TECHNICAL REVIEW

Optimising flavour in parsley

Figure 1. Later cuts of parley are reported to have better flavour than younger plants

Action points

- **Parsley is best grown under low stress conditions, although mild water stress may be used without harming the flavour of curly leaf varieties**
- **Later cuts of parsley may have a preferable flavour profile to the first cuts although younger plants tend to have higher content of 1,3,8-menthatriene, the typical flavour compound in the leaves than older plants, and a more intense flavour (Figure 1)**
- **Ensure minimal damage and a cool post-harvest chain of around 0–2°C to limit loss of flavour components such as menthatriene which rapidly degrates**
- **Ensure plants are not over-fertilised with nitrogen, with a soil content of no more than 200kg/ha and in accordance with RB209 fertiliser manual**

This review covers the chemical basis of flavour in fresh cut and potted parsley grown in the UK. It aims to provide information explaining factors which can influence flavour, both positively and negatively, and also gives advice on growing practice and available technologies to maximise flavour while maintaining yield and quality. Species, stress-free growth (although parsley can withstand mild drought stress) and sufficient mineral nutrition are the most important factors to take into account when growing parsley.

Introduction

Two main species are grown in the UK, *Petroselinum crispum* (curly leaf parsley) and *Petroselinum neapolitanum* (flat leaf or Italian parsley), but other varieties can also be grown for the roots. Flat leaf and curly leaf are different species and can respond differently to their environment in some cases.

Flavour components

Around 45 different volatile compounds have been identified in parsley essential oil in total, with the essential oil primarily consisting of monoterpenes (Table 1). There is also a flavour contribution from other secondary metabolites and some fatty acid derivatives which are primary metabolites.

The compounds most closely associated with flavour in parsley are monoterpenes and the fatty acid hexenal. Depending on variety and growing conditions, the content and composition of monoterpenes varies greatly [1]. Different varieties have very different content of the main flavour compounds (1,3,8)-menthatriene and myristicin (Table 2). Due to differences in the detection threshold, the absolute concentration of the compounds does not explain all of the variation in flavour. The sensory detection thresholds (the minimum concentration for trained consumers to recognise the compound) for some flavour components is known in parsley, and so the relative contribution of each chemical can be worked out.

The majority of flavour comes from hexanal which gives a green and grassy aroma that is typical to many herbs. Menthatriene and myristicin are also highly significant and are the most typical contributors to parsley aroma. Higher content of these, and specifically menthatriene, is associated with high quality fresh herbs. Myristicin is generally upregulated under stress conditions and, while we do not know how much impact it has on flavour in parsley; it is responsible for the typical flavour of nutmeg.

The volatile compound most quickly lost under poor storage conditions is 1,3,8-menthatriene. Up to 40 per cent is lost within five minutes of opening a vial of essential oil [1], and it is also rapidly lost in damaged leaves, so the leaves should be treated with extra care. This is also a major contributor to the difference between the flavour of fresh and dry herbs.

The overall content of flavour compounds can directly affect flavour with low oil leaves being perceived as watery and insipid. Consumers show a preference for more intense flavour in parsley, and for the aroma to be ‘typical’ and ‘parsley like’. Concentration of different compounds varies greatly, especially between varieties.

Compounds which are often cited as being present at over 60 per cent of the total oil content are apiole, myristicin and 1,3,8-menthatriene although, in each case, the varieties are still identifiable by a recognisable parsley flavour. As described above the overall composition is important, although the most abundant compounds are not necessarily those with the greatest effect on flavour.

Sensory attributes associated with preference of parsley are ‘sweetish’, ‘spicy’ and ‘typical’, while ‘bitter’, ‘grassy’, ‘herbaceous’ and ‘pungent’ are negative [2]. The chemical most associated with typical aromas is menthatriene and in most varieties is the most significant, although β-phellandrene and apiole are also implicated in the typical parsley aroma.

