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RESEARCH ARTICLE

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GC-MS analysis of the chemical constituents of the essential oil from the leaves of yacon (*Smallanthus sonchifolia*)

Abstract The essential oil from the leaves of yacon grown in China was isolated by hydrodistillation and distillation-extraction. Chemical constituents of the essential oil were separated and identified by means of gas chromatography/mass spectrometry (GC/MS) for the first time, and the relative content of each constituent was determined by area normalization. Twenty-one chemical constituents were identified, and their amounts accounted for 96.2% of the total composition. The main components of the essential oil were β-phellandrene (26.3%), β-cubebene (17.7%), β-caryophyllene (14.0%) and β-bourbonene (10.2%). Therefore, in the volatile oil from the leaves of yacon, sesquiterpenes are major compounds, accounting for 52.2%.

Keywords GC-MS, chemical constituent, essential oil, *Smallanthus sonchifolia*

1 Introduction

Yacon [*Smallanthus sonchifolius* (Poepp. et Endl.) H. Robinson], a native tuberous plant of South America in the Andean highlands closely related to sunflower, is a vigorous, herbaceous perennial plant (family Compositae). The plant grows in warm, temperate Andean valleys, but can be found at altitudes of up to 3200 m (Zardini, 1991). Yacon tubers have been found containing fructose, glucose, saccharose and inulin type of oligofructans (Ohyama et al., 1990; Goto et al., 1995; Lachman et al., 2004), and thus may be prospective prebiotics as they are fermented by beneficial species of gut bacteria (Pedreschi et al., 2003). Furthermore, many constituents are present in yacon leaves, where catechol, terpenes and flavonoids have been reported found (Valentová et al., 2001). Recently, antifungal activities of the leaf extract have been reported (Inoue et al., 1995), which infers that the aerial parts of yacon may contain some antifungal and pesticidal compounds, making it unnecessary to use pesticides in its cultivation.

The ancient, traditional use of plants as medicines provided the basis for essential oils and plant extracts to be possibly useful for specific medical conditions, so the resurgence of interest in the natural control of phytopathogens and increasing consumer demand for effective, safe and natural products means that quantitative data on plant oils and extracts are required. Although the main constituents of its tuber have been reported, few studies have been conducted on the components of the leaves of yacon, and the chemistry of its essential oils have not been previously investigated. Thus, it was thought worthwhile to carry out a detailed chemical analysis of the oil composition of the leaves by GC/MS for the first time in China. In view of the pharmacological potential and commercial value of this species, the aim of this study was to evaluate the quantity and the composition of the essential oil obtained from the leaves of yacon grown southwest of Sichuan Province, China.

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2 Materials and methods

2.1 Plant material

The leaves of yacon were collected from Ya'an city, Sichuan, China, in October, 2006 and 2007 at its florescence. The leaf samples were dried until reaching a constant weight, ground using a mill (Retsch ultracentrifugal mill and sieving machine, Haan, Germany) to obtain coarse powder (20 mesh), and then stored at room temperature prior to oil isolation.

2.2 Isolation of the essential oil

The leaf samples (50 g with 3 replicates) were separately treated by means of hydrodistillation for 5 h using a

Clevenger-type apparatus. The oils were collected and dried over anhydrous sodium sulfate, and then preserved in a sealed vial at 4°C until further analysis.

2.3 GC/MS analysis

The GC-MS analysis of oils was performed using an Agilent GC/MS equipped with a HP-5MS capillary column (30 m×0.25 mm, 0.25 μm film thickness). Heating programs were heating from 70°C to 200°C at a rate of 5°C·min^{-1}, lasting 3 min, with the He carrier gas at a flow rate of 1 mL·min^{-1} in the split mode (1∶50). An aliquot (0.2 μL) of oil was injected into the column with the injector heater at 250°C. The mass spectrometer was operating (full scan-mode) in the EI-mode at 70 eV. The ion source temperature was 230°C.

2.4 Identification of components

The relative percentage of the oil constituents was expressed as percentages by peak area normalization. Identification of components of the oil was conducted based on GC retention time on the HP-5MS capillary column, and by computer matching of the acquired mass spectra with those stored in the spectrometer data base using the NIST Mass Spectral Library (Suo and Yang, 2006; Guido et al., 2007).

