Project title:	Determining the basis of variation in herb flavour
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Key staff:	Ana Contente Dr Maria-Jose Oruna-Concha
Location of project:	University of Reading
Industry Representative:	Philip Dodd, Herbs Unlimited, York
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The results and conclusions in this report are based on an investigation 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.

Professor Carol Wagstaff

Principal Investigator, Head of School Chemistry, Food and Pharmacy

University of Reading

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CONTENTS

GROWER SUMMARY

Headline

Sensory analysis of fresh samples of three culinary herbs (rosemary, coriander and basil) from a range of UK locations and productions systems provided initial evidence of factors that may affect the perception of flavour for the different herb species.

Background

Herb flavour can vary in its composition as well as intensity. This variation can happen as a result of different cultivars, agronomic practices, season and climate. The consumption of culinary herbs has increased due to pressure to reduce salt content in foods whilst retaining a flavourful eating experience, such that flavour is a key attribute of herbs. Therefore, understanding how flavour varies in composition and abundance within a herb species as a result of different production systems and climate conditions, and how these differences are perceived by consumers, will help growers to adjust their practices to enable the industry to deliver a more consistent and acceptable product.

The overall aim of this 4-year PhD study is to elucidate the chemical profile of commercially important culinary herb crops and understand how season, agronomic practice, cultivation system and environment interact with this. The focus of work in this project year was to investigate sensory perception of three key herb species.

Summary

Three different herbs were selected for study by the project steering group as being of the greatest commercial relevance and covering both annual, perennial, soft and woody herbs: basil, coriander and rosemary. The variety selected was consistent for basil and coriander, but less so for rosemary. The steering group provided a number of sites giving rise to a breadth of production methods that were sampled from West Sussex, Lincolnshire, and York. These sites provided samples covering herbs produced in protected conditions under glasshouse, grown in pots (Pots), soil (Soil) or hydroponic system (Hydroponics). Samples grown on outside fields (Field) were also provided for analysis. Not all the production types were analysed for each of the three herbs, as this was dependent on what was available at the collaborating sites. Table 1 shows which production types were analysed for each of the herbs and the corresponding geographical location.

Table 1. Sampling sites for three culinary herb species and associated production systems

	Rosemary	Coriander	Basil
West Sussex	Pots	Pots, Field	Pots, Hydroponics
Lincolnshire		Pots	Pots
York	Soil, Field	Field	

Initial sampling of the three herbs provided baseline data of the key flavour volatiles found in each crop type. For all the three herbs, the main compounds mentioned in the literature as contributing to flavour, were detected in all the samples. In the case of rosemary these compounds were alpha-pinene, camphene, beta-pinene, 1,8-cineole, linalool, camphor, alpha-terpineol and verbenone, described as giving a wood, pine, camphor, menthol aroma. For coriander, the compounds provided a soapy, waxy, citrus, fruity aroma, and this was due to the presence of E-2-undecenal, dodecanal, E-2-dodecenal and E-2-decenal. Basil's main compounds were 1,8-cineole, linalool, methyl chavicol and eugenol, providing an aroma described as sweet, herbal, menthol, floral and spicy.

The same samples provided for the volatile analysis were also used for sensory analysis in 2019. Tasting sessions were conducted using a trained panel (n=11), and an average of 27 herb flavour attributes describing appearance, aroma, taste, flavour, mouthfeel and after-effects were included. Fresh samples were assessed by the panellists (in duplicate) at individual booths at the Sensory Science Centre at the University of Reading. Rosemary was described as being bitter and having a pine and menthol aroma and taste, which corresponds with the compounds found in these samples. Coriander was scored as being salty and bitter which describes the characteristics of the compounds found in its samples. Basil samples were described as sweet and with a flavour of cloves and menthol, agreeing with some of the compounds found in the same samples.

Basil samples showed some significant differences ($p<0.05$) that were influenced by the geographic location (or environmental conditions). There were also some basil attributes where the significant differences ($p<0.05$) were determined by the type of production (hydroponics vs pots). In the case of rosemary, type of production did not seem to affect the sensory profile, however, there were some significant differences ($p<0.05$) which were clearly influenced by the different varieties of the rosemary samples included. Coriander significant differences ($p<0.05$) were largely determined by the type of production (field vs pots), where field samples were scored higher for a range of sensory attributes compared with pot samples.

Financial Benefits

This project will provide UK herb growers with information to help them understand better the variations in their product, and in doing so, help to deliver a more consistent product throughout the year.

Action Points

None to date.

SCIENCE SECTION

Introduction

The consumption of herbs has been recently associated with several health benefits like anti-diabetic, anti-inflammatory, anti-carcinogenic properties and also lowers the risk of cardiovascular diseases; they are also known for their antioxidant properties (Chohan, Forster-Wilkins and Opara, 2008; Opara and Chohan, 2014; Bower, Marquez and de Mejia, 2016; Kuban-Jankowska *et al.*, 2018). The replacement of salt by culinary herbs has caused an increase in the frequency of consumption of herbs (Bower, Marquez and de Mejia, 2016). The use of culinary herbs provides flavour to the dishes and also will contribute to the health of those who consume them due to their high content in polyphenols; despite their low intake it still provides some beneficial effect (Opara and Chohan, 2014).

