DOI 10.5162/SMSI2020/P1.3

Smart gas sensor systems can help to reduce food waste

My Sa Marschibois[1], Tilman Sauerwald[1]*, Martin Leidinger[2], Thorsten Conrad[2], Andreas Schütze[1]
[1] Saarland University, Lab for Measurement Technology Saarbrücken, Germany
[2] 3S GmbH – Sensors · Signal processing · Systems, Saarbrücken, Germany
m.marschibois@lmt.uni-saarland.de

Summary:
Food waste in developed countries is an enormous ecological burden, while millions suffer from hunger around the globe. We are targeting novel smart gas sensor systems to reduce food waste mainly from end consumers. Preliminary GC/MS studies during aging of different foods show that typical emissions, e.g. hydrogen sulfide and methanethiol from minced meat, show characteristic compositions reflecting the aging process. This change in gas composition could be detected by low-cost sensor systems. We are planning a methodic study of different foods to identify and detect these patterns.

Keywords: food waste, gas chromatography/mass spectrometry (GC/MS), smart gas sensor, hydrogen sulfide, methanethiol.

Background, Motivation

Approximately a third of the global food production is wasted while approx. one billion people worldwide are suffering hunger. In Europe, mostly fruit and vegetables go to waste or are discarded during production. Around 50% of overall food waste is due to consumer behavior. Since food waste accounts for 3.5 billion tons of CO_2 emissions, it is also a huge burden for the environment. Against the backdrop of today's climate crisis, this is another reason to minimize food waste [1].

Low-cost gas sensor systems could help consumers reduce food waste. Different solutions seem possible, i.e. handheld devices for immediate analysis of dairy products after opening instead of relying on the "best before" date or continuous monitoring of the inside of a refrigerator (cf. FreshMeter technology by Grundig). Specific gas emissions could, e.g., help determine when specific foods should be consumed. These sensor solutions could therefore prevent disposing of edible food or spoilage of food during storage.

Materials and Method

During a preliminary study, food-specific gas patterns indicating aging or deterioration were detected using gas chromatography/mass spectrometry (GC/MS, Thermo Fischer scientific, Trace 13000 Gas Chromatograph, ISQ 7000 Single Quadrupole Mass Spectrometer). As a first example, minced meat was specifically chosen as it deteriorates quickly and thus allows fast experiments.

Minced meat was first stored in the refrigerator for one week at a temperature of 7°C. Subsequently, it was stored for three days at room temperature while gas samples were taken every 24 hours from the headspace of the vial containing a defined amount of meat. A Restek Rt-q-plot column (30 m length, Ø 0.32 mm, 10 µm film thickness) serves as a separating column. The GC oven's temperature profile was set as follows: Starting temperature at 40°C with a temperature increase of 10°C/min to 230°C final temperature, which is held for 10 min. The GC-oven's temperature cycle thus lasts 30 min.

Results

The GC/MS measurements indicate that hydrogen sulfide and methanethiol could be suitable target gases for indicating the deterioration of minced meat.

Hydrogen sulfide (H_2S) is detected from minced meat stored in a refrigerator without protective gas atmosphere at 7°C for one week, Fig. 1. The observed H_2S concentrations increases further for samples stored at room temperature and reaches its peak after 48 hours. Subsequently, a rapid drop of the H_2S concentrations is observed accompanied by an increase of the methanethiol concentration. After 72 hours at room temperature, the methanethiol concentration exceeds the maximum level for hydrogen sulfide reached after 48 hours, Fig. 2.

**currently at: Fraunhofer Institute for Process Engineering and Packaging IVV, Freising, Germany*

DOI 10.5162/SMSI2020/P1.3

This example shows that not only absolute gas concentrations but also changing ratios of various gases can be used to determine the level of aging or degradation of food. This is highly important as the concentration of a single target gas would also depend on the amount of food tested, ambient conditions and the specific measurement set-up, while gas mixture ratios might be more stable under real-life test conditions. Similarly, other target gases could be identified to determine fruit ripening.

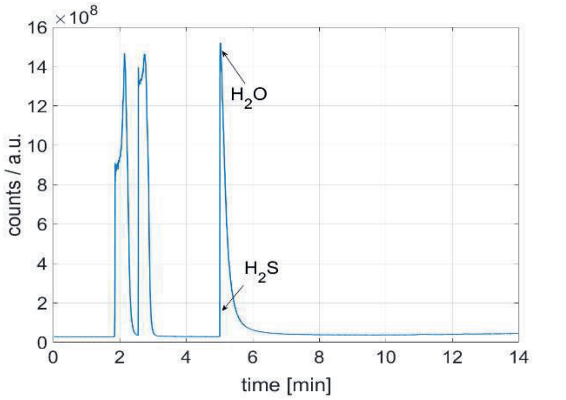

Fig. 1: Hydrogen sulfide emissions from minced meat stored in a refrigerator at 7°C for 1 week.