Table 1. The main constituents of parsley essential oils showing the metabolic class they belong to and the aroma they impart

Compound	Chemical class	Sensory description						
(Z)-3-Hexenyl acetate	Fatty acid	Fresh	Green	Sweet	Fruity	Banana	Apple	Grassy
1,3,8-p-Menthatriene	Monoterpene	Turpentine	Camphor	Herbal	Woody			
Apiole	Phenylpropanoid	Parsley like	Herbaceous					
Germacrene-D	Sesquiterpene	Woody	Spice					
Myrcene	Monoterpene	Peppery	Terpene	Spicy	Balsam	Plastic		
Myristicin	Phenylpropanoid	Spice	Warm	Balsam	Woody			
p-Cymene	Monoterpene	Fresh	Citrus	Terpene	Woody	Spice		
Terpinolene	Monoterpene	Fresh	Woody	Sweet	Pine	Citrus		
trans-β-Caryophyllene	Sesquiterpene	Sweet	Woody	Spice	Clove	Dry		
trans-β-Ocimene	Monoterpene	Citrus	Tropical	Green	Terpene	Woody	Green	
α-Phellandrene	Monoterpene	Citrus	Herbal	Terpene	Green	Woody	Peppery	
α-Pinene	Monoterpene	Fresh	Camphor	Sweet	Pine	Earthy	Woody	
α-Terpineol	Monoterpene alcohol	Pine	Terpene	Lilac	Citrus	Woody	Floral	
β-Phellandrene	Monoterpene	Mint	Terpentine					
β-Pinene	Monoterpene	Dry	Woody	Resinous	Pine	Hay	Green	

Table 2. Adapted from Masanetz and Grosch [1]: key odourants in varieties of curly leaf parsley, and the proportion to which each contributes to the overall flavour. The components are ordered by their contribution to variety 1, although in variety 2 it is myristicin not 1,3,8-p-Menthatriene which is more significant

Odourant	Detection Threshold µg/kg	Concentration mg/g	Concentration mg/g	Odour activity value (OAV)	Odour activity value (OAV)	% Contribution	% Contribution
		Variety 1	Variety 2	Variety 1	Variety 2	Variety 1	Variety 2
1,3,8-p-Menthatriene	15	393.29	56.35	26219	3757	41.0	10.4
(Z)-6-Decenal	0.34	5.90	2.96	17347	8712	27.1	24.1
β-Phellandrene	36	204.19	184.64	5672	5129	8.9	14.2
(E,E)-2,4-Decadienal	0.2	1.06	0.85	5290	4265	8.3	11.8
2-sec-Butyl-3-methoxypyrazine	0.003	0.008	0.010	2567	3333	4.0	9.2
Myristicin	30	57.80	178.20	1927	5940	3.0	16.4
Methanethiol	0.2	0.26	0.18	1300	875	2.0	2.4
Myrcene	14	17.98	24.07	1284	1719	2.0	4.7
(Z)-1,5-Octadien-3-one	0.0012	0.001	0.001	833	750	1.3	2.1
(Z)-3-Hexenal	0.25	0.20	0.25	800	992	1.3	2.7
2-Isopropyl-3-methoxypyrazine	0.004	0.001	0.002	350	450	0.5	1.2
p-Cymene	85	15.85	7.19	187	85	0.3	0.2
Linalool	6	0.69	0.28	116	47	0.2	0.1
1,3-Octenone	0.05	0.003	0.009	60	170	0.1	0.5

Sugars alone impart sweetness, and while this has been reported as a trait associated with preference, there is no information as to how best to manipulate the sugar content of parsley leaves.

Other factors influencing taste are polyphenols which may impart a bitter taste and aldehydes including hexanal, often associated with 'green' aroma which is undesirable in parsley. Ketones are minor constituents, eg 2-butyl-3-methoxypyrazine which imparts a musty or earthy aroma, is detectable at 1:300 000. The concentration of 1,3,8-menthatriene though it is not always detectable.

