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PRESERVATION OF FLAVOUR COMPONENTS IN PARSLEY (*PETROSELINUM CRISPUM*) BY HEAT PUMP AND CABINET DRYING*

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The effects of different temperature and drying method on the volatile components in parsley leaves (*Petroselinum crispum*) are presented in this study. The volatiles were extracted using Likens and Nickerson apparatus then identified by spectrometry (GC-MS) and quantified. Fresh parsley leaves were dried from 87–90% to 4–6% (wet basis). Two dryer types and two drying temperatures were used: a heat pump dryer at 45°C, 55°C and a cabinet dryer at 55°C, 65°C. The drying times in the heat pump dryer at 45°C, 55°C were 21 and 13 h, respectively. Those in the cabinet dryer at 55°C, 65°C were 8.5 and 7 h. The drying rates have been determined for both dryer types and temperatures. 15 compounds were found in fresh parsley leaves with major ones being 1,3,8-p-Menthatriene, Pinene, Myrcene, Phellandrene and Apiole. Both drying methods reduced the amount of volatile components with increasing temperature. However, there was no significant difference in the organoleptic tests carried out by sensory panels.

Abbreviations used: k – Drying constant (-); M – Moisture content (kg/kg); Me – Equilibrium moisture content (kg/kg); Mo – Initial moisture content (kg/kg); MR – Moisture ratio (-); and T – Time (s).

INTRODUCTION

Drying is widely used not only as a way to preserve foods but also to reduce weight of the product. However, the amount of energy consumed in the process is significantly higher in comparison with other preservation methods. The quality of the dried product can be affected by high temperatures resulting in off-odours, change of colour or loss of nutrients.

Heat pump drying or dehumidifier drying offers the advantages of energy recovery, energy efficiency, produces a better quality product and has less impact on the environment [Mason *et al.*, 1994]. Recently, heat pump drying has been increasingly used in food and timber industry since the quality of the dried products improves due to the use of low temperature and relative humidity of the drying air.

The recent research in heat pump drying is looking at a variety of designs, capacities, working fluids and new areas of application.

In food industry, the customer satisfaction is achieved through the quality of the product. Therefore, heat pump drying has been considered as a means to improve the quality of dried products. In spice production, drying is used to prepare the product for the market since the fresh product contains more than 80% water whereas the moisture content in the final product should not exceed 15% and generally is around 5%. Furthermore, drying reduces the risk of microorganisms' growth as well as that of biochemical changes and also of the loss of aroma due to release or modification of volatiles profile [Diaz-Maroto *et al.*, 2002]. Modification of the composition of volatiles in spices may be the result of dryer type and drying conditions [Venskutonis, 1997].

In the last few decades, condiments and seasonings have been included in a variety of national and international dishes as a result of fascination of the society with ethnic oriented restaurants in the metropolitan area. The Food and Drug Administration (FDA) in the US defines the term spice as meaning "any aromatic vegetable substance in the whole, broken or ground form, except for those substances which have been traditionally regarded as food such as onion, garlic and celery, whose significant function in food is seasoning rather than nutrition, that is true to name and from which no portion of any volatile or other flavouring principle has been removed". In this definition, spices are referred to as tropical aromatics, while herbs means leaves and seeds of certain temperate zone plants. Parsley is listed as a spice that is widely used in many dishes such as pasta, soup or salad in either dried or fresh form.

Smell and taste in dried spices are different from the fresh ones due to changes in volatile profile during the drying process. Different methods of drying have different effect on the dried product. Studies by Yousif *et al.* [1999] show that the amount of volatile oil extracted from vacuum-

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-microwave dried samples was higher than from air-dried samples. Likewise, Diaz-Maroto *et al.* [2002] compared volatile components in bay leaf, which were obtained by four different methods: air-drying at ambient temperature, oven drying at 45°C, freezing and freeze-drying. The results from air drying and oven drying were similar with insignificant loss in volatile components in comparison with fresh leaf, whereas freezing and freeze-drying caused greater changes in aroma due to the increases in the concentration level of some compounds, such as eugenol, elemicin, spathulenol and α-eudesmol. Venskutonis *et al.* [1996] postulated that the loss of volatile oil depended mainly on drying parameters and the biological characteristics of the plants.

