Quality control in the meat industry using gas sensor arrays

R. van Dijk, P. Sterrenburg and P.C