『長崎国際大学論叢』 第12巻 2012年3月 141頁～147頁

Controlling the Concentration of Malodorous Components in Kitchen Scraps

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生ゴミの臭気成分とにおいの抑制

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要 旨

家庭内で発生する生ゴミはそのままの状態で保管しておくと悪臭が発生する。この悪臭は微生物の発生に起因するものと考えられ、微生物の増殖（腐敗）を阻害することで生ゴミの悪臭発生の抑制が期待できる。腐敗菌の増殖抑制手段として、温度、酸素濃度、二酸化炭素濃度、水分量などの環境制御因子が挙げられる。今回の実験では、生ゴミを保管する環境中の温度と酸素濃度を別々に制御して、生ゴミの形態、外観、臭気がどのように変化するのかを調べ、生ゴミの防臭手段にこれらが効果的なのかを検討した。

保管温度の点では、腐敗の激しい25℃に比較して、５℃と15℃ではイオウ系化合物等の臭気成分濃度及び形態観察に顕著な差は見られなかったことから、15℃前後の保管温度の有効性が示唆された。次に、酸素濃度の影響については、初期の酸素濃度を低くすることにより、生ゴミ臭は弱くなると考えられ、特に、初期酸素濃度５％に設定したものが一番臭いが弱く効果的であることが分かった。しかしながら、４日以上経過すると初期酸素濃度に関わらず、においの強さにはほとんど違いが見られなかった。尚、初期酸素濃度０％の無酸素状態では10日以上経過しても外観は開始時とほとんど同一であった。

キーワード

生ゴミ、温度、酸素濃度、臭気成分

Abstract

The emission of malodor by kitchen scraps is a serious problem in typical households, and thus preventing such malodor emission is crucial in achieving a healthy indoor environment. Upon disposing kitchen scraps, controlling environmental factors such as temperature, oxygen concentration, pH, osmotic pressure and the water content of food is effective in inhibiting microbial growth. This research was conducted focusing especially on the effects of temperature on the emission of malodorous compounds as food decays over time. Models of kitchen scraps were observed under three different temperatures：5℃, 15℃ and 25℃. The result showed that the model kept under 25℃ showed the highest concentration of malodorous components such as diacetyl, acetaldehyde, methyl mercaptan, ethyl mercaptan, propyl mercaptan and dimethyl disulfide. However, there was only a subtle difference between the models kept under 5℃ and 15℃. Therefore, in consideration of energy conservation, keeping kitchen scraps at 15℃ would be the most efficient means of preventing malodor emission. The second research was performed to examine how oxygen concentration affected the emission of malodorant from kitchen scraps under five different oxygen concentrations：0%, 5%, 10%, 15% and 20%. As a result, the model kept under 5% oxygen concentration had lower malodorous level；however, after about four days, there was no obvious difference among all the models.

Key words

kitchen scraps, malodorous compounds, oxygen concentration, temperature

1. Introduction

Among various problems in general households, malodor emission by kitchen scraps is one of the greatest concerns after malodor emission from the toilet. Malodorous compounds are produced by kitchen scraps owing to microbial growth. First, kitchen scraps emit the smell of individual foods. Then, as they decay through chemical reactions and microbial actions, they produce some liquid that highly contributes to malodor emission.[1] This implies that inhibiting microbial growth would prevent kitchen scraps from emitting malodorants. Controlling environmental factors (Fig. 1) such as temperature, oxygen concentration, pH, osmotic pressure and the water content of food is effective in inhibiting microbial growth.[2)–7)] This research was conducted focusing especially on the effects of temperature and oxygen concentration on malodor emission.

2. Materials and Methods

Experiments were conducted using models of kitchen scraps prepared according to the official data obtained from published reports.[8)–10)] Various ingredients shown in Table 1 were placed in a 50-L plastic bag and mixed together for the experiment on temperature.

Models of kitchen scraps were kept at three temperatures, i.e., 5℃, 15℃ and 25℃, for 25 days. To measure the concentration of gases emitted by the models of kitchen scraps, a gas chromatograph equipped with a flame photometric detector and a flame ionization detector (GC/FPD/FID), and a gas chromatography/mass spectrometry (GC/MS) system were used.[11)]

For oxygen concentration, the air in the container with the models of kitchen scraps

Table 1 Model of kitchen scraps

Material		Ratio (%)	Weight (g)
Vegetable	Potatoes	7	14
	Cabbage	21	42
	Onion	7	14
Fruits	Banana skin	13	36
	Orange peel	10	20
	Apple skin	10	20
Fish	Sardine	10	20
Meat	Ground beef	10	4
Grain	Rice	2	20
Tea leaves	Green tea	10	10
Total		100	200