Parsley (*Petroselinum crispum*), family Apiaceae (Umbelliferae), is a biannual herb grown widely in the temperate and subtropical areas throughout many parts of the world (Europe, USA and western Asia). There are three cultivated varieties, which in part differ by their chemisms. Var. *latifolium* (broad-leaved) and var. *crispum* (curly-leaved) are grown for their leaves, and var. *tuberosum* is grown for its root.

According to Katzer [2003], the essential oils of leaves and root show approximately the same composition. The main components (10–30%) are myristicin, limonene and 1,3,8-p-menthatriene; minor components are mono- and sesquiterpenes. The curly varieties (var. *crispum*) tend to be richer in myristicin, but contain much less essential oil than var. *latifolium* (0.01 and 0.04%, respectively).

In contrast, the essential oil from the fruits (3–6%) is either dominated by myristicin (60 to 80%; mostly var. *tuberosum* and var. *crispum*) or by apiole (70%; mostly var. *latifolium*). A third chemical race shows allyl tetramethoxy benzene (55 to 75%), which can also appear in apiole-dominated oils (up to 20%).

Parsley has been used for seasoning and garnishing in many types of cuisine since the ancient Greek period. It was used either in fresh or dried form since it gives meals such as salad, meat, fish or soup a very fresh and harsh odour. The essential oil from parsley can be used in fragrant products such as perfume, soaps and creams [Mordy, 1999]. Parsley is used for its aroma and appearance. Therefore, its aroma, greenness and size are the main quality attributes.

Drying is an important way of extending the shelf life and reducing the weight of parsley as the fresh plant material has a moisture content as high as 80%, whereas that of the dried product should not exceed 4.5%. A variety of drying methods have already been trialled such as convection dryers, microwave dryers and infrared dryers [Koller, 1988].

The objectives of this study were to: (1) to identify and quantify volatile components in fresh parsley; (2) to study the effects of heat pump dryer and different drying temperatures on the volatile components in parsley; and (3) to compare the volatile profiles obtained from heat pump drying with those obtained using a cabinet dryer.

MATERIALS AND METHODS

Parsley. Samples of curly variety of parsley (*P. crispum*) were purchased from the local grocery shop during the winter month of August. They were supplied by the local grower in Rockdale NSW (suburb of Sydney). The initial moisture content was 85-90% wet basis. The samples included stems and leaves. Both parts of the plant were used in the experiments.

Drying treatments. A pilot scale heat pump dryer and a cabinet dryer were use in these experiments. The drying air temperature was set to 45°C and 55°C with 20% RH for heat pump dryer, and 55°C and 65°C for the cabinet dryer. The drying runs were duplicated for each temperature in each of the two dryers.

An 800 g sample of parsley was placed in a wire mesh tray. A datalogger was used for monitoring temperature and humidity during the process with probes inside the chamber. During drying, the samples were taken regularly to determine the moisture content. The moisture content of parsley was determined using the oven method at 105°C for 4 h.

The drying process was carried out until the weight of samples became constant. Dried parsley was ground and placed in a jar sealed with an aluminium foil/polystyrene lined lid. Samples were stored at 5°C until volatile components determination.

Determination of volatile compounds. Simultaneous Distillation Extraction (SDE), also called Likens Nickerson method (Figure 1) was used for extraction of volatile components. A 50 g sample of fresh parsley with both stem and leaves (15 g were used for dried product) was placed in a 3 L round bottom flask with 1000 mL of water, which was boiled from 1400 to 1000 mL combined with 75 μg internal standard (Tridecane, C13).