3 Results

A total of twenty-one compounds were identified in the sample oils, accounting for 96.2% of the oils, and the main compositions are listed in Table 1.

The main constituents in the oils from leaves were β-phellandrene (26.3%), β-cubebene (17.6%), caryophyllene (14.0%), and β-bourbonene (10.2%). Thus, in the essential oils from leaves, sesquiterpenes were the major compounds, accounting for about 52.6% of the total composition, including monocyclic sesquiterpenes (2.4%), bicyclic sesquiterpenes (21.3%) and tricyclic sesquiterpenes (28.5%); this was followed by monoterpenes accounting for 33.9% of the total composition, including monocyclic, bicyclic and acyclic monoterpenes of 26.9%, 1.9% and 0.5%, respectively. Among monoterpenes, oxygenated derivatives such as alcohols (4.4%) were also identified. Furthermore, some non-terpene derivatives that were mainly alcohols (6.8%) were also detected. Overall, the hydrocarbons accounted for 86.4% of the total essential oil from the leaves.

The most abundant β-phellandrene was peppery, minty, and refreshing, with a slightly citrusy odor and poor tenacity, which is preferred for artificial essential oils, such as angelica, pepper and geranium (Arctander, 1969). Therefore, on the basis of its having the highest percentage and a high aroma property, β-phellandrene, with an aroma active compound characteristic, was believed to typical of

Table 1 Chemical components of the essential oil from the leaves of yacon

no.	t_R/min	name of compound	molecular weight	molecular formular	relative content/%
1	3.65	α-phellandrene	136	$C_{10}H_{16}$	0.2
2	3.77	α-pinene	136	$C_{10}H_{16}$	1.6
3	4.34	β-phellandrene	136	$C_{10}H_{16}$	26.3
4	4.43	sabinene	136	$C_{10}H_{16}$	0.3
5	4.56	β-myrcene	136	$C_{10}H_{16}$	0.5
6	5.07	benzyl alcohol	108	C_7H_8O	0.2
7	5.21	p-cymene	134	$C_{10}H_{14}$	0.4
8	5.87	δ-terpinen	136	$C_{10}H_{16}$	1.4
9	8.55	terpinen-4-ol	154	$C_{10}H_{18}O$	3.0
10	12.51	δ-elemene	136	$C_{10}H_{16}$	0.7
11	13.27	α-muurolene	204	$C_{15}H_{24}$	1.1
12	13.48	α-cubebene	204	$C_{15}H_{24}$	0.7
13	13.72	β-bourbonene	204	$C_{15}H_{24}$	10.2
14	13.83	epi-bicyclosesquiphellandrene	204	$C_{15}H_{24}$	1.6
15	14.58	β-caryophyllene	204	$C_{15}H_{24}$	14.0
16	14.8	germacrene D	204	$C_{15}H_{24}$	1.1
17	15.4	α-humulene	204	$C_{15}H_{24}$	0.6
18	16.06	β-cubebene	204	$C_{15}H_{24}$	17.6
19	17.04	δ-cadinene	204	$C_{15}H_{24}$	4.6
20	19.46	β-vatirenene	202	$C_{15}H_{22}$	3.5
21	20.75	7-tetracycloundecanol	220	$C_{15}H_{24}O$	6.6

the leaves of yacon. Moreover, caryophyllene exhibited a complete mycelial growth inhibition against *F. oxysporum* (Singh et al., 2002). Therefore, in these essential oils, β-phellandrene, β-cubebene, caryophyllene and β-bourbonene were found as major components and they were also characterized in terms of having a high content of sesquiterpenes. From some plant oils, such as wintergreen, eucalyptus, clove and sage, there has been much research and reports of toxic and irritant properties (Lawless, 1995; Newall et al., 1996). In spite of this, most of these oils are available in whole or as a part of pharmaceutical or cosmetic products, indicating that toxic properties do not prohibit their use. However, ongoing investigations on toxic or irritant properties are imperative, especially when considering any new medicinal products for human use, or otherwise.