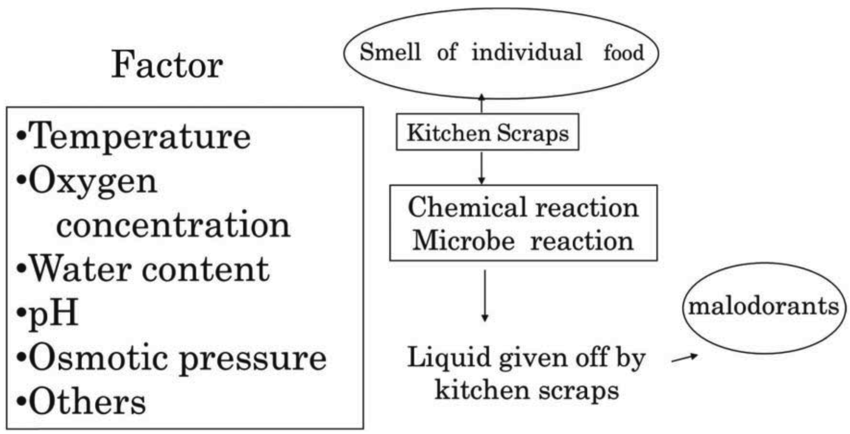

Fig. 1 Putrefaction process of kitchen scraps

was replaced with a mixture of oxygen and nitrogen with various oxygen concentrations : 0%, 5%, 10%, 15% and 20% (Fig. 2). Oxygen concentration was measured with disposable detectors. Malodorant level was determined by organoleptic tests and GC (TCD) was used to measure the concentrations of CO_2 and CH_4 in the container.

Odor intensity was evaluated according to the six-points odor intensity scale of the Offensive Odor Control Law (0: not detected, 1: can be barely detected, 2: weak odor, 3: easily detected, 4: strong odor, 5: very strong odor).

3. Results and Discussion

Analysis of malodorous components in kitchen scraps

Malodorants emitted from kitchen scraps consist of various malodorous components such as triethyl amine. Among these components, sulfur compounds with lower threshold value, particularly propyl mercaptan, contributed highly to malodor emission (Table 2, Fig. 3).

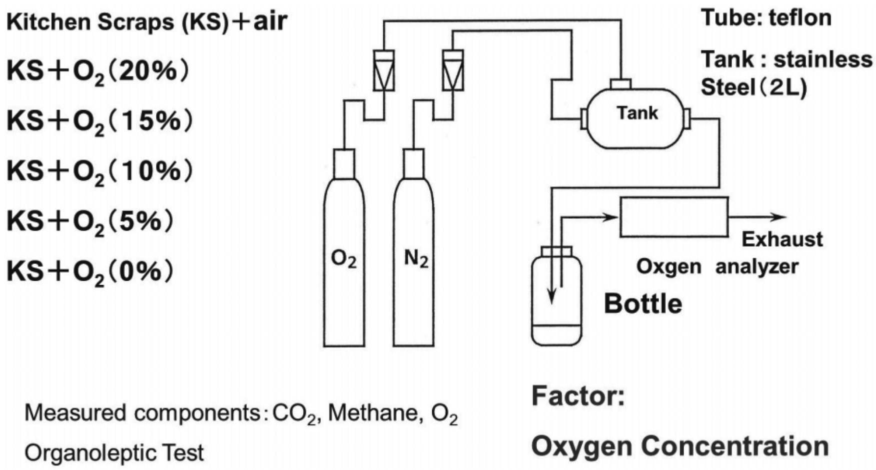

Fig. 2 Method of deoxygenizing the container

Table 2 Concentrations of malodorous compounds (25℃/after 7 days)

Functional group	Compound	Rational formula	Gas concentration (ppb)	Odor intensity
Ketone	Diacetyl	$CH_3COCOCH_3$	89	4.0
Amine	Trimethyl amine	$(CH_3)_3N$	21	3.8
Aldehyde	Acetaldehyde	CH_3CHO	1400	4.0
	Propyl aldehyde	C_2H_5CHO	14	2.0
	n-Butyl aldehyde	C_3H_7CHO	12	2.6
	n-Valeric aldehyde	C_4H_9CHO	6.2	2.3
Sulfur	Methyl mercaptane	CH_3SH	260	5.0
	Ethyl mercaptane	C_2H_5SH	230	4.3
	Propyl mercaptane	C_3H_7SH	1700	5.0
	Dimethyl sulfide	CH_3SCH_3	57	3.1
	Dimethyl disulfide	CH_3SSCH_3	400	4.1

