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## Caraway essential oil composition and morphology: The role of location and genotype



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### ABSTRACT

Caraway (*Carum carvi*) is used as a vegetable; more commonly, the fruits are used to flavour foods or as a preservative. Quality is a key issue; however, little is known about the respective influences of type of material and location and the interaction of these factors on essential oil composition. In this study, wild populations and commercial cultivars from the Nordic germplasm collection were examined. Plants were grown in two locations (Iceland and Sweden) and essential oil composition and phenotypic characteristics identified. Carvone and limonene were the two major compounds detected at levels around 14 and 70% of total peak area, respectively. Also *p*-cymene, *trans*- $\beta$ -ocimene,  $\alpha$ -Terpinolene and myrcene each were detected at levels above or around 2%. In total, 47 compounds were detected of which 40 were identified. The effects of material type and location were established, where location had a greater impact than genotype. In 15 out of the 35 compounds detected at levels below 2%, significant location-dependent differences were detected. For morphological traits, genotype had a more significant effect than location.

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## 1. Introduction

Caraway (*Carum carvi* L.) belongs to the Apiaceae family and is a popular plant species widely used in the food industry. The plant is native to Western Asia, Europe and Northern Africa. A search on the species resulted in more than 29,000 geo-referenced occurrences at the [Global Biodiversity Information Facility](http://www.gbif.org/) (2015). The growth pattern is biennial, producing a leaf rosette the first year and flowers the second year; however annual cultivars can also be found. Traditionally, leaves have been collected and used as a fresh herb; fruits are used as seasoning and preservative in bread, cheese and alcoholic drinks (Høeg, 1976). Little is known about how cultivation began but the plant has been introduced to new areas by man, most likely for cultivation. The introduction of caraway to Iceland is known to have occurred in the mid-seventeenth century by Gísli Magnússon (1621–1696) who settled in Hlíðarendi in the South of Iceland, and allegedly brought the plant from Denmark or the Netherlands (Benediktsson, 1939). In Hlíðarendi, caraway can still be found growing wild in the meadows (included in the

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study as accession NGB20109). Today, caraway is cultivated on a large scale and commercial cultivars have been developed (McCouch et al., 2013). Whether this has changed the biochemical and morphological properties of the species is unclear.

The preservative effect of caraway has been known since ancient Egypt. The fruits are rich in essential oils, with the two main constituents being carvone and limonene (Embong et al., 1977). Essential oil quality is generally expressed as the percentage of carvone in the essential oil, or more precisely as the ratio of carvone to limonene (Bouwmeester and Kuijpers, 1993). Little emphasis has been given to caraway's minor compounds. Essential oil composition in leaves, stems and flowers of thyme and basil has been affected by genotype (Echeverrigaray et al., 2001; Loziene and Venskutonis, 2005; Chalchat et al., 2008). The same is found for fruit essential oil composition of coriander and caraway (Galambosi and Peura, 1996; Msaada et al., 2009). Despite the wide-spread use of caraway, relatively few studies investigating the influence of genotype and locations on essential oil composition have been reported. This lacuna may be mirrored in the quality obtained in the market: as demonstrated by Raal et al. (2012), who examined twenty commercial caraway samples obtained from retail pharmacies and health shops and demonstrated essential oil contents ranging from 0.6% to 5.4%. The concept of quality is increasingly important commercially, and documented and certified use of natural and high-quality ingredients are emphasized in marketing products. The use of caraway may rise in the future; recent studies have documented antibacterial effects of its fruit essential oil (Iacobellis et al., 2005), as well as insecticidal (Seo et al., 2009) and fungicidal effects (Razzaghi-Abyaneh et al., 2009) of the same oil. This paves the way for research on the use of caraway in protecting foods and feeds from decay and contamination. Gniewosz et al. (2013) suggest the feasibility of applying a pullulan film containing caraway essential oil to extend the microbiological stability of minimally processed foods. Another example of the potential use of caraway is as a sprout suppressant in potato tubers, potentially replacing synthetic chemicals currently used in the processing industry (Gomez-Castillo et al., 2013).

The current study investigates essential oil composition in wild populations and commercial cultivars of biennial caraway genotypes grown at two different locations. The study also describes phenotypic data of the plants, as this is important for cultivation and systematics.

## 2. Material and method

### 2.1. Cultivation and characterization

A pre-study was conducted in 2009–2010, where eleven accessions from the Nordic germplasm collection were screened for essential oil composition. Four of these, two wild populations and two commercial cultivars, were selected for field studies carried out in 2012–2013 (Table 1). The fields were planted in May/June, with a spacing of 25 cm between plants. A total number of 40 plants divided into two randomised blocks, (I) and (II), were used per accession and location. The locations were Reykjavik Botanical Garden, Iceland (64°08'N, 21°56'W) with a cool and humid climate, and Alnarp, Sweden (55°39'N, 13°04'E), the latter with a warmer and drier climate than the Icelandic location (SMHI, 2015; Icelandic Met Office, 2015). At the Icelandic location soil is sandy; at the location in Sweden soil is loamy clay. No fertilizer was applied. Plants were harvested when fruits were fully mature, in August/September at the location in Iceland and in July/August at the location in Sweden. After harvest, fruits were dried and then packed in air-tight bags and stored at  $-18^{\circ}\text{C}$  before chemical analysis. For logistical reasons, fruits from the location in Iceland were stored for two months before packing, while fruits from the Swedish location were stored for one month. Single plants were scored according to a morphological descriptor list developed by Dusek et al. (2011). Fruit length was measured by digital photo analysis employing Image J software (2015) covering 50 fruits per block, accession and location.

### 2.2. Gas chromatography and compounds identification

In the pre-study, a static headspace GC method was used where the area of each resulting curve is proportionate to the concentration of the respective compound for all samples. In the pre-study, 24 compounds were detected; only 16 were identified, however. Initial analysis showed that two unidentified compounds were the most important in separating types of material. Therefore, the method was improved as follows: caraway fruits were ground using a Waring blender. The sample (2.5 g) was weighed in a 100 mL gas washing bottle which was equilibrated to  $37 \pm 1^{\circ}\text{C}$  in a circulating water bath and then purged with nitrogen ( $50\text{ mL min}^{-1}$ ) for 10 min. Volatile compounds were collected on Tenax-TA traps. The traps contained

**Table 1**

Overview of the material included in the study.

Code	Accession number	Type of material	Accession details <sup>a</sup>
A	NGB4077	Commercial cultivar	'Kami', L. Dæhnfeldt A/S, Denmark
B	NGB4570	Commercial cultivar	'Polaris', NLH, Norway
C	NGB11322	Wild population	Lia i Vefsn, Norway, 66°55'N, 13°17'E, 61 masl
D	NGB20109	Wild population	Visi-Gíslí, Iceland, 63°43'N, 19°54'W, 71 masl

<sup>a</sup> More details are available from the database SESTO (2015).

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