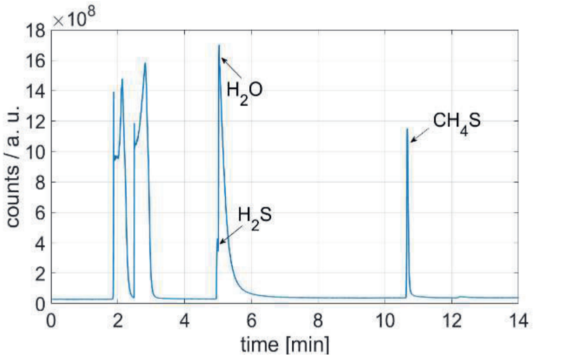

Fig. 2: Hydrogen sulfide concentrations emitted from minced meat decrease after storage at room temperature for 72 hours, while the amount of methanethiol increases rapidly.

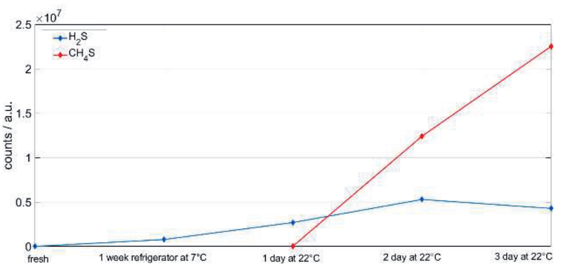

Fig. 3: Levels of hydrogen sulfide and methanethiol during the aging and deterioration of minced meat.

Outlook

Based on these observations, we are currently establishing a test set-up for multiple foods with multiple samples of each food to determine characteristic patterns during storage and aging. A large refrigerator is equipped with closed storage boxes containing different food samples. The storage boxes are connected to a valve block which allows sampling each headspace of the boxes individually. At defined intervals gas samples from the boxes are automatically analyzed by the GC/MS and in parallel by a multi gas sensor system supplied by the company 3S [2]. The gas sensor system contains two semiconductor gas sensors (UST series 1000 and 2000) which are operated using TCO (temperature cycled operation) [3].

Food to be tested include different fruits (banana, citrus fruits,…) and vegetables (tomatoes, potatoes,…).

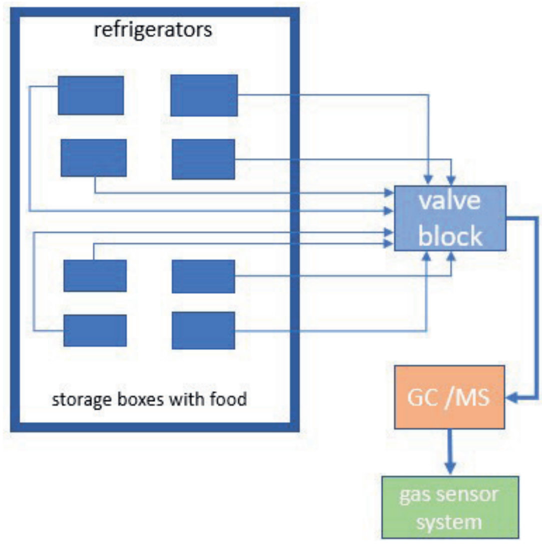

Fig. 4: Sketch of the test set-up with refrigerator with measuring unit, GC/MS and gas sensor system.

Acknowledgment

This work is sponsored by the DBU – Deutsche Bundesstiftung Umwelt in the frame of the project SiVERiS.

References

[1] „UN beklagen Umweltschäden durch verschwendete Lebensmittel", https://www.zeit.de/wissen/umwelt/2013-09/un-lebensmittel-verschwendung-umwelt

[2] 3S GmbH - Sensors, Signal Processing, Systems, www.3s-ing.de

[3] A. Kreiter, T. Sauerwald, A. Schütze, T. Conrad, Selective detection of (E)-hexenal in the sub-ppm range and of ethanol in the low-ppm range using semiconducting gas sensors with temperature cycled operation (TCO), SENSOR 2013 - 16th International Conference on Sensors and Measurement Technology, Nuremberg, Germany, May 14 - 16, 2013.