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Deodorization of garlic odor by spearmint, peppermint, and chocolate mint leaves and rosmarinic acid

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ABSTRACT

The deodorization capacity of mint leaves against garlic odor has been linked to their phenolic and enzymatic components. This study determined the deodorizing effect of 3 types of fresh mint leaves (peppermint, spearmint, and chocolate mint) and pure rosmarinic acid on garlic volatiles. Garlic volatiles were measured in the headspace of a sealed bottle containing pre-weighed garlic cloves blended with mint leaves, rosmarinic acid, or a mint leaves-rosmarinic acid mixture, using selected ion flow tube-mass spectrometry (SIFT-MS). All 3 mint leaf cultivars significantly reduced the headspace concentrations of sulfur volatiles in crushed garlic. Although chocolate mint leaves had the highest rosmarinic acid content, peppermint and spearmint leaves were more effective in decreasing the headspace garlic volatiles. Increasing the amount of peppermint leaves (from 1 to 10 g) blended with garlic cloves increased the deodorizing effect. Pure rosmarinic acid significantly reduced the levels of most garlic volatiles, however, the deodorization was not strongly dependent on the amount (2 vs. 40 mg) of rosmarinic acid. Moreover, the mixture of peppermint and rosmarinic acid significantly reduced garlic volatiles as compared to rosmarinic acid alone. This suggests a synergistic effect between other components in peppermint and rosmarinic acid in the deodorization of garlic odor.

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1. Introduction

Garlic (*Allium sativum* L., Family Liliaceae) is a bulb widely used around the world for its many benefits including culinary, therapeutic, and medicinal properties. Despite the reputed positive benefits of consuming garlic, the strong and lingering odor of garlic on the breath is an unpleasant experience and may persist for up to 24 h (Mirondo & Barringer, 2016). The distinct flavor of garlic cloves is a result of complex biochemical reactions producing volatile organosulfur compounds as well as non-volatile amino acids (Amagase, Petesch, Matsuura, Kasuga, & Itakura, 2001; Martins, Petopoulos, & Ferreira, 2016). Although the underlying proposed mechanism of deodorization is not fully understood, recent studies have shown that food and food components can effectively lower the concentration of the volatiles related to garlic odor (Hansanugrum & Barringer, 2010; Mirondo & Barringer, 2016; Munch & Barringer, 2014).

The deodorization of garlic odor and the accompanying garlic breath has been linked to significant concentrations of phenolic compounds in different fruits and vegetables, as well as enzymes such as polyphenol oxidase (PPO) and peroxidase (POD) (Negishi & Negishi, 1999; Negishi & Ozawa, 1997; Negishi, Negishi, & Ozawa, 2002). One of the proposed deodorization mechanisms involves the reaction of phenolic radicals with garlic volatiles. The oxidation of phenols initiates the subsequent formation of the radical quinone that binds with volatile compounds (such as thiols and other organosulfur compounds). The resulting phenol-volatile complex is free of odor or has a different aroma (Negishi & Negishi, 1999). In enzymatic deodorization, PPO or POD enzymes catalyze the oxidation reaction of phenolic compounds, and also enhance the subsequent addition reaction of volatile compounds to radical quinones (Negishi & Negishi, 1999; Negishi et al., 2002; Yasuda & Onogi, 1996). Therefore, the use of both enzymes and phenolic compounds should produce a higher deodorization effect.

Mint leaves have been reported to produce the greatest decrease in the level of garlic volatiles in human breath relative to other food materials tested (Mirondo & Barringer, 2016; Munch & Barringer, 2014). Munch and Barringer (2014) observed that parsley, spinach, and mint (unspecified cultivar) leaf treatments were all effective in the deodorization of garlic breath volatiles, including

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ally methyl disulfide, diallyl disulfide, ally mercaptan, and allyl methyl sulfide. The mint leaves were more effective in lowering these garlic volatiles, as compared to parsley or spinach leaves. The study concluded that enzymatic activity was most likely involved in the deodorization mechanism of parsley, spinach, and mint treatments, rather than their chlorophyll (or its derivatives) contents.

A follow-up study conducted by Mirondo and Barringer (2016), also observed the deodorizing effect of fresh spearmint leaves against garlic breath volatiles, which were found to be more effective than raw apple slices, lettuce leaves, apple juice and spearmint juice treatments. In this study, it was suggested that the deodorizing capacity of spearmint leaves is linked to its total phenolic content. They observed that spearmint leaves, with approximately 148.4 mg total phenolics/100 mL, was more effective than lettuce leaves (22.4 mg total phenolics/100 mL), apple slices (80.4 mg total phenolics/100 mL), and green tea (134.7 mg total phenolics/100 mL). In the same study, it was observed that pure rosmarinic acid significantly reduced the headspace concentrations of garlic volatiles and was far more effective than quercetin, catechin, polyphenol oxidase (PPO), or a PPO-catechin mixture. Thus, pure rosmarinic acid was shown to have a higher deodorizing effect on the headspace garlic odor volatiles compared to other pure phenolic compounds, like quercetin or catechin.

