# Essential Oil Profile and Yield of Corolla, Calyx, Leaf, and Whole Flowering Top of Cultivated *Lavandula angustifolia* Mill. (Lamiaceae) From Utah

Tyler M. Wilson*, Ariel Poulson, Chris Packer, Richard E. Carlson
D. Gary Young Research Institute, Young Living Essential Oils, 1538 W. Sandalwood Drive, Lehi, UT 84043, USA *Corresponding author: tywilson@youngliving.com

## INTRODUCTION

*Lavandula angustifolia* Mill. (lavender) is an essential oil-bearing plant in the Lamiaceae family. The plant part used for extraction is a contributing factor to the aromatic profile and yield of lavender essential oil. Previous studies have shown that linalool, linalool (linalyl) acetate, lavandulyl acetate, and α-terpineol are the predominant constituents in the essential oil extracted from the flowering top, and yield was significantly higher in essential oil extracted from the flowering top compared to the stem [1,2]. Essential oil extracted from the leafy stem is prominent in borneol, (E)-caryophyllene, camphor, 1,8-cineole, and linalool [1,3]. In this study, essential oil produced through steam distillation of lavender was examined to establish the aromatic profile and yield from each portion of the plant – namely, the corolla, calyx, leaf, and whole flowering top. This study establishes the influence the corolla, calyx, and leaf exert on the aromatic profile of the whole flowering top and provides insight into authentication of lavender essential oil.

## METHODOLOGY

The corolla, calyx, leaf and whole flowering top of lavender plants (n = 10) were separated, and steam distilled (indirect steam) in a laboratory setting. The resulting essential oil was examined to establish the essential oil yield and aromatic profile from each portion of the plant. Aromatic compounds were identified by GC-MS and quantified by GC-FID. The percent yield was calculated as the ratio of the mass of processed plant material immediately before distillation to the mass of the essential oil produced, multiplied by 100.


**Figure 1.** Portions of *Lavandula angustifolia* used: (**A**) corolla, (**B**) calyx, (**C**) leaf, (**D**) flowering top.

## ESSENTIAL OIL COMPOSITION AND YIELD

The different plant parts generally shared similar compounds but in varying relative percentages. Aromatic profiles of the whole flowering top and calyx were similar, with prominent compounds being linalool acetate (34.3%, 32.0%), linalool (26.5%, 32.9%), lavandulyl acetate (5.6%, 4.9%), terpinen-4-ol (5.3%, 7.0%), and (Z)-β-ocimene (4.5%, 5.4%), respectively. Aromatic profiles for the corolla and leaf were unique. Prominent aromatic compounds of the corolla included linalool acetate (18.4%), linalool (10.8%), epi-α-cadinol (10.0%), borneol (7.3%), and lavandulyl acetate (6.3%). Prominent aromatic compounds of the leaf included epi-α-cadinol (19.8%), γ-cadinene (11.0%), borneol (6.0%), caryophyllene oxide (4.9%), and bornyl acetate (4.8%). The calyx is the main site of essential oil accumulation (yield 1.3%), followed by the corolla (0.1%), and the leaf (0.05%). The whole flowering top, composed of corolla, calyx, stem, and leaf, had a yield of 0.7%.

