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Chemical composition variability of essential oil during ontogenesis of *Daucus carota* L. subsp. *sativus* (Hoffm.) Arcang

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ABSTRACT

Daucus carota L. (Apiaceae) is an important vegetable crop cultivated worldwide for its nutritive roots. The aim of this study was to examine changes occurring in the essential oil yield and chemical composition of *D. carota* L. subsp. *sativus* (Hoffm.) Arcang. 'umbels' during flowering and fruiting process. The essential oil yield varied from 0.7% to 1.8% (v/w) during umbel ontogeny. The resulted essential oils were analysed by gas chromatography–flame ionization detector (GC–FID) and GC–mass spectrometry (GC–MS). Altogether, 34 constituents, forming 94.5–97.9% of the total compositions were identified. The essential oil composition was characterized by high proportions of monoterpenoids (35.9–81.3%) and sesquiterpenoids (15.1–62.0%). Major constituents of the essential oils were carotol (10.2–58.5%), α-pinene (21.2–41.2%), myrcene (6.4–14.1%), limonene (4.4–12.7%), and sabinene (0.2–5.3%). The results obtained are of significance for determining the most favorable time for harvesting carrot umbels for better yield of quality essential oil.

1. Introduction

Daucus carota L. (Apiaceae), commonly known as 'carrot', is a biennial herb, mainly distributed in Europe, Asia and Africa. It is commercially cultivated almost all over the world for its nutritive roots (vegetable), which are an important source of carotenoids in daily diet (Arscott and Tanumihardjo, 2010). However, its seeds produce fatty oil (rich in petroselinic acid) and essential oil (Ozcan and Chalchat, 2007). Carrot seeds yield about 0.5–1.6% (v/w) essential oil, which is widely used in the formulation of certain alcoholic liquors, flavoring food products and in the making of aromatic and fragrance compositions as it blends very well in all kinds of perfumes (Ozcan and Chalchat, 2007; Staniszewska et al., 2005). The fruits of the plant have been used traditionally in the treatment of ancylostomiasis, dropsy, chronic kidney disease and bladder afflictions (Pant and Manandhar, 2007). A wide range of pharmacological activities, *viz.* antibacterial (Rossi et al., 2007), antifungal (Tavares et al., 2008), anthelmintic, hepatoprotective (Bishayee et al., 1995) and cytotoxic (Yang et al., 2008) activities are reported for *D. carota*. The sesquiterpenoids (Ahmed et al., 2005), chromones (Czepa and Hofmann, 2003), flavonoids (Gebhardt et al., 2005), coumarins (Ivie et al., 1982) and anthocyanins (Kurilich et al., 2005) have been isolated and characterized from *D. carota*.

The chemical composition of the carrot essential oil has been extensively investigated from various countries. The reported essential oils of *D. carota* belong to different chemotypes, *viz.* carotol, geranyl acetate, sabinene, α-pinene, geraniol, β-bisabolene, γ-bisabolene, (*E*)-methyl isoeugenol, and (*E*)-asarone (Gonny et al., 2004; Imamu et al., 2007; Lawrance, 1988, 1999; Mockute and Nivinskiene, 2004; Pinilla et al., 1995; Rossi et al., 2007; Staniszewska and Kula, 2001; Tavares et al., 2008). In spite of these complexities, carrot seed is the major source of the carotane sesquiterpene, carotol, which is of some interest for fragrance synthesis (Kula et al., 2006). Carotol possess strong antifungal activity against *Alternaria alternata*, a most popular phytotoxic fungus (Jasicka-Misiak et al., 2004).

It is well known that the genetic constitution of the plant and the environmental conditions influence essential oil yield and chemical composition. At the same time, a number of other factors such as the developmental stage of the plant, its physiology, also influence its content and composition considerably. In fact, during ontogenesis a number of transformations occur, revealed by morphological changes and variability of physiological processes (Telci et al., 2009; Verma et al., 2012). Like other aromatic plants, *D. carota* shows large variations in the chemical compositions of their essential oils during ontogenesis (Gonny et al., 2004). To the best of our knowledge, the essential oil of carrot has scarcely been studied from India. Therefore, in this research, chemical composition of the essential

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Fig. 1. *Daucus carota* L. subsp. *sativus* umbels from different stages (I: full bloom stage; II: seed setting initiation stage; III: green seed stage; IV: light brown seed stage; V: fully brown seed stage).

oils derived from the five different stages, occurring during blooming and seed development of the Indian population of cultivated carrot [*D. carota* L. subsp. *sativus* (Hoffm.) Arcang.] have been investigated and compared.

2. Material and methods

2.1. Plant material

The fresh umbels of the *D. carota* subsp. *sativus* were collected at five distinct maturity stages, *viz.* I: full bloom stage; II: seed setting initiation stage; III: green seed stage; IV: light brown seed stage; and V: fully brown seed stage from the experimental field at CSIR—Central Institute of Medicinal and Aromatic Plants, Research Centre Pantnagar (Uttarakhand) in month of May, 2012 (Fig. 1). The experimental site is located between coordinates 29.02°N, 79.31°E and an altitude of 243 m in foothills of North India, experiencing the subtropical climate. The samples were dried in shade prior to isolation of essential oil.

2.2. Isolation of essential oil

The shade dried umbels were subjected to hydro-distillation in a Clevenger's type apparatus for 3 h for isolation of essential oils. The essential oils were measured directly in the extraction burette and content (%) was calculated as volume (mL) of essential oil per 100 g of dry plant material. The oils were dehydrated over anhydrous Na_2SO_4 and kept in a cool and dark place prior to analysis.

2.3. Gas chromatography (GC)

GC analysis of the oil samples was carried out on a Nucon gas chromatograph model 5765 equipped with flame ionization detector (FID) and DB-5 (5% phenyl polysiloxane, 30 m length × 0.32 mm internal diameter; 0.25 μm film coating) fused silica capillary column. Hydrogen was the carrier gas at 1.0 mL min^{-1}. Temperature programming was done from 60 °C to 230 °C at 3 °C min^{-1} with final hold time of 10 min. Injector and detector temperatures were 220 °C and 230 °C, respectively. Injection size was 0.02 μL neat