<u>Polyphenols</u>

Polyphenols are secondary metabolites of plants and are generally involved in defence against ultraviolet radiation or biotic stressors (Di Ferdinando *et al.*, 2014). They consist of aromatic rings with hydroxyl groups attached (phenol ring). These can be classified into different groups according to the number of phenol rings and other chemical groups that might be connected to this structure. The main groups of polyphenols present in herbs are phenolic acids, flavonoids, stilbenes, lignans, coumarins and tannins (Opara and Chohan, 2014). Dried herbs have higher concentration of polyphenols (rosemary: 2518 mg/100g and coriander: 2260 mg/100g) when compared with fresh herbs (rosemary: 1082 mg/100g and coriander: 159 mg/100g) and also when compared with other foods known to have high levels of polyphenols, like dark chocolate (1860 mg/100g) (Opara and Chohan, 2014). However, herbs are used as seasoning, so the amount of intake is very low when compared to other leafy vegetables or even other food that possess any health benefit. This makes the polyphenol intake lower than what would be expected for most leafy vegetables, but does not mean that there is not going to be any beneficial effect (Opara and Chohan, 2014).

Polyphenols are known for their health benefits, the main one being their capacity to reduce the free reactive oxygen present in the body. This antioxidant activity is thought to be related with other defence mechanisms like anti-diabetic, anti-inflammatory, anti-cancer and also slowing down other cardiovascular diseases. This happens because polyphenols affect the production and activity of immune system cells, affecting the defence mechanisms (Kuban-Jankowska *et al.*, 2018).

Herb production systems

There has been an increase in the consumer interest for purchasing fresh herbs in supermarkets due to their desirable aromas and flavours. Herb crops grown outdoors come mainly from warm climates or are produced under warmer seasons in the UK. When this climate is not available the crops are exported from warmer countries or produced under protected environments in the UK. Within this type of protected production there are potted herbs, soil grown and hydroponic production under glass. Crops grown in glasshouses can use a lot of energy resource due to the use of supplementary lighting systems. The most common ones are high-pressure sodium (HPS) and metal halide (MH) due to their low costs, with HPS also contributing to the temperature since they provide heat. Light-emitting diode (LED) lights are another option since they are energy efficient and wave lengths and light colour can be personalised, however these lights require higher investment (Seely, 2017).

Hydroponic system is a method that does not require soil to grow plants, where the nutrients are provided via salts dissolved in water through an irrigation system. Here the roots can be partially or completely submersed in water. In this system the growers can control the concentration of the fertilizers supplied to the roots of the plant and have a more even distribution of the nutrients. This type of production gives growers a higher control of the phenotype of their crops (Putra and Yuliando, 2015).

Fresh herbs, as for any other type of fresh produce, suffers from degradation and spoilage after it has been harvested. That is why for many years, and still in many cases currently, most the herbs are consumed dried. Fresh herbs are comprised mainly of water (75-80%) thus it needs to be reduced in order to preserve them for longer. In order to decrease this perishability, the herbs go through a drying process; this affects their properties, like their appearance, losses in volatiles and increase in polyphenols concentration (Hossain *et al.*, 2010; Opara and Chohan, 2014). For this reason, fresh herbs are described as having better flavour (Hossain *et al.*, 2010).

Flavour comes from the essential oils present in the oil glands (trichomes) on the leaf and stem. Variation in the composition and abundance of the compounds present in the essential oil has a significant impact on the flavour characteristics. The analysis of the aroma is more efficient when done on fresh herbs compared to dried herbs, since when you dry herbs there is a loss in the volatile content (10-30%) (Díaz-Maroto *et al.*, 2004; Ravi, Prakash and Bhat, 2007).

Herb metabolites

Plants, through the process of photosynthesis, produce organic compounds called primary metabolites (Cruickshank, 2012). The function of the primary metabolites is associated with the structure and physiology of the plant, and consist of carbohydrates, proteins, nucleic acids and lipids. These metabolites are universal to the plants and do not confer uniqueness to individual varieties (Rosenthal and Berenbaum, 2012). Secondary metabolites are smaller compounds, with simpler structures that result from further metabolization of the primary compounds (Cruickshank, 2012). They are responsible for signalling mechanisms and plant defence, interacting with the environment around the plant and external organisms as well (Rosenthal and Berenbaum, 2012). Within the secondary metabolites of relevance to herbs it is possible to divide them into terpenes, alkanes, phenolics and aldehydes (Rohloff, 2006).

Aroma Volatile Compounds

Some secondary metabolites are volatile compounds, and get dispersed through the air, allowing the plant to communicate with the environment and other living organisms around the plant.

Volatiles are complex structures, with a broad variety, that consist of a hydrocarbon structure with oxygen, nitrogen and sulphur. The many different structures that these compounds can have makes them specific for their function, and they also present a low detection threshold for their target. Volatiles like isoprenoids are a result of an enzymatic process, for instance to achieve geraniol, the activity of geranyl diphosphate synthetase is required in the synthesis pathway. Geranyl diphosphate is a precursor for different monoterpenes including geraniol (Valcourt, 2014). In Figure 1 is possible to see a simple pathway of the synthesis of some terpenes.