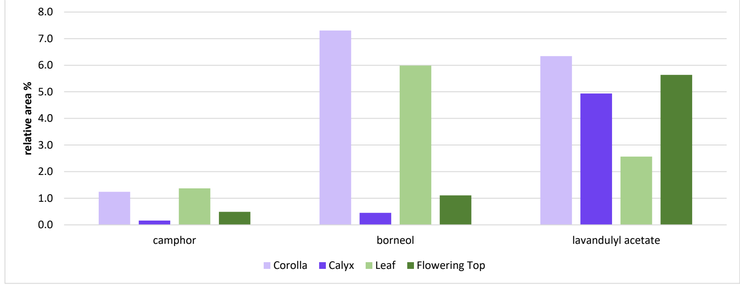
| Compound | Corolla | Calyx | Leaf | Flowering Top |
|---|---|---|---|---|
| tricyclene | nd | nd | t | 0.1 |
| α-thujene | nd | 0.1 | t | 0.2 |
| α-pinene | t | 0.2 | 0.1 | 0.3 |
| camphene | 0.1 | 0.1 | 0.6 | 0.4 |
| sabinene | t | t | 0.1 | 0.1 |
| 1-octen-3-ol | 0.1 | 0.2 | nd | nd |
| β-pinene | nd | nd | 0.2 | 0.2 |
| 3-octanone | 0.1 | 0.7 | 0.2 | 1.1 |
| myrcene | 0.1 | 0.4 | 0.6 | 0.6 |
| 3-octanol | t | nd | nd | nd |
| butyl butanoate | nd | 0.2 | nd | 0.2 |
| α-phellandrene | t | t | 0.2 | t |
| hexyl acetate | t | 0.3 | nd | nd |
| δ-3-carene | nd | nd | 1.8 | 0.5 |
| α-terpinene | t | t | t | 0.2 |
| p-cymene | t | t | 0.7 | 0.1 |
| o-cymene | 0.2 | 0.1 | 1.5 | 0.4 |
| limonene | 0.3 | 0.2 | 1.8 | 0.4 |
| β-phellandrene | t | 0.1 | 2.3 | 0.3 |
| 1,8-cineole | 0.9 | 0.3 | 1.2 | 1.5 |
| (Z)-β-ocimene | 0.5 | 5.4 | 0.3 | 4.5 |
| (E)-β-ocimene | 0.3 | 1.6 | 0.2 | 2.9 |
| γ-terpinene | t | 0.2 | 0.1 | 0.1 |
| cis-sabinene hydrate | 0.1 | 0.2 | 0.1 | 0.2 |
| cis-linalool oxide | t | 0.1 | nd | t |
| trans-linalool oxide | t | t | nd | t |
| p-mentha-2,4(8)-diene | nd | nd | 0.3 | nd |
| terpinolene | t | t | 0.2 | t |
| linalool | 10.8 | 32.9 | 1.1 | 26.5 |
| n-nonanal | 0.2 | nd | nd | nd |
| hexyl propanoate | nd | nd | nd | 0.1 |
| 1-octen-3-yl acetate | 0.4 | 0.5 | 1.5 | 0.7 |
| cis-p-menth-2-en-1-ol | 0.2 | nd | 0.1 | nd |
| 3-octanol acetate | nd | 0.1 | nd | 0.1 |
| α-campholenal | 0.1 | nd | 0.1 | nd |
| allo-ocimene | nd | 0.4 | nd | 0.3 |
| cis-limonene oxide | 0.1 | nd | t | nd |
| trans-pinocarveol | 0.2 | nd | t | nd |
| trans-p-menth-2-en-1-ol | 0.1 | nd | t | nd |
| camphor | 1.2 | 0.2 | 1.4 | 0.5 |
| camphene hydrate | nd | nd | t | nd |
| isoborneol | 0.1 | nd | 0.1 | nd |
| lavandulol | 0.8 | 1.0 | 0.3 | 0.6 |
| borneol | 7.3 | 0.4 | 6.0 | 1.1 |
| terpinen-4-ol | 1.9 | 7.0 | 0.4 | 5.3 |
| p-cymen-8-ol | 0.2 | t | 0.1 | 0.1 |
| cryptone | 1.7 | nd | 0.3 | 0.2 |