4 Discussion

The essential oils from the leaves of yacon (*Smallanthus sonchifolia*) grown in Ya'an, Sichuan, China, were investigated for the first time. In terms of some components, this study was in agreement with the previous study on *Helianthus annuus* L. by Ceccarini et al. (2004), which belongs to the same sunflower family as yacon, but the main compounds of the essential oil of yacon, such as β-phellandrene, β-cubebene and β-bourbonene were not detected at all in the Czech Republic study (Adam et al., 2005). These differences could be related to the distinct habitat in which the plant was collected, the developmental stage and seasonal variation. However, based on the aroma characteristics of its essential oil composition, the essential oils from the leaves of yacon could be used as a flavouring agent in food and also in the medical or perfume industries, in addition to its use as a herb tea. However, this needs to be tested in further researches.

References

Adam M, Juklova M, Bajer T, Eisner A, Ventura K (2005). Comparison of three different solid-phase microextraction fibres for analysis of essential oils in yacon (*Smallanthus sonchifolius*) leaves. Journal of Chromatography A, 1084: 2–6

Arctander S (1969). Perfume and Flavor Chemicals (Aroma Chemicals) Vol. 2. New Jersey: Steffen Arctander, 65–67

Ceccarini L, Macchia M, Flamini G, Cioni P L, Caponi C, Morelli I (2004). Essential oil composition of *Helianthus annuus* L. leaves and heads of two cultivated hybrids "Carlos" and "Florom 350". Ind Crops Prod, 19(1): 13–17

Goto K, Fukai K, Hikida J, Nanjo F, Hara Y (1995). Isolation and structural analysis of oligosaccharides from yacon (*Polymnia sonchifolia*). Biosci Biotechnol Biochem, 59: 2346–2347

Guido F, Pier L C, Ivano M, Ammar B (2007). Essential oils of the aerial parts of three *Salvia* species from Jordan: *Salvia lanigera*, *S. spinosa* and *S. syriaca*. Food Chem, 100: 732–735

Inoue A, Tamogami S, Kato H, Nakazato Y, Akiyama M, Kodama O, Akatsuka T, Hashidoko Y (1995). Antifungal melampolides from leaf extracts of *Smallanthus sonchifolius*. Phytochem, 39(4): 845–848

Lachman J, Havrland B, Fernandez E C, Dudjak J (2004). Saccharides of yacon [*Smallanthus sonchifolius* (Poepp. et Endl.) H. Robinson] tubers and rhizomes and factors affecting their content. Plant Soil EnViron, 50: 383–390

Lawless J (1995). The illustrated encyclopedia of essential oils. Dorset: Element Books Ltd, 78–79

Newall C A, Anderson L A, Phillipson J D (1996). Herbal Medicines, A Guide for Health-care Professionals. London: The Pharmaceutical Press, 46–48

Ohyama T, Ito O, Yasuyoshi S, Ikarashi T, Minamisawa K, Kubota M, Tsukihashi T, Asami T (1990). Composition of storage carbohydrate in tubers of yacon (*Polymnia sonchifolia*). Soil Sci Plant Nutr, 36(1): 167–171

Pedreschi R, Campos D, Noratto G, Chirinos R, Cisneros-Zevallos L (2003). Andean yacon root (*Smallanthus sonchifolius* Poepp. Endl.) fructooligosaccharides as a potential novel source of prebiotics. J Agric Food Chem, 51: 5278–5284

Singh G, Singh O P, Maurya S (2002). Chemical and biocidal. investigations on essential oils of some Indian Curcuma species. Program Cryst Growth Characterization, 45: 75–81

Suo M R, Yang J S (2006). Survey in studies on chemical constituents of sesquiterpene and their physiological activities in plants of *Helianthus* L. Chinese Traditional and Herbal Drug, 37: 135–140 (in Chinese)

Valentová K, Frček J, Ulrichova J (2001). Yacon (*Smallan-thus sonchifolius*) and Maca (*Lepidium meyenii*), traditional Andean crops as new functional foods on the European market. Chem Listy, 95: 594–601

Zardini E (1991). Ethnobotanical notes on 'yacon', *Polymnia sonchifolia* (Asteraceae). Econ Bot, 45: 72–85