Environmental effects and agronomic impacts

Stress should be kept to a minimum to maintain the typical flavour profile of parsley. The exception to this is that curly leaf parsley varieties appear to be resistant to water deficit, which can be applied without adversely affecting the flavour.

Cultivar

Curly leaf parsley and flat leaf parsley have different chemical compositions and react differently to environmental stimuli. In a salinity trial [3], curly leaf varieties had around 60 per cent myristicin as the main constituent and mild salt stress increased the levels of 1,3,8-menthatriene and α-phellandrene. In flat leaf parsley, the main constituent by volume was β-phellandrene with no clear changes in oil composition. However, other varieties have very different compositions, such as those shown in Table 2 [1] which have higher levels of menthatriene. It is unclear if varieties fall into broad classes based on their chemical constituents, as is the case with herbs such as basil, or if varieties used in the UK are dominated by a specific chemotype (grouping based on the essential oil composition).

Growers must choose varieties which are suited to their growing conditions. Varieties high in 1,3,8-menthatriene have a more preferable aroma due to a stronger typical flavour, while cultivars which have a strong aroma are regarded as the highest quality.

Fertiliser and nutrition

High nitrogen fertilisation, at about double the ideal rate (more than 300mg/l in this study) reduced β-phellandrene [4] and overall oil content, especially in curly leaf parsley. Under the study conditions, myristicin rose [5] although it was not fully understood what effect this had on the flavour quality. A total of 100kg/ha of nitrogen per cut is considered the maximum to apply with no more than 200kg/ha load in the soil to maximise on flavour.

Planting density also affects composition of the parsley essential oil [7], with slightly higher abundance of oils in plants at a close planting density. It is unsure whether this is the result of competition for resources or an allelopathic response due to proximity to nearby plants.

Oil content is generally positively correlated with yield and quality, but negatively correlated with nitrogen and ammonium content, so factors which benefit plant growth are recommended to maximise oil production. Limiting stress, frequent nutrient monitoring and supplying adequate nutrition in terms of NPK and micronutrients is advised. Iron is also often implicated in the synthesis of monoterpenes, although there is no specific information with regards to parsley.

Biostimulants and growth regulators

There is no information on how biostimulants affect parsley.

Irrigation

Curly leaf parsley plants grown in Spain can tolerate water deficit of up to one third less than field capacity, although over watering causes a greater change in volatile composition and reduction in growth. Sensory profile is improved at lower irrigation (861m^3/ha rather than the standard 1300m^3/ha) [7]. 1,3,8-menthatriene, myristicin, limonene, α and β phellandrene and α-pinene concentration increases under mild water deficit, while myrcene and terpinolene concentration is highest when irrigated to excess. Curly leaf parsley responds better to water deficiency than flat leaf parsley in terms of flavour, due to an increase in total oil abundance in curly leaf under these conditions, while in flat leaf there is a fall in total content of the beneficial 1,3,8-menthatriene [8].

Mild salt stress up to 0.45S/m^2 can increase oil production and alter the chemical composition, with effects equivalent to water deficit [3].

Light quality

A lower light intensity (2.9mol/m^2, as opposed to 3.8mol/m^2) leads to taller plants and higher yield, but with no specific information on flavour. Crop response to light intensity and wavelength is specific to variety and to the chemicals involved so, without further research in this aspect, no recommendations can be made regarding light quality.

Day length

Warmer temperatures and longer days during the growing period lead to a greater concentration of menthatriene in flat leaf parsley, but a slightly lower concentration in curly leaf parsley [9]. Longer sunlight hours leads to more photosynthate and an ability for the crop to accumulate flavour compounds.

The typical UK parsley season is shown in Figure 2 [10], although modern glasshouse production extends this significantly. This is a factor of available light outside of summer months. More research is required to ascertain whether extending day length through supplementary lighting has an effect on flavour.