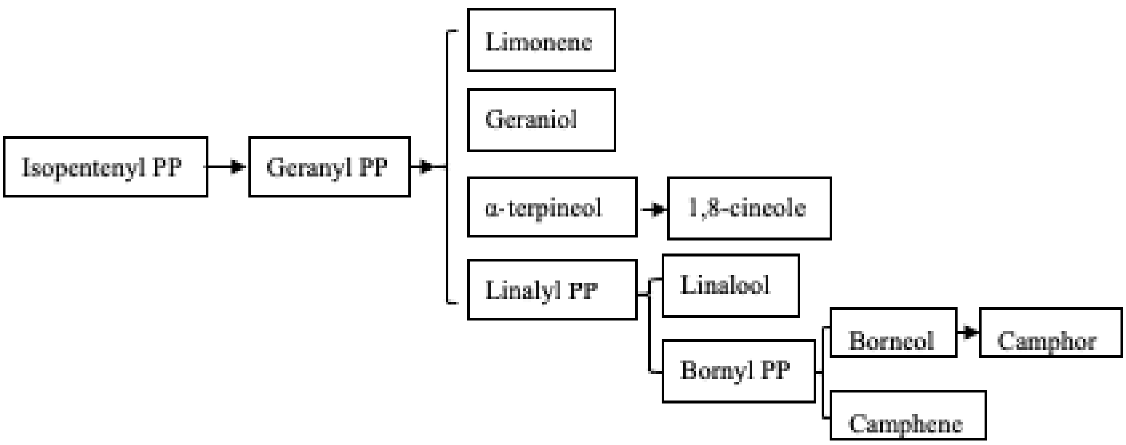

Figure 1. Simplified synthesis pathway of some terpenes. (PP) = diphosphate

Plants like herbs, which produce essential oils in their trichomes or glandular cells, produce some volatile compounds including monoterpenes and sesquiterpenes. These are produced and stored in specific structures of leaves, flowers and seeds and only in certain types of plant families. Because of this, their contribution to the air volatiles is very low, especially when compared to isoprenes which are volatiles that are produced by every plant in every green cell (Valcourt, 2014).

Volatiles can also be classified as plant pheromones, since they are signalling molecules that are involved in the defence mechanism of the plant. There are two types of defence mechanisms, direct and indirect. In the first one, certain compounds are produced in order to repel or intoxicate the pests. The indirect mechanism is where volatiles are involved, and they work as a calling signal to predators of the organism that is threatening the plant. Aldehydes, like other volatiles, take part in this type of defence mechanism. The production of these volatiles is induced when the plant is wounded or attacked by insects (Chehab *et al.*, 2008; Meerburg, Brom and Kijlstra, 2008). Aldehydes are produced through two enzymatic reactions, involving lipoxygenase and hydroperoxide lyase. They act in different stages, the substrate being polyunsaturated fatty acids. The first enzyme catalyses their oxygenation giving rise to unstable compounds that are then split into aldehydes and oxo acids. Aldehydes can be transformed into alcohols. Besides being a defence mechanism, aldehydes also contribute to the flavour of the plant (Meerburg, Brom and Kijlstra, 2008), usually conferring a ‘green’ and ‘waxy’ type of flavour.

Rosemary

Rosemary (*Rosmarinus officinalis*) comes from the family Lamiaceae (the same as mint); it is used fresh, dried and for its essential oil. It is produced worldwide, however the main area of production is the Mediterranean countries. The oil of the rosemary mainly comprises monoterpenes, like camphor, 1,8-cineole and alpha-pinene (Pintore *et al.*, 2002). However, the essential oil can also be described as primarily borneol and 1,8-cineole, followed by camphor and limonene. When it comes to the oil composition, Pintore *et al.* (2002) distinguish two groups, oils with over 40% 1,8-cineole and equal ratios of 1,8-cineole, α-pinene and camphor. Rosemary extract has been described as having health benefits like being anti-diabetic and anti-carcinogenic (Opara and Chohan, 2014).

Coriander

Coriander (*Coriandrum sativum*) is a plant from the Umbelliferae family. India is the world’s largest coriander producer and exports to other countries. Coriander flavour is mainly given by primary compounds, unlike most of the herbs which are defined by their secondary metabolites, which means coriander flavour is less affected by environmental changes (Chadwick, 2018). Aroma and flavour come from the essential oil present in the oil gland on the leaf. The international standard for coriander oil is 70% linalool content. Coriander with strong sweet, floral odour has been attributed to the presence of geranyl acetate in higher amounts (Ravi, Prakash and Bhat, 2007). Coriander leaves and seeds are consumed as seasoning, and both have shown to have beneficial effects on health when consumed (Opara and Chohan, 2014), however there is not a lot of human trials investigating this effect and the knowledge is based on diets that have been practiced like the 'Mediterranean' diet.

Basil

Basil (*Ocimum basilicum)* is from the Lamiaceae (mint) family and it is highly cultivated in Mediterranean areas, and it is used both fresh and dried. Basil can be classified as different sub-species according to the content of certain volatiles. Chemical composition of the essential oil of basil is very variable with the many constituents being linalool, estragole, eugenol and/or methyl cinnamate. Basil synthesises and stores its essential oil on the leaf and stem surface in peltate trichomes. As described above, drying basil will affect its appearance as well as flavour, since the process leads to changes in the volatile profile. Diaz-Maroto (2004) observed that volatiles losses were 28.6% in oven dried, 27.4% in freeze-dried and 13.6% in air dried. However, an increase of sequisterpenes during the drying process has been described in basil and some other herbs. Samples dried at ambient temperature have similar composition to fresh samples (Díaz-Maroto *et al.*, 2004).

Figure 2 shows some of compounds mentioned above, with their corresponding chemical structures.

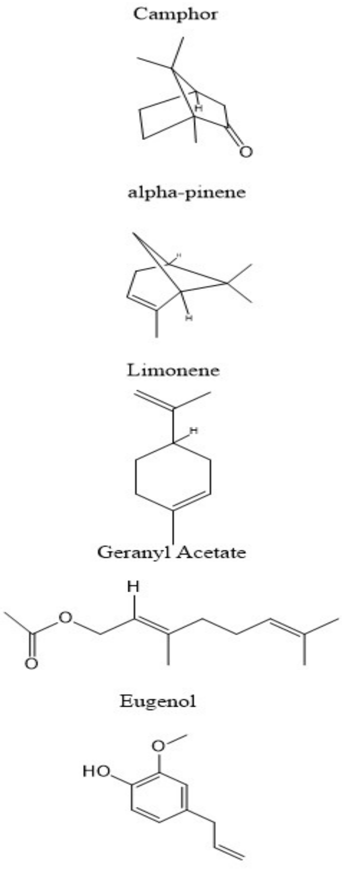

Figure 2. Structures of some of the compounds described in the literature as part of the three herbs volatile profile.

