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(English Abstract)

学位論文題目 Application of Microwave Technology to Extraction of Essential Oils from Natural Plant Products of Afghanistan

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The first chapter of this thesis represents a survey on Afghanistan medicinal plants containing essential oils. Afghanistan has many kind of volatile-oil-rich and not-fully-utilized flora. The Lamiaceae, Asteraceae and Apiaceae are the most important botanical families, widely found and used as traditional medicines, food and spices in Afghanistan. Over 215 plants are used in traditional therapy in Afghanistan and ninety-three plants of that contain essential oils. Out of them, twenty-two plants were applied to oil extraction by microwave extraction techniques and forty-nine plant by conventional methods. Totally forty-one extracted species belonging to the above mentioned botanical families could be found in Afghanistan too. But still there are some species of these families which are endemic in Afghanistan and not studied yet. The plant *P. atriplicifolia* which belongs to the Lamiaceae family was chosen for this study.

In the second chapter an instrument has been developed. A single-mode microwave extractor with the maximum power of 300 W was used for essential oil extraction of *P. atriplicifolia*. A reduced extraction system is suitable in laboratory. For this purpose, we tried to make a specially designed glassware for extraction solvent recycling. The plant dried material was heated with a small amount of solvent in the sample vessel by the microwave. The generated vapour of extracted oil was cooled on the condenser above the sample vessel. And the cooled droplet was transferred separately and collected in an accumulator of the glassware. There were two phases. The lower phase of the extraction solvent was returned back to the sample vessel. The separators in different geometrical configurations were examined in this work for two goals of the purpose. The first was to reuse extraction solvent and the second was to separate a small amount of essential oil. It resulted that the used amount of extraction solvent could be reduced. Typically, several grams of leaves of *P. atriplicifolia* with 25 mL of water was heated at 110 °C for 15 min at a 200 W power. It succeeded that less than 0.1 mL essential oil could be extracted by 15 min microwave heating.

In the third chapter of this thesis a high performance thin layer chromatography (HPTLC) with support of an image processing method has been developed and validated for qualitative and quantitative analysis of β -caryophyllene and *d*-camphor from *P. atriplicifolia* essential oil extracted by microwave assisted hydrodistillation and hydrodistillation methods. The HPTLC analysis was performed in a twin trough chamber on silica gel 60 sheet using toluene-ethyl acetate (95:5, v: v) as mobile phase and anisaldehyde solution as derivatizing reagent. The scanned digital images of

sheets were analyzed by means of an ImageJ software. The R_f values estimated by ImageJ for β -caryophyllene and d -camphor were 0.75 ± 0.06 and 0.15 ± 0.01 , respectively. A linear relationship was found in the range of 0.905-5.43 $\mu\text{g}/\text{spot}$ for β -caryophyllene and 0.025-0.15 mg/spot for d -camphor. The quantification limit for both analytes were found to be 1.79 $\mu\text{g}/\text{spot}$ and 0.13 mg/spot , and the detection limit to be 0.53 $\mu\text{g}/\text{spot}$ and 0.04 mg/spot , respectively. The results obtained in validation represents good accuracy and precision of the developed HPTLC methods.

In the chapter four, the variation of yield and chemical composition of the essential oils isolated from fresh and dried *P. atriplicifolia* Benth., fresh *P. atriplicifolia* cv. Little Spire and *P. atriplicifolia* cv. Blue Spire have been investigated. The hydro-distillated essential oils from fresh and dried plants resulted in yields of 0.2% and 0.93% ,0.24% and 0.6%, respectively. A GC-MS analysis were performed using methyl n-decanoate as an internal standard for quantitative analysis. Totally, twenty-five, twenty-one, twenty-six and twenty-three compounds were identified in the oils from fresh and dried *P. atriplicifolia* Benth., *P. atriplicifolia* cv. Little Spire and *P. atriplicifolia* cv. Blue Spire, respectively. α -myrcene (16.75%) was the main component of the oil in fresh *P. atriplicifolia* Benth. and 1,8-cineole (23.36%, 17.79% and 15.72%) were the dominant component of the oils of dried *P. atriplicifolia* Benth., 'Little Spire' and 'Blue Spire'. Camphor (14.28%, 7.3%) was the second main component of 'Little Spire' and 'Blue Spire'. 'Little Spire' was rich of D-limonene (12.56%) in early stage of growth. The results showed that higher composition was observed in the oils of fresh plant 'Little Spire' a cultivar of *P. atriplicifolia* and its rich of 1,8-cineole, camphor, D-limonene, δ -3-carene and α -pinene although the amount of D-limonene was high only in early stage of growth.