Rosmarinic acid, an ester of caffeic acid and 3,4-dihydroxyphenyllactic acid, is a major phenolic compound found in mint leaves. Mirondo and Barringer (2016) proposed that rosmarinic acid may be responsible for the high deodorization capacity of mint leaves. Several studies have shown the diversity of rosmarinic acid content in different mint varieties. For instance, the concentration of rosmarinic acid in mint leaves belonging to the genera *Mentha, Melissa,* and *Nepeta* varies from 26.5 to 362 mg/100 g (Tahira, Naeemullah, Akbar, & Masood, 2011). For various laboratory grown spearmint cultivars cultured under different CO_2 and O_2 conditions, the range of rosmarinic acid is between 5.5 and 22.7 mg/g (Berhow, Rayford, Vaughn, Palmquist, & Tisserat, 2008). As for the different peppermint clones (*Mentha* x *piperita* Lamiaceae) collected from Europe and North America, the concentration ranges from 9.7 to 29.7 mg/g (Guédon & Pasquier, 1994). Such array of rosmarinic acid concentration in mint could arise from differences in variety, genotypes, and the plant's growth and environmental conditions (Berhow et al., 2008; Guédon & Pasquier, 1994; Tahira et al., 2011). These concentration differences of rosmarinic acid mean that all mint leaves are not the same, and therefore may have varying effectiveness for deodorization. Also, it is possible that the higher rosmarinic acid content in a particular mint leaf variety may explain its high deodorizing capacity compared to other varieties or even other food samples.

One objective of this study was to compare the deodorization capacity of 3 cultivars of fresh mint leaves and assess their effectiveness at reducing the headspace concentration of garlic volatiles. The effect of different concentrations of peppermint, pure rosmarinic acid, and combinations of rosmarinic acid and peppermint leaves in the deodorization of garlic volatiles was also evaluated.

2. Materials and methods

Three different cultivars of mint leaves, including spearmint (*Mentha spicata*), peppermint (*Mentha piperita*), and chocolate mint (*Mentha piperita 'Chocolate'*) leaves, were obtained from a local market. Pure rosmarinic acid (Sigma-Aldrich, St. Louis, MO, USA) and HPLC grade water (Fisher Chemical, Fair Lawn, NJ, USA) were purchased from Fisher Scientific.

2.1. Headspace volatile levels

2.1.1. Fresh mint leaves treatment

Fresh mint leaves (10 g), peeled fresh garlic cloves (5 g) and water (50 mL) were blended (magic bullet model MB 1001B, Ningbo Great Height Commodity, Ningbo, China) for 30 s. The blended mixture was transferred into a 500 mL Schott glass bottle and was covered with a Teflon-sealed screw cap prior to the subsequent headspace volatile analysis. The headspace refers to the gas phase, containing the volatile components, above a blended sample phase mixture in a sealed bottle. Immediately after blending, the headspace volatiles of the mixture were analyzed using selected ion flow tube mass spectrometry (SIFT-MS, V200 Syft Technologies, Christchurch, New Zealand). Volatile analysis was done at room temperature (25 ± 1 °C) from 0 to 30 min at 5-min intervals with an analysis time of 1 min per scan.

2.1.2. Peppermint leaves, pure rosmarinic acid, and peppermint-rosmarinic acid mixture treatments

The same procedures above were followed for the following treatments, which were all blended with 5 g of freshly peeled garlic cloves: different amounts of fresh leaves of peppermint, pure rosmarinic acid, and peppermint leaves-rosmarinic acid mixtures. The different amounts of peppermint leaves used were 1, 5, or 10 g. For the rosmarinic acid, either 2 or 40 mg of the compound was used. For the peppermint-rosmarinic acid combination, 2 or 40 mg of rosmarinic acid was added to 1 or 10 g of peppermint leaves.

2.1.3. Selected ion flow tube-mass spectrometry (SIFT-MS)

Table 1 summarizes the volatile compounds analyzed and their corresponding ion product, mass-to-charge ratios (*m/z*), the precursor or reagent ions and the reaction rates used in SIFT-MS. SIFT-MS is a direct mass spectrometric method that analyses volatile organic compounds in air with typical detection limits at parts-per-trillion (ppt_v) by volume level. Real-time, quantitative analysis is achieved by applying precisely controlled soft chemical ionization and eliminating sample preparation, pre-concentration and chromatography. Chemical ionization of the headspace volatiles occurs after their reaction with selected precursor ions (H_3O^+, NO^+ or O_2^+) generated from a microwave discharge ion source (Spanel & Smith, 1998). The concentrations of volatile compounds are obtained via a predetermined rate constant (k) and reaction time (t_r) between precursor ions and the compound of interest, precursor/reagent ion ($[R^+]$) and product ion ($[M^+]$) count rates (Spanel & Smith, 2001).

2.2. Total phenolic content

2.2.1. Sample preparation for total phenolic extraction

A 0.5 g sample of mint leaves was placed in a 15 mL glass tube and 5 mL acetone (10.9 mol/L) acidified with 0.003 mol/L hydrochloric acid solution was added. The extract was vortexed for 30 s and then centrifuged at 2264 g for 10 min. After collecting the supernatant, the phenolics from the mint leaves sample were re-extracted using the same procedures. The collected supernatants were combined and 10 mL chloroform was added. This mixture was centrifuged at 2264 g for 10 min and the top aqueous layer was collected. Any residual chloroform was evaporated from the extract under vacuum using a rotary evaporator (model WU 23012-12 Cole-Parmer, Chicago, IL, USA.). The extract was brought to a final volume of 5 mL with 0.003 mol/L hydrochloric acid solution. Sample extracts were refrigerated at 5 °C until further analysis.