<u>Sensory analysis</u>

Volatiles compound analysis can help us to understand the chemical profile of the herbs, however that does not translate into what is perceived by the public when consuming culinary herbs. For this reason, it is necessary to complement the chemical analysis with the sensory analysis.

The aim of this project is to provide knowledge for herb growers on what influences the flavour of herbs and also to understand whether flavour differences are perceived when consumed. The focus of research in project year 2 was to use sensory analysis as a first step towards understanding perception of herb flavour. For the first sensory analysis, a quantitative descriptive analysis (QDA) was used; this method uses individuals who are more sensitive to product differences (trained panel) to discriminate the products being analysed (Murray, Delahunty and Baxter, 2001). This does not represent the general public, since these individuals are more sensitive to flavour, but it is a good indicator if differences between products are perceived, and later can be tested with the general consumer.

Materials and methods

Samples

Herbs including rosemary (*Rosmarinus officinalis*), coriander (*Coriandrum sativum* var. Cruiser) and basil (*Ocimum basilicum* var. Sweet Genovese*),* were provided by different growers across the United Kingdom (UK), and for each herb more than one type of agronomic production was considered. The types of agronomic practice for the samples consisted of herbs grown in pots under protected conditions (Pot), produced in soil protected under glass or plastic (Soil), grown in open field subject to weather conditions (Field) and using a hydroponics system (Hydroponics). Table 2 shows the different samples analysed in 2019 for each of the herbs with the respective locations. Each sample, from the different types of production and location, was analysed in triplicate (n=3) for the volatiles analysis and was analysed in duplicate (n=2) for the sensory analysis. Information about the cultivation variables was collected using a form and filled by the growers (Appendix I). All the samples were harvested at commercial maturity and sent by a courier in boxes with cooling packs and stored at 5ºC (cut samples) or at room temperature (pot samples). Analyses were carried out within 2 days upon arrival.

Table 2. Sample information for rosemary, coriander and basil, including types of production with their corresponding geographical location and time of harvesting in the summer season

	Rosemary	**Coriander**	**Basil**
West Sussex	Pots	Pots 1, Field 2	Pots 1, Hydroponics
Lincolnshire		Pots 2	Pots 2
York	Soil, Field 4	Field 1	
Harvesting	**June 2019**	**June 2019**	**July 2019**

Sensory analysis

Sample preparation

Sensory analysis was done using fresh samples of rosemary, coriander and basil grown at different locations across the UK with different types of production (Table 2, Figure 3). Samples were washed and cut to the same length (8 cm).The herbs were served in individual Petri dishes, identified with 3-digit codes and were given to the trained panel member to taste and score.

Vocabulary development session

The analysis of each herb was done within a week. The first day of analysis consisted of the vocabulary analysis development. This session consists of a discussion of words that describe the samples for appearance, aroma, taste, flavour, mouth feel and after-effects. This was conducted using university's trained professionals (n=11).

Training session

After the first session (vocabulary development), words describing the samples for appearance, aroma, taste, flavour, mouth feel and after-effects (attributes) were selected. Also, during the first session, the lower and higher end of the unstructured scale were defined (anchors). The training session is the last session before the scoring of the samples and is when the attributes and respective anchors are clarified using references so that during the scoring session all the accessors are scoring using the same references.

Scoring session

The scoring session was done in duplicate (n=2), using fresh samples. Panel members scored each sample in individual booths in a controlled environment so that there were no distractions. Each member was given water and natural yoghurt (zero percent fat) as palate cleansers to use between each herb sample. Samples were given in a randomized order, and each member scored each attribute, using the Compusense program.

Results analysis

Results were extracted from the Compusense database, and imported into the Senpaq software, where all the statistical analysis was conducted.