| Compound | Corolla | Calyx | Leaf | Flowering Top |
|---|---|---|---|---|
| α-terpineol | 0.3 | 0.4 | 0.1 | 0.3 |
| hexyl butanoate | nd | 0.4 | nd | 0.4 |
| myrtenol | 0.3 | nd | 0.2 | t |
| trans-piperitol | 0.3 | nd | 0.1 | nd |
| trans-carveol | 0.2 | nd | 0.1 | nd |
| nerol | nd | 0.1 | nd | t |
| isobornyl formate | 1.0 | 0.1 | 1.6 | 0.2 |
| cumin aldehyde | 2.0 | nd | 1.3 | 0.2 |
| carvone | 0.5 | nd | 0.3 | t |
| linalool acetate | 18.4 | 32.0 | 3.0 | 34.3 |
| bornyl acetate | 2.3 | nd | 4.8 | nd |
| lavandulyl acetate | 6.3 | 4.9 | 2.6 | 5.6 |
| p-cymen-7-ol | 0.5 | nd | nd | t |
| carvacrol | nd | nd | t | nd |
| hexyl tiglate | t | t | nd | t |
| 3-oxo-p-menth-1-en-7-al | 0.1 | nd | nd | nd |
| benzyl butanoate | nd | t | nd | nd |
| neryl acetate | 0.6 | 0.2 | 0.6 | 0.2 |
| geranyl acetate | 0.9 | 0.4 | 2.5 | 0.3 |
| hexyl hexanoate | nd | 0.1 | nd | nd |
| β-elemene | nd | nd | 0.1 | nd |
| α-cedrene | 0.1 | nd | 0.3 | nd |
| α-cis-bergamotene | nd | nd | 0.1 | nd |
| α-santalene | 0.8 | 0.2 | 1.1 | 0.2 |
| (E)-caryophyllene | 1.7 | 2.5 | 2.2 | 2.3 |
| β-cedrene | t | nd | 0.1 | nd |
| α-trans-bergamotene | 0.2 | 0.1 | 0.3 | 0.1 |
| coumarin | nd | nd | 0.5 | 0.2 |
| (Z)-β-farnesene | 1.4 | 1.8 | nd | 1.6 |
| α-humulene | nd | 0.1 | 0.1 | 0.1 |
| cis-muurola-4(14),5-diene | nd | 0.1 | 0.8 | 0.1 |
| dauca-5,8-diene | 0.1 | nd | nd | nd |
| 10-epi-β-acoradiene | t | nd | 0.2 | nd |
| germacrene D | 0.3 | 0.4 | 0.3 | 0.3 |
| β-bisabolene | 0.1 | 0.1 | t | t |
| γ-cadinene | 5.1 | 0.4 | 11.0 | 0.7 |
| cis-calamenene | 0.2 | t | 0.6 | t |
| α-cadinene | nd | nd | 0.1 | nd |
| caryophyllene oxide | 4.9 | 0.1 | 4.9 | 0.3 |
| 1-epi-cubenol | 1.0 | 0.1 | 1.8 | 0.1 |
| epi-α-cadinol | 10.0 | 1.1 | 19.8 | 1.3 |
| germacra-4(15),5,10(14)-trien-1-α-ol | 0.4 | nd | nd | nd |
| cis-14-nor-muurol-5-en-4-one | 1.2 | 0.1 | 1.2 | 0.1 |
| unknown compound | 1.4 | t | 1.5 | t |
| benzyl benzoate | t | t | t | t |
| unknown compound | 1.3 | nd | 0.2 | nd |

Values less than 0.1% are denoted as trace (t) and those not detected in a portion of the plant as not detectable (nd). Values are a relative area %.

## ESSENTIAL OIL COMPOSITION AS PER PLANT PART

**Figure 2.** Relative area % of camphor, borneol, and lavandulyl acetate in each portion of *L. angustifolia*, namely the corolla, calyx, leaf, and whole flowering top. The profiles of the calyx and whole flowering top are similar. Despite the low yield of the corolla and leaf, both portions impact the profile of the whole flowering top.




## CONCLUSION

This study establishes, for the first time, the complete aromatic profile of the corolla and calyx. The corolla, calyx, and leaf, due to their unique aromatic profiles and yields, influence the aromatic profile of the whole flowering top and provide insight into authentication of lavender essential oil. While the yield of the corolla and leaf are substantially lower than that of the corolla, several prominent compounds in both oils (i.e., 1,8-cineole, camphor, borneol, lavandulyl acetate, γ-cadinene, caryophyllene oxide, epi-α-cadinol) contribute to the overall profile of the flowering top.

For additional information: Wilson, T.M., Poulson, A., Packer, C., Carlson, R.E., Buch, R.M. 2021. Essential oil profile and yield of corolla, calyx, leaf, and whole flowering top of cultivated *Lavandula angustifolia* Mill. (Lamiaceae) from Utah. *Molecules,* 26, 2343.

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