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Study of odor from boiled eggs over time using gas chromatography

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ABSTRACT

In this study, emission characteristics of volatile odorant species released from boiled egg samples were investigated and correlated to boiled egg aging and growth of microorganisms. To this end, air samples from boiled eggs were collected at five different times during storage at (elapsed (E-) days of 0, 1, 3, 6, and 9). The concentrations of the volatile organic compounds (VOC) and reduced sulfur compounds (RSC) were measured by thermal desorber (TD)/gas chromatography (GC)/mass spectrometry (MS) and TD/GC/pulsed flame photometric detector (PFPD), respectively. The emission patterns of volatile components generally fell into three distinct stages: (1) fresh: E-0 and 1, (2) decaying or intermediate: E-3, and (3) decayed: E-6 and 9. In terms of the magnitude of concentration (ppb) and odor activity value (OAV), H_2S at the fresh stage (E-0) was the most critical component of odor with 3655 and 8915, respectively. The overall results of this study, if examined in terms of the sum of OAV for all odorants during the whole period, suggest that the strongest odorant emission occurs from the fresh boiled eggs with its value exceeding that of others by about an order of magnitude.

1. Introduction

Each food material possesses its own characteristic flavor and odor due to various processes throughout its product life cycle from production and consumption (e.g., fruit ripening, maturation of wine and cheese, cooking, and food decay [1–5]). These flavors, aroma, and odorants released from food materials characterize not only the freshness status but also the taste. The chemical components of food flavor are often found to be present at trace concentrations. However, the taste and quality of food can be altered in relation to the changes in the relative composition of trace components [6]. Because of changing characteristics of food flavors, considerable research effort has been carried out to handle the qualitative and quantitative information on volatile components [7].

Many previous studies were carried out to measure volatile and odorous gas released from food samples. Some of them focused on cooked eggs as the target of study because they produce very unique and offensive odorants through aging. Fleming-Jones and Smith [8] found fairly high concentration levels of volatile organic compounds (VOC) in scrambled eggs with the maximum value of 100 (toluene), 40 (benzene), and 10 ppb (styrene). In decaying boiled eggs (after one month of storage), the concentrations of nitrogenous compounds (e.g., trimethylamine and ammonia) were reported to be 1.59 and 1020 ppm, respectively [9]. Aldehyde compounds (such as hexanal, 2-methylbutanal, and 3-methylbutanal) also increased in raw egg yolk stored under sub-zero (°C) temperature conditions for 6 months [10]. In addition, methional, phenyl acetaldehyde, and heptanal were identified as the major odorants emitted from heated egg yolk [11].

In general, boiled eggs are well-known to emit sulfurous gases (e.g., hydrogen sulfide) considerably as the protein matter is decomposed/metabolized by microorganisms during decay process. Hence, hydrogen sulfide is commonly defined as the key odorant of rotten egg odor [12]. In this study, emission characteristics of volatile odorous compounds released from boiled egg samples were investigated as a function of time or in relation to growth of microorganisms. Because odors from decaying eggs are one of the commonly offensive odorants encountered in our daily activities, we explored the occurrence patterns of volatile odorants emitted from boiled egg samples covering the freshly boiled, decaying, and decayed stages. To elucidate the generation patterns of volatile components with the aging of food, air samples for boiled eggs were collected at five different time intervals (0, 1, 3, 6, and 9 days) after their preparation for the total duration of 9 days. Those samples were analyzed using thermal desorber (TD)/gas chromatography (GC)/mass spectrometry (MS) as the main instrument for this study. A TD/GC set up with pulsed flame photometric detector (PFPD) was also employed as an auxiliary equipment to sensitively quantify odorous sulfur compounds. Through a conversion of the concentration data obtained from GC-based analysis, odor activity

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Table 1
Information of target food sample (boiled egg) kept for 9 days at 25°C[a] and sample code used for each sample retrieval period.

Order	Elapsed time (day)	Sample code[b]
1	0	E-0
2	1	E-1
3	3	E-3
4	6	E-6
5	9	E-9

[a] Initial weight after boiling: 50.2 g.
[b] 'E' for sample code denotes the number of elapsed time.

values (OAVs) of the major volatile compounds were evaluated. Eventually, based on this research, generation of odorous gas was also assessed in relation to the growth of microorganisms in egg samples.

2. Materials and methods

2.1. Preparation of boiled egg samples and collection of odorant gases

To prepare boiled egg samples in this study, fresh raw eggs of South Korean origin were purchased at a local food market. On the same day of purchase, an arbitrarily selected egg was placed in a pot containing cold water and boiled for 15 min; the water was obtained from a HC potable water dispenser in the lab office. Upon being cooled down to the room temperature (over a period of 30 min before deshelling), 50 g of the deshelled boiled egg was cut in to 8 pieces (3 cm × 4 cm × 3.5 cm) and placed inside a 500 mL impinger bottle (Table 1). These boiled egg samples were then kept for 9 days in an open impinger bottle to allow the collection of odor samples at storage periods (elapsed time) of 0, 1, 3, 6, and 9 days.