Results

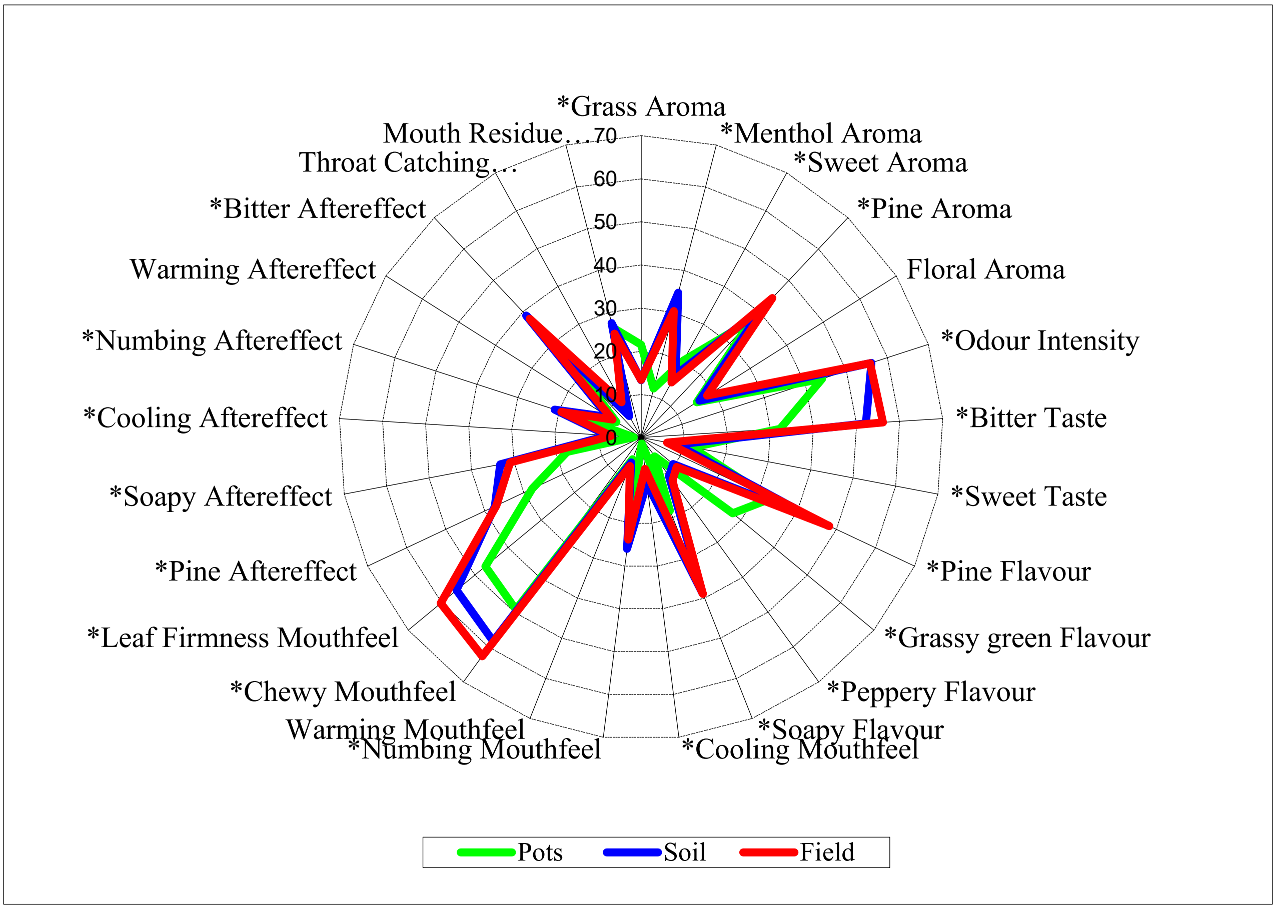

Figure 3. Star diagram of the sensory analysis results for rosemary's summer harvest 2019. *-significant difference (p-value<0.05).

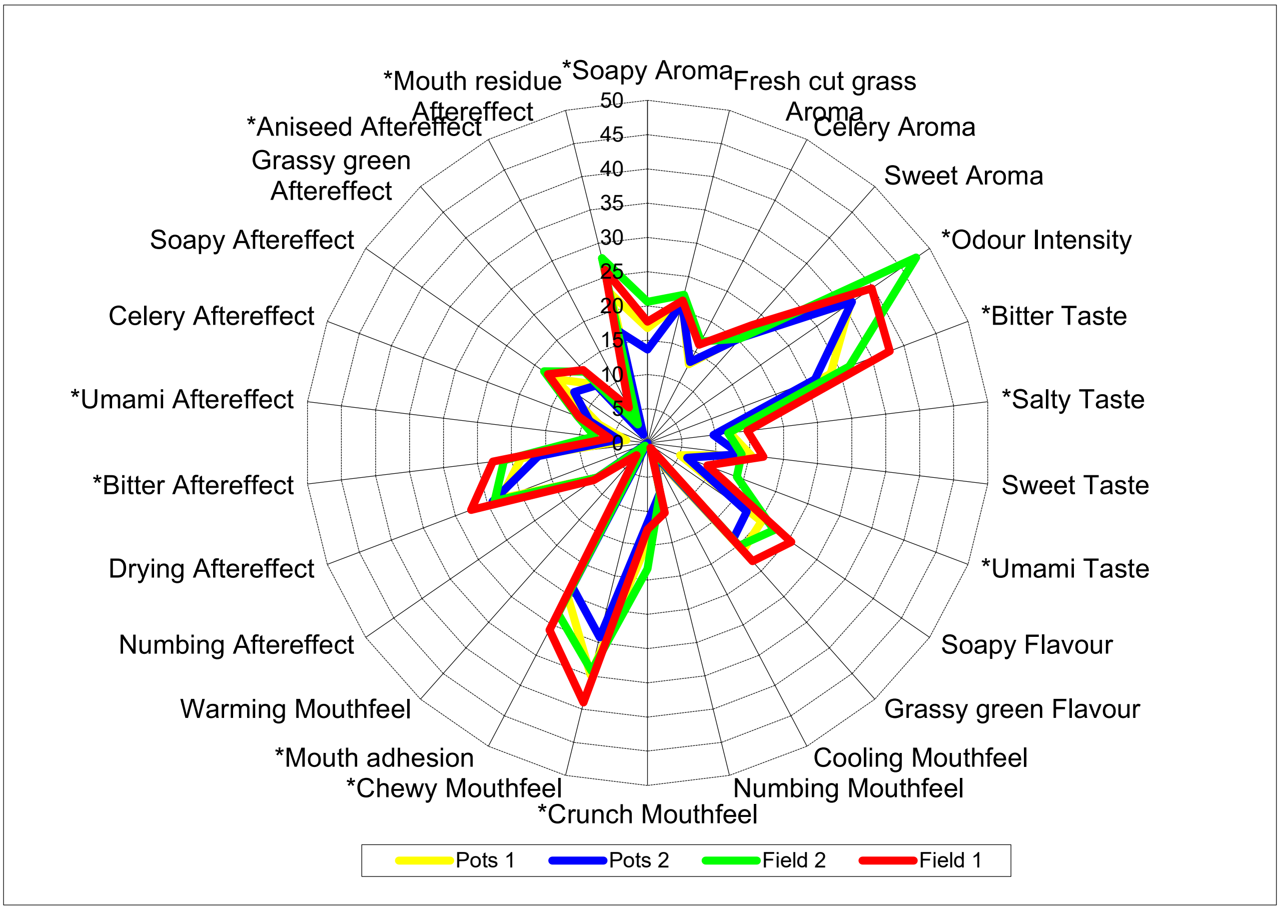

Figure 4. Star diagram of the sensory analysis results for coriander's summer harvest 2019. *-significant difference (p-value<0.05).