Another round flask containing solvent, which was 40 mL dichloromethane. Both flasks were heated until the liquids reached their boiling points; then both vapours were mixed and condensed back in a column by density separation. The flavours were extracted from parsley by steam distillation, then exchanged with solvent vapour. The extraction process continued for 1.5 h.

The extracted solvent with mixture of volatile component, solvent and some water was frozen in dried ice in order to separate water from the mixture, then the liquid was transferred to a new flask to remove exceed water by

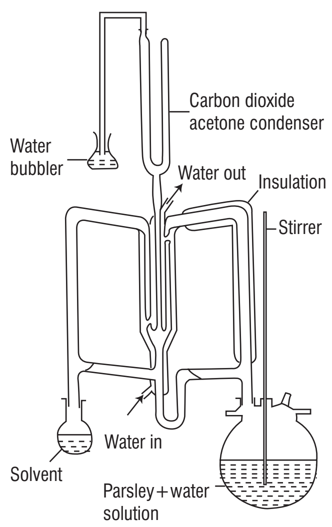

FIGURE 1. Likens Nickerson simultaneous distillation extraction apparatus.

adding anhydrous sodium sulphate. During the final step, the liquid was concentrated to 1 mL using nitrogen gas at room temperature before being injected to GC-MS.

The aroma related compounds were quantified using a Hewlett Packard Model 5980 (series II) gas chromatograph (GC) connected to a Hewlett Packard mass spectrometer (MS) model 5972 with DB5 column that was used to analyse volatile components using a PC with ChemStation software. All the chromatogram peaks were identified by the mass spectral library (National Bureau of Standards) of ChemStation software, then were confirmed by comparison with the retention time of the authentic reference. The quantitative analysis of relevant compounds was done by comparing the peak area of the studied compound with that of an internal standard.

Sensory tests. Samples of dried product, which showed the highest amount of apiole from each of the two dryers, were taken for sensory analysis using a triangular test (three coded samples with two identical reference samples and one with the product to be tested). The dried parsley was mixed with butter, and then spread on bread. The sensory test was carried out by 24 panelists.

RESULTS AND DISCUSSION

The samples of fresh parsley with 87–90% moisture content (wet basis) were dried in a heat pump dryer and a cabinet dryer down to 4–6 % moisture content (wet basis) with a water activity of 0.18–0.24 at 25°C. The fresh and dried samples were analysed using GC-MS to identify and quantify their volatile components.

Drying characteristics of parsley

Batches of fresh parsley were dried in a heat pump dryer at 45°C and 55°C and in a cabinet dryer at 55°C and 65°C until its constant weight was achieved. Then, samples were taken to determine the moisture content. In a heat pump dryer constant weight was reached after about 21 h and 13 h at 45°C with moisture contents of 10% and 5.5% (dry basis), respectively.

As for parsley dried in the cabinet dryer at 55°C and 65°C, the final moisture content was 5.3% and 4.1% (dry basis), respectively. The drying time at 55°C was 8.5 h and at 65°C – 7 h.

While drying parsley in the heat pump dryer at the same temperature (at 55°C) as in the cabinet dryer, the drying time in the cabinet dryer was reduced by over 45%.

The following equations were used to predict the drying rate:

$$MR = \ln [(M-Me)/(Mo-Me)] \quad (1)$$

$$\ln [(M-Me)/(Mo-Me)] = \exp(-kt) \quad (2)$$

Assuming that most of the drying occurs in the constant rate drying period:

$$MR = \ln [M/Mo] \quad (3)$$

$$\ln [M/Mo] = \exp (-kt) \quad (4)$$

TABLE 1. Drying constants for two dryer types used in the experiments.

Dryer type	Drying temperature	Drying constant
Heat pump dryer	45°C	-0.0898
	55°C	-0.1809
Cabinet dryer	55°C	-0.2504
	65°C	-1.166

The drying constants in equation (4) are represented in Table 1. From the model of the drying time of parsley at each temperature of the two temperatures can be predicted if the final moisture content is specified.