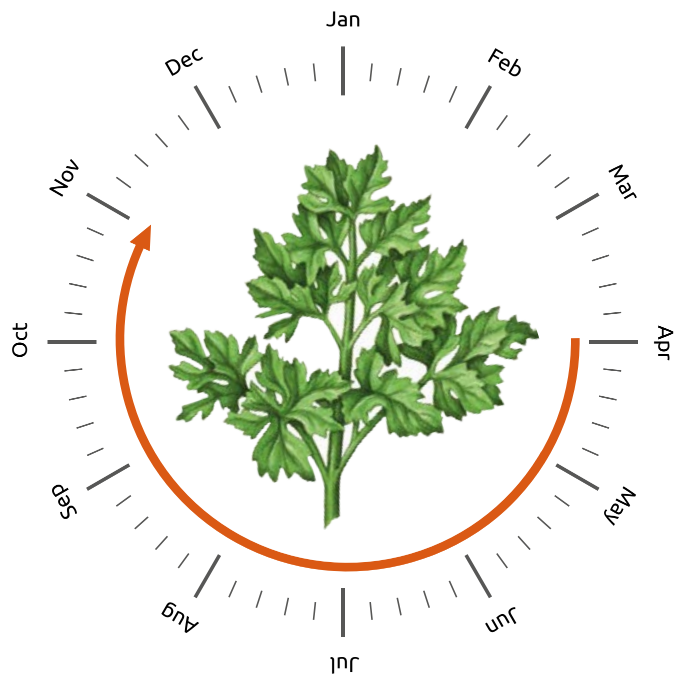

Figure 2. UK main cut parsley season shown in red. Parsley is mostly grown from April to November although, with supplementary lighting, it can be grown under glass for an extended season

Temperature

The ideal temperature to promote growth is approximately 25°C, although there is no specific information on the effects it has on flavour. In general, higher temperatures lead to faster growing plants, although how this influences flavour differs between species. On the whole, higher temperatures and faster growth only benefits flavour if the desirable flavour compounds are involved in stress response; this is not the case with parsley.

Harvest time

There is no conclusive information on when to harvest during the day to have the greatest impact on flavour.

More oil is present in parsley on the first cut than in subsequent cuts, although the later cuts are thought to have better flavour composition [6].

Plant physiology

Terpenes in parsley are produced non-specifically inside all cells, rather than in specific secretory glands as is the case with herbs such as mints and basil, and consequently, the physiology of the plant will not affect flavour from this point of view. Younger leaves have more of the characteristic compound 1,3,8-menthatriene in both curly leaf and flat leaf parsley, while older leaves tend to have higher content in the leaf stem [9] and so younger leaves will have a stronger characteristic flavour. Initiation of flowering will lead to higher concentration of compounds, although this is associated with a decrease in palatability.

Post-harvest

Parsley is relatively robust in terms of shelf life, with little chemical change seen through a typically shelf life storage of 12 days, although 1,3,8-menthatriene is lost rapidly when the leaves are damaged. Colour is lost more quickly than volatiles. Protein degradation and lipid degradation both correlate to rates of ethylene production in climacteric plants. Ethylene blockers, such as 1-MCP, are effective at reducing the effects of post-harvest respiration which leads to loss of flavour [11].

Conclusion

- While the flavour profile of parsley is well understood relative to other herbs, the conditions in the field affecting flavour are under researched in many areas, especially regarding growing season and ideal light conditions, which typically have a large effect on the production of terpene flavour compounds
- Choice of cultivar is likely to be of the greatest benefit to flavour, due to the specific variation in the metabolic pathways of terpenes
- Water deficit and mild salt stress can modify the oil content and composition, especially of curly leaf varieties which appear to be more responsive to the environment than flat leaf
- Minimise respiration post-harvest and harvest when field conditions are as cool as possible by harvesting early in the day, which limits respiration. Limiting exposure to ethylene by atmosphere control or chemical means can also prevent the loss of flavour, as can storage at 0–2°C
- Do not over fertilise with nitrogen, as this can lead to a reduction in flavour. Ideally no more than 100kg/ha of nitrogen per cut is ideal, with no more than 200kg/ha of nitrogen in the soil

Authors

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