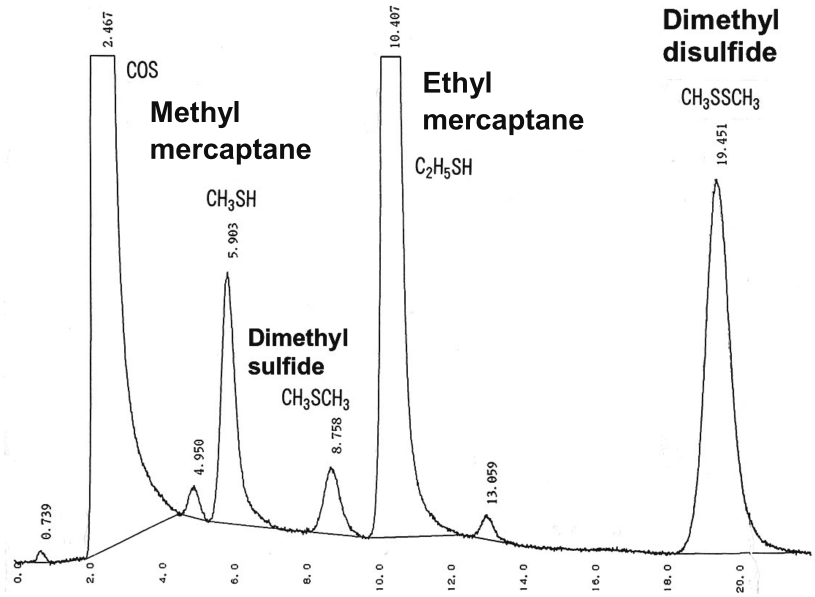

Fig. 3 Chromatogram of sulfur compounds emitted by kitchen scraps (25℃, after 8 days)

Controlling temperature and its effect on malodor emission

After 7 days, the model kept at 25℃ showed the highest concentration of all sulfur compounds. However, there was a small difference between the results obtained from the 5℃ and 15℃ models. Also, after about a week, there was not much difference in the concentration of methyl mercaptane (MM) among the three models, However, a remarkable difference was observed with the 25℃ model after a week, compared with the other two models (Figs. 4 and 5).

Moreover, after about a week, some liquid was produced at the bottom of the bag and malodorants were produced from kitchen scraps owing to the occurrence of a gas/liquid distribution equilibrium, which implies that the liquid produced by the kitchen scraps contributed to the emission of a stronger malodor. Interestingly, sulfur compounds and esters were produced from the solid part of the kitchen scraps, and acetic acid, aldehyde, ammonia and amine were produced from the liquid part. The liquid part of the kitchen scraps after 16 days had a pH of 4.2 (acidic) for the 5℃ and 15℃ models ; however, it had a pH of 6.0 (neutral) for the 25℃ model.

Furthermore, the number of bacteria in the liquid part was significantly larger for the 25℃ model. Although it was found to be 1×10^6 (colony/mL) for the 5℃ model and 2×10^6 with the 15℃ model, it was 4×10^7 for the 25℃ model.

With the results obtained from this experiment, it is suggested that not only microbial degradation but also chemical factors highly contribute to the malodor emission from kitchen scraps. Also, it became clear that, considering energy conservation, keeping kitchen scraps at 15℃ would be the most efficient means of preventing malodor emission.

