| | 537 USA Polyploid | 5.6 | 6.0 | 5.7 | 6.0 | 5.9 | 6.0 | 5.6 | 6.0 |
| | 802 USA Organic | 6.5 | 7.0 | 5.7 | 6.0 | 6.6 | 7.0 | 5.9 | 6.0 |
| Texture | 156 Top Stubble | 5.8 | 6.0 | 5.4 | 5.0 | 5.5 | 5.0 | 5.6 | 6.0 |
| | 269 Bottom Stubble | 5.8 | 6.0 | 6.0 | 6.0 | 6.1 | 6.5 | 5.8 | 6.0 |
| | 364 Top Seedling | 6.8 | 7.0 | 6.4 | 7.0 | 6.8 | 7.0 | 6.5 | 7.0 |
| | 486 Bottom Seedling | 6.9 | 7.0 | 6.3 | 7.0 | 6.9 | 7.0 | 6.5 | 7.0 |
| | 537 USA Polyploid | 6.0 | 6.0 | 6.2 | 6.0 | 6.4 | 6.5 | 6.0 | 6.0 |
| | 802 USA Organic | 6.7 | 7.0 | 6.5 | 7.0 | 6.8 | 7.0 | 6.5 | 7.0 |
| Aftertaste | 156 Top Stubble | 5.4 | 6.0 | 5.0 | 5.0 | 5.2 | 5.0 | 5.2 | 5.0 |
| | 269 Bottom Stubble | 5.6 | 6.0 | 4.8 | 4.5 | 5.2 | 5.0 | 5.2 | 6.0 |
| | 364 Top Seedling | 6.0 | 6.0 | 5.2 | 5.5 | 5.6 | 6.0 | 5.6 | 6.0 |
| | 486 Bottom Seedling | 6.0 | 6.0 | 5.5 | 5.0 | 5.9 | 6.0 | 5.6 | 5.5 |
| | 537 USA Polyploid | 5.4 | 5.0 | 5.6 | 6.0 | 5.8 | 6.0 | 5.4 | 5.0 |
| | 802 USA Organic | 6.4 | 7.0 | 5.4 | 6.0 | 6.5 | 7.0 | 5.7 | 6.0 |
| Count | | 52 | | 54 | | 30 | | 76 | |

| Attribute | Sample | Age (Years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18-24 | | 25-34 | | 35-44 | | 45-54 | | 55-64 | |
| | | Mean | Median | Mean | Median | Mean | Median | Mean | Median | Mean | Median |
| Overall | 156 Top Stubble | 5.2 | 6.0 | 5.2 | 6.0 | 5.6 | 6.0 | 5.3 | 5.5 | 4.7 | 4.0 |
| | 269 Bottom Stubble | 4.9 | 5.0 | 5.8 | 6.0 | 6.9 | 8.0 | 5.6 | 6.5 | 5.5 | 6.0 |
| | 364 Top Seedling | 5.1 | 5.5 | 6.0 | 7.0 | 5.8 | 6.5 | 6.5 | 7.0 | 6.4 | 7.0 |
| | 486 Bottom Seedling | 6.2 | 6.5 | 6.2 | 7.0 | 6.6 | 7.0 | 6.5 | 7.0 | 6.7 | 7.0 |
| | 537 USA Polyploid | 5.5 | 5.5 | 6.2 | 7.0 | 6.3 | 6.5 | 4.8 | 4.0 | 5.0 | 5.0 |
| | 802 USA Organic | 5.8 | 6.5 | 5.8 | 6.0 | 6.2 | 7.0 | 6.8 | 7.0 | 6.0 | 6.0 |
| Appearance | 156 Top Stubble | 5.8 | 6.0 | 5.7 | 6.0 | 5.6 | 5.5 | 6.2 | 7.0 | 5.9 | 7.0 |
| | 269 Bottom Stubble | 6.0 | 6.0 | 6.0 | 6.0 | 6.9 | 8.0 | 5.8 | 7.0 | 6.2 | 7.0 |
| | 364 Top Seedling | 5.6 | 5.5 | 6.8 | 7.0 | 6.1 | 8.0 | 6.4 | 7.0 | 7.5 | 8.0 |