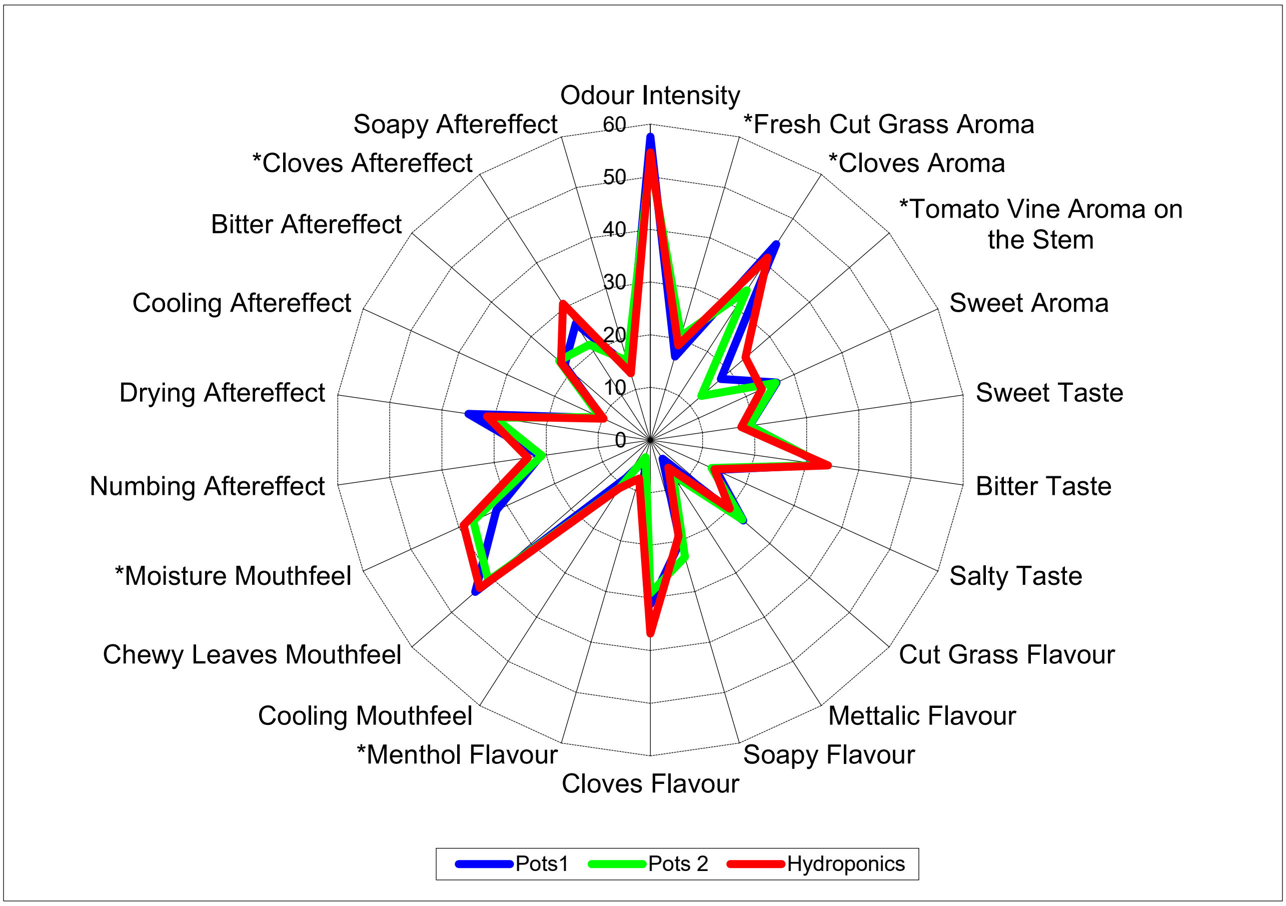

Figure 5. Star diagram of the sensory analysis results for basil's summer harvest 2019. *- significant difference (p-value<0.05).

Discussion

The sensory profile identified in each of the herbs, allows us to understand and identify the differences perceived when tasting the herbs between samples of the same herb species. This also allows us to establish possible similarities between samples, and to relate this with the results obtained from the chemical analysis and also to determine if the chemical differences translate into tasting differences when being consumed.

The sensory results are displayed in the form of diagrams (Figure 3, Figure 4, Figure 5), making it easier to visualise the difference and similarities between samples of the same herbs.

Rosemary

The sensory profile for rosemary can be seen in Figure 3 with the attributes showing some significant differences.

The menthol aroma, odour intensity, bitter taste, and pine and soapy flavour in pot samples from West Sussex were significantly lower ($p<0.05$) than soil and field samples from York. In the case of grass aroma, sweet taste and peppery flavour, pots from West Sussex were significantly higher ($p<0.05$) than field and soil samples from York. Pine aroma and peppery flavour were significantly higher ($p<0.05$) in West Sussex pots than in York field samples, the opposite was seen in sweet aroma attributes.

Rosemary samples consisted of two different varieties. Field and soil rosemary produced in York were the same variety (var. Miss Jessops) and the pot samples from West Sussex were a different variety (var. Perigord). This variety difference might be the cause of the significant differences seen between the samples, since when comparing the samples from York, no significant differences were found for any of the attributes.

When comparing the results of the samples produced in York, cultivation system did not seem to have an effect on the attributes.