The drying constants represent the slope of the drying curve. In the heat pump dryer, the drying rate increased about two times as the temperature increased by 10 degrees. In the cabinet dryer, the increase of drying temperature by 10 degrees resulted in the fourfold increase of the drying rate. The comparison of drying rates in both dryers at 55°C shows that the drying rate in cabinet drying is higher than that in the heat pump dryer. As a consequence the drying time is nearly half that used in the heat pump dryer.

Analysis of volatile compounds in parsley

The identification of peaks in the chromatograms was achieved by comparing their retention times with a known standard and confirmation of their identity using mass spectra following the method described in Adams [2001].

The quantitative analysis was carried out by comparing the peak area of each relevant volatile compound with the peak area of the internal standard. The plot of a mixture of hydrocarbons (C_6–C_{22}) was used for the selection of the internal standard. From among them, C_{13} was selected as an internal standard in this study with 7.5 μg being added to each extracted sample.

As a result of GC/MS analyses 15 compounds have been identified in fresh samples. Their concentrations of volatiles found in the fresh and in the dried parsley samples are shown in Table 2. Among compounds with the highest con-

TABLE 2. Volatile compounds identified in fresh and dried parsley leaves in ppb, dry basis.

Compound	Fresh parsley	Heat pump 45°C	Heat pump 55°C	Cabinet dryer 55°C	Cabinet dryer 55°C
α-pinenene	534	17	11	9	6
Sabinene	23	1	n.d.	n.d	n.d
β-pinene	304	10	6	5	7
β-myrcenee	520	28	14	14	13
α-phellandrene	205	7	6	4	5
α-terpinene	28	n.d.	n.d.	n.d.	n.d.
Ortho-cymenene	196	4	4	n.d.	n.d.
β-phellandrene	1862	107	35	85	52
α-terpinene	82	2	1	1	n.d
Terpinolene	220	5	3	2	7
Para-cymenene	264	19	5	11	8
1,3,8-p-methatriene	4042	54	32	27	25
Caryophylene	256	20	22	17	13
Germacrene D	230	22	26	18	14
Apiole	3484	169	113	113	81

n.d. = not detected

centration is apiole that is the main contributor to parsley's flavour [Farrell, 1990]. The concentration of volatiles generally decreased with the increase in drying temperature and thus the highest concentration was found in parsley dried in the heat pump at 45°C and the lowest in the samples dried in the cabinet dryer at 65°C. However, no significant difference was observed at the same temperature between the two dryers. One compound, α-terpinene, could not be detected in the dried samples whereas two other compounds, asinine and ortho-cymenene, could not be detected in samples dried at temperatures above 55°C.

In the sensory tests, the samples of dried parsley were presented as bread spread being a mixture of dried parsley with butter. Parsley dried at 45°C in the heat pump dryer and at 55°C with the cabinet dryer was used as the odd sample. The spread was served between two slices of bread to eliminate any difference in appearance. As a result, 17 out of 24 panelists (70%) were not in the position to identify the odd sample correctly, which means that there was no significant difference ($p<0.05$) between the samples.

CONCLUSIONS

The effects of drying on the volatile aroma components of parsley using a heat pump dryer and a cabinet dryer, each using two drying air temperatures have been studied.

The drying experiments led to the determination of the drying constants for the constant rate period. The highest drying rates have been achieved with the cabinet dryer operating at 65°C and the lowest ones with the heat pump dryer operating at 45°C.

A total of 15 aroma related volatiles have been identified and quantified in fresh parsley using GC-MS technique. The highest concentrations were those of apiole and 1,3,8-p-methatriene. The concentration of volatiles was decreasing with the increase of drying temperature. Four out of the 15 volatiles could not be detected at higher drying temperatures. Temperature seems to have had a stronger effect than the dryer type as samples dried at the same temperature in different dryers had a similar volatile concentration. The sensory evaluation did not show a significant difference in flavour perception between samples dried at 45°C and 55°C.

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