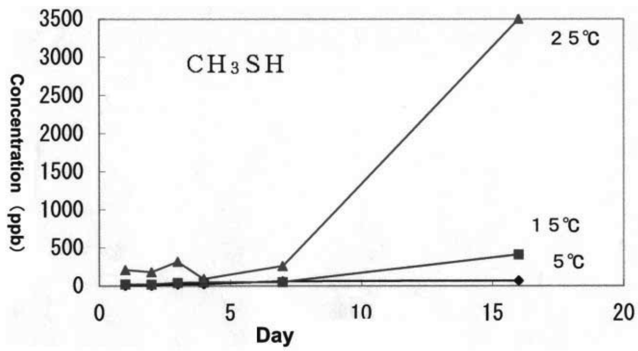

Fig. 4　Changes in the concentration of methyl mercaptane

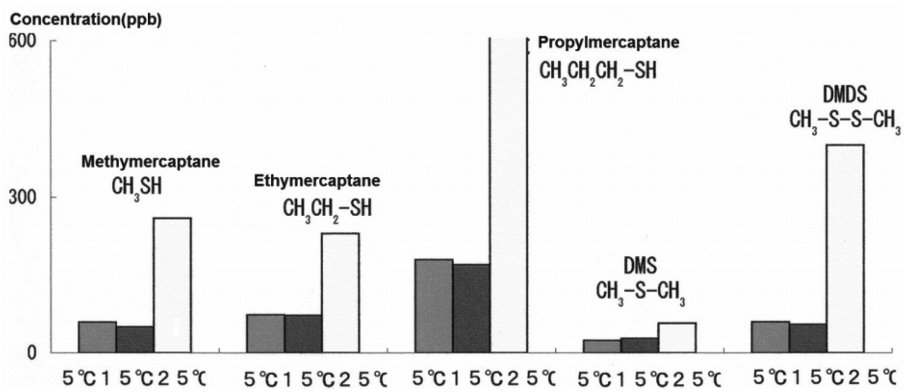

Fig. 5　Comparison of sulfur compounds concentration (after 7 days)

Controlling oxygen concentration and its effect on malodor emission

After first 2 days, the models with lower oxygen concentration, especially the 5% model, had lower level of malodorants but on the other hand, the 20% model had a strong malodorant after even one day; however, after about 4 days, all the models had stronger malodorants and there was no clear difference among the models (Fig. 6).

Materials in the models kept at 5%, 10%, 15% and 20% turned brown over time yet interestingly, the model of kitchen scraps kept at 0% oxygen concentration showed no change in its appearance even after 10 days (Fig. 7).

The amount of liquid observed in the container varied among the models and there was a clear correlation between the amount of liquid and the original oxygen concentration in the container: the most liquid was observed in the model started with 20% oxygen concentration. In organoleptic tests, acetic odor was recognized conspicuously and acetic acid was detected by GC analysis.

The model kept at 5% oxygen concentrations had lower malodorant level; however, after about 4 days, there was no clear difference among all the models. Considering energy conservation, in order to prevent the emission of malodorants from kitchen scraps, it is best to keep it at 15℃ with about 5% of oxygen concentration. With the results we obtained from this experiment, it is suggested

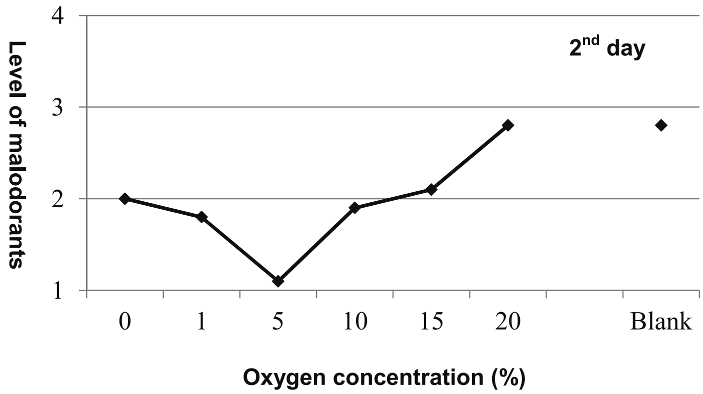

Fig. 6 Level of malodorants at various oxygen concentration

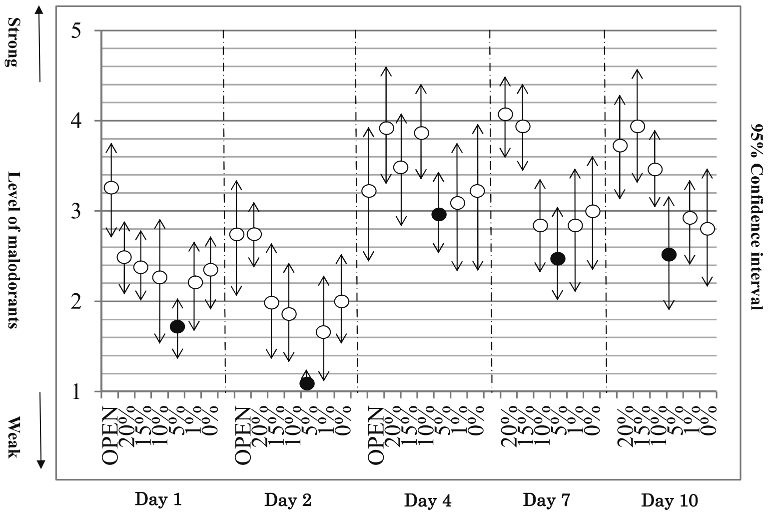

Fig. 7 Results of organoleptic tests

that not only microbe degradation but chemical factors may be contributing highly to the emission of malodorants from kitchen scraps.

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