| | 486 Bottom Seedling | 6.9 | 7.0 | 6.8 | 7.0 | 6.7 | 7.0 | 6.7 | 7.0 | 7.4 | 8.0 |
| | 537 USA Polyploid | 5.9 | 6.0 | 6.2 | 7.0 | 5.9 | 6.5 | 6.0 | 6.0 | 6.5 | 7.0 |
| | 802 USA Organic | 6.1 | 7.0 | 6.2 | 6.0 | 6.6 | 7.0 | 6.5 | 7.0 | 6.6 | 7.0 |
| Flavour | 156 Top Stubble | 5.1 | 5.0 | 5.3 | 6.0 | 5.2 | 6.0 | 5.5 | 6.0 | 5.3 | 5.0 |
| | 269 Bottom Stubble | 4.4 | 4.0 | 5.2 | 5.0 | 6.6 | 7.5 | 5.4 | 5.5 | 5.5 | 7.0 |
| | 364 Top Seedling | 5.4 | 6.0 | 5.7 | 6.0 | 5.2 | 5.0 | 6.6 | 7.0 | 6.2 | 7.0 |
| | 486 Bottom Seedling | 5.9 | 6.0 | 5.5 | 6.0 | 6.7 | 7.0 | 6.6 | 7.0 | 6.5 | 7.0 |
| | 537 USA Polyploid | 5.6 | 6.0 | 6.4 | 6.0 | 5.9 | 6.5 | 5.2 | 6.0 | 4.7 | 5.0 |
| | 802 USA Organic | 5.8 | 6.5 | 5.9 | 6.0 | 6.1 | 6.0 | 6.5 | 7.0 | 6.3 | 7.0 |

| Attribute | Sample | Age (Years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18-24 | | 25-34 | | 35-44 | | 45-54 | | 55-64 | |
| | | Mean | Median | Mean | Median | Mean | Median | Mean | Median | Mean | Median |
| Texture | 156 Top Stubble | 6.2 | 6.0 | 5.2 | 5.0 | 5.4 | 5.0 | 5.5 | 5.5 | 5.4 | 5.0 |
| | 269 Bottom Stubble | 5.8 | 6.0 | 6.0 | 6.0 | 6.6 | 7.5 | 5.4 | 5.5 | 5.9 | 6.0 |
| | 364 Top Seedling | 6.0 | 6.0 | 6.4 | 7.0 | 6.9 | 7.0 | 7.1 | 7.5 | 7.0 | 8.0 |
| | 486 Bottom Seedling | 6.8 | 7.0 | 6.2 | 7.0 | 6.4 | 7.0 | 6.5 | 7.0 | 7.5 | 8.0 |
| | 537 USA Polyploid | 6.1 | 6.0 | 6.4 | 6.0 | 6.5 | 6.5 | 5.6 | 6.0 | 6.0 | 6.0 |
| | 802 USA Organic | 6.4 | 6.0 | 6.8 | 7.0 | 6.3 | 7.0 | 6.9 | 7.0 | 6.5 | 7.0 |
| Aftertaste | 156 Top Stubble | 5.3 | 5.0 | 5.0 | 5.0 | 5.1 | 5.0 | 5.3 | 6.0 | 5.2 | 5.0 |
| | 269 Bottom Stubble | 4.5 | 4.0 | 5.5 | 5.0 | 6.5 | 7.0 | 5.0 | 5.0 | 4.5 | 5.0 |
| | 364 Top Seedling | 4.9 | 4.0 | 5.3 | 5.0 | 5.7 | 6.0 | 6.4 | 7.0 | 6.1 | 7.0 |
| | 486 Bottom Seedling | 5.1 | 5.0 | 5.6 | 5.0 | 6.1 | 6.5 | 5.8 | 6.0 | 6.6 | 7.0 |
| | 537 USA Polyploid | 5.5 | 5.0 | 5.8 | 6.0 | 6.3 | 6.5 | 4.8 | 4.5 | 5.1 | 5.0 |
| | 802 USA Organic | 5.4 | 6.0 | 6.2 | 6.0 | 6.0 | 6.0 | 6.2 | 7.0 | 5.9 | 6.0 |
| Count | | 28 | | 25 | | 18 | | 24 | | 11 | |