Coriander

Coriander significant differences ($p<0.05$) were present for soapy aroma, odour intensity, umami taste, bitter taste, salty taste, crunch mouthfeel, chewy mouthfeel, mouth adhesion, bitter after-effect, umami after-effect, aniseed after-effect and mouth residue after-effect attributes (Figure 4). For all of these attributes, field produced samples were scored significantly higher than for pot herbs. Field samples from West Sussex scored significantly higher ($p<0.05$) for the attributes soapy aroma, odour intensity, umami taste, crunch mouthfeel, umami after-effect and mouth residue after-effect. However, the attributes of bitter taste, salty taste, chewy mouthfeel, mouth adhesion, bitter after effect and aniseed after effect, scored highest ($p<0.05$) for the field sample from York.

Coriander samples were not influenced by variety since all the samples were of the same variety (Cruiser), however significant differences were seen between field and pot produced samples, with the field samples scoring significantly higher for a list of attributes ($p<0.05$).

Although odour intensity showed a significant difference between location of production for field samples (higher for West Sussex vs York), overall the results suggested that significant differences in coriander sensory attributes were influenced more by production type than location or variety.

Basil

Basil results (Figure 5) showed the following significant differences for sensory attributes: Fresh cut grass aroma scored significantly higher ($p<0.05$) in pots grown in Lincolnshire, however, the West Sussex sample was significantly higher ($p<0.05$) than Lincolnshire's sample for the cloves aroma. Tomato vine aroma, menthol flavour, moisture mouthfeel and cloves after effect all scored significantly higher ($p<0.05$) in hydroponics than in both pot-grown samples.

For most of the flavour and taste attributes, no significant differences were seen between the samples, indicating that type of production and location do not influence significantly the taste and flavour of basil perceived by the assessors.

Pots grown in Lincolnshire for most of the attributes were scored lower than Pots from West Sussex and Hydroponics.

Conclusion

The results gathered so far for herbs sensory analysis have helped to give a better idea of what is perceived when herb samples are tasted. This will help to understand the correlation between the volatile profile of the herb species being studied and the taste of the herbs when consumed. This experiment was the first phase to understand the sensory profile of the herbs and what affects them. As it has been stated before, for this experiment the samples were scored by a trained panel, which is not representative of the general population since these panel is formed of professionals trained to characterize and pull apart every taste and flavour present in the samples. To better understand flavour of the samples and what affects them, a consumer study needs to be conducted which will indicate if the general consumer detects the differences previously stated.

Basil samples showed some significant differences ($p<0.05$) that were influenced by the location (West Sussex vs Lincolnshire) but there were also some attributes where the significant differences ($p<0.05$) were determined by the type of production (hydroponics vs pots). In the case of rosemary, type of production did not seem to affect the sensory profile, however results showed some significant differences ($p<0.05$) influenced by different varieties of the rosemary samples (York vs West Sussex). Coriander significant differences ($p<0.05$) were determined by the type of production (field vs pots), where field samples were scored higher for a range of sensory attributes compared with pot samples.

The results have shed some light on how herb samples can be tasted and if the differences between samples, influenced by growing conditions, are perceived; this is a step forward for the growers to understand their products better. Other analyses need to be done in order to complement what has been found and also to draw more definitive conclusions, as well as other comparisons. Understanding how these differences are perceived by the consumer will help determine how relevant these differences are for those who buy these products.

Knowledge and Technology Transfer

Presentations:

- Eucarpia Leafy Vegetables Conference, 2019
- Nursten Symposium, 2019
- Pangborn Sensory Science Conference, 2019
- Food and Nutritional Sciences Research Symposium, November 2019
- AHDB Herb Growers Flavour Day, 2019
- AHDB Crops PhD Student Conference, 2020

Courses:

- AFTP Consumer Module
- Statistical Training Workshop using XLSTAT

Glossary

ANOVA: Analysis of variance

SPME: Solid-Phase Microextraction

GC-MS: Gas Chromatography- Mass Spectrometry

UK: United Kingdom

HPS: High-Pressure Sodium

MH: Metal Halide

LED: Light-Emitting Diode

LRIs: Linear Retention Indices

PCA: Principal Component Analysis

QDA: Quantitative Descriptive Analysis

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Appendices

I. Form given to growers to provide information about the herb sample.

FV / PE 455 Herb flavours project

Product life cycle and submission information

1. **Herb species and variety:**

☐Rosemary ☐Coriander ☐Basil

a. Herb variety:

☐Perigord ☐Miss Jessops ☐Unknown
☐Cruiser ☐Santo ☐Chetchnya
☐Sweet Genovese ☐Other:_______________

2. **Grower:**

☐Vitacress ☐Herbs Unlimited ☐Liconlshire ☐Valley Produce ☐J Bond & Son ☐NV Produce ☐Red Deer Herbs

3. **Production Method:**

☐Organic ☐Conventional ☐Hydroponic ☐Soil Protected ☐Pots

4. **Planting date: ___/___/_____**
5. **Harvesting date: ___/___/2019**
6. **Temperature average during growth:**

☐<0 ˚C ☐0-5˚C ☐6-10 ˚C ☐11-15 ˚C ☐16-20 ˚C ☐20-25 ˚C ☐ >25 ˚C ☐No records

7. **Light exposure (protected crops):**

a. Type: ☐Natural ☐LED ☐HPS ☐MH

Other:_____________

b. Time of exposure: ____hour(s) of lights on.