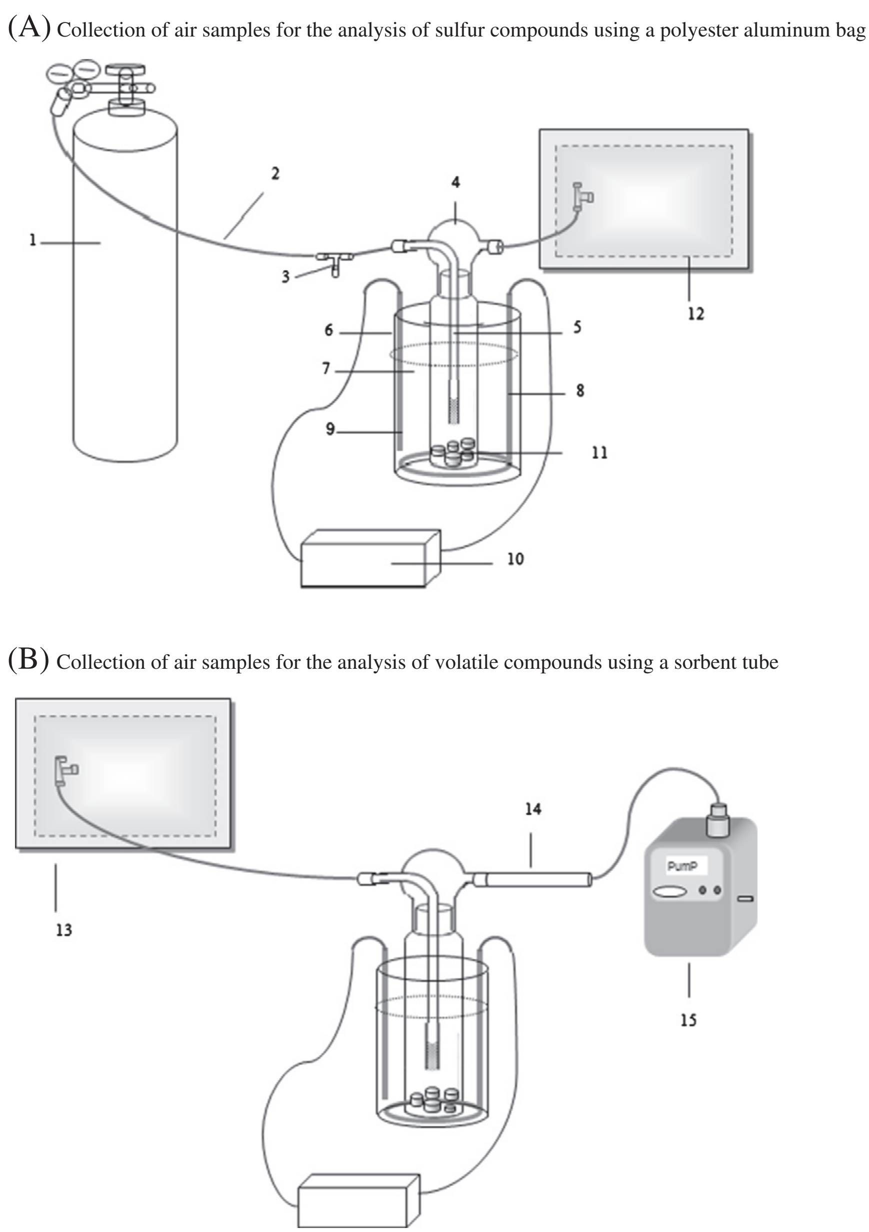

Fig. 1. Illustration of impinger system used for the collection of gas samples released from boiled egg samples. (A) Collection of air samples for the analysis of sulfur compounds using a polyester aluminum bag. (B) Collection of air samples for the analysis of volatile compounds using a sorbent tube 1] Pure air gas cylinder; 2] Teflon tubing; 3] Air flow regulator; 4] Impinger bottle (500 mL); 5] Glass tubing with a bubbler tip; 6] Aluminum container; 7] Water heated to 25 °C; 8] Heater; 9] Sensor; 10] Temperature regulator; 11] Pieces of boiled egg (50 g); 12] 10 L polyester aluminum (PEA) bag; 13] 10 L PEA bag filled with pure (99.999%) N_2 gas; 14] Sorbent tube; and 15] Mini vacuum pump.