8. **Water supply**: ☐Rainfall ☐Irrigation

a. Quantity (if known) :_________/week

9. Fertiliser and crop protection product application (please provide records if available)

☐CAN ______/day ☐CN_____/day ☐SOP_____/day ☐None ☐ Records provided

10. Shipping date: ___/___/2019

11. Duration between harvest and cooling: ______minutes

12. Average temperature during transport (if known)

☐<0 ˚C ☐0-5 ˚C ☐6-10 ˚C ☐11-15 ˚C ☐>15 ˚C ☐Unknown

13. Crop stage/maturity when harvested: (select all that apply)

☐First cut ☐Second cut ☐Fully matured ☐Target____cm

14. Pot production :product used as soil or growing media:

☐Peat ☐Coir ☐Mixture

II. Vocabulary development sheet given to the trained panel for rosemary

Attribute	◯	△	□	☆	◇	×
Appearance:						
Colour of Leaf						
Leaf Size						
Stem Thickness						
Freshness						
Stem Colour						
Leaf Thickness						
Aroma:						
Woody						
Fresh Cut Grass						
Pine						
Menthol						
Sweet						
Odour Intensity						
Taste and Flavour:						
Sweet						
Bitter						
Menthol						
Peppery						
Grassy Green						
Pine						
Parfum						
Mouthfeel/Texture:						
Cooling						
Numbing						
Warming						
Chewy						
Leaf firmness						
Aftertaste:						
Soapy						

Attribute	◯	△	□	☆	◇	×
Cooling						
Numbing						
Throat catching						
Warming						
Mouth Residue						

III. Training session sheet given to the trained panel for rosemary

Rosemary June 2019

Name:________________________ Date:_________________ Sample:___________________

Attribute	Low Anchor Point		High Anchor Point
Appearance			
Colour of Leaf	Light		Dark
Leaf Size	Small		Large
Leaf Thickness	Thin		Thick
Stem Thickness	Thin		Thick
Stem Colour	Light		Dark
Freshness	Not		Very
Aroma			
Fresh cut grass	Not		Very
Pine	Not		Very
Sweet	Not		Very
Odour Intensity	Not		Very
Taste/Flavour			
Sweet	Not		Very
Bitter	Not		Very
Pine	Not		Very

Peppery	Not		Very
Grassy Green	Not		Very
Soapy	Not		Very
Mouthfeel			
Cooling	Not		Very
Numbing	Not		Very
Warming	Not		Very
Chewy	Not		Very
Leaf firmness	Not		Very
After effects			
Soapy	Not		Very
Cooling	Not		Very
Numbing	Not		Very
Throat Catching	Not		Very
Warming	Not		Very
Mouth Residue	Not		Very
Pine	Not		Very

IV. Vocabulary development sheet given to the trained panel for coriander

Attribute	◯	△	□	☆	◇
Appearance:					
Green Colour					
Leaf Size					
Stem Thickness					
Freshness					
Blackening					
Openings					
Aroma:					
Soap					
Fresh Cut Grass					
Peppery					
Celery					
Sweet					
Odour Intensity (?)					
Taste and Flavour:					
Sweet					
Bitter					
Salty					
Soapy					
Grassy Green					
Parfum					
Mouthfeel/Texture:					
Cooling					
Numbing					
Crunch					
Chewy					
Mouth adhesion					
Aftertaste:					
Celery					
Bitter					

Parfum
Numbing
Grassy green
Mouth Residue
Drying

V. <u>Training session sheet given to the trained panel for coriander</u>

Coriander June 2019			
Name:___________________ Date:______________ Sample:_______________			
Attribute	**Low Anchor Point**		**High Anchor Point**
Green Colour	Light		Dark
Leaf Size	Small		Large
Stem Thickness	Thin		Thick
Freshness	Not		Very
Leaf Damage	None		Lot
Soap aroma	Not		Very
Fresh Cut grass aroma	Not		Very
Celery aroma	Not		Very
Sweet aroma	Not		Very
Odour intensity	Low		High
Sweet taste	Not		Very
Bitter	Not		Very
Salty	Not		Very

Umami	Not		Very
Soapy	Not		Very
Grassy Green	Not		Very
Cooling	Not		Very
Numbing	Not		Very
Crunch	Not		Very
Chewy	Not		Very
Mouth adhesion	Not		Very
Warming	Not		Very
Celery	Not		Very
Bitter	Not		Very
Soapy	Not		Very
Numbing	Not		Very
Grassy green	Not		Very
Mouth residue	None		Lot
Drying	Not		Very

VI. Vocabulary development sheet given to the trained panel for basil

Attribute	◯	△	☆
Appearance:			
Green Colour			
Leaf Size			
Stem Thickness			
Freshness			
Light Spots			
Leaf to Stem Ratio			
Blackening			
Aroma:			
Fennel			
Fresh Cut Grass			
Cloves			
Tomato Vine			
Sweet			
Odour Intensity			
Taste and Flavour:			
Sweet			
Bitter			
Cut Grass			
Metallic			
Parfum			
Aniseed			
Cloves			
Mouthfeel/Texture:			
Numbing			
Moisture			
Chewy Leaves			
Aftertaste:			
Soapy			
Cloves			

Attribute	○	△	☆
Bitter			
Numbing			
Dry			

VII. Training session sheet given to the trained panel for basil

Basil July 2019

Name:____________________ Date:______________ Sample:________________

Attribute	Low Anchor Point		High Anchor Point
Appearance			
Green Colour of Leaf	Light		Dark
Variation of Leaf Size	None		Lot
Stem Thickness	Thin		Thick
Frehness	Not		Very
Damage of Leaves	None		Lot
Aroma			
Fresh cut grass	Low		High
Cloves	Low		High
Tomato Vine on the Stem	Low		High
Odour Intensity	Low		High
Sweet	Low		High
Menthol	Low		High
Taste/Flavour			
Sweet	Not		Very

Bitter	Not		Very
Salty	Not		Very
Cut Grass	Not		Very
Mettalic	Not		Very
Soapy	Not		Very
Aniseed	Not		Very
Cloves	Not		Very
Menthol	Not		Very
Mouthfeel			
Numbing	Not		Very
Chewy Leaves	Not		Very
Moisture	Not		Very
After effects			
Soapy	Not		Very
Cooling	Not		Very
Numbing	Not		Very
Cloves	Not		Very
Bitter	Not		Very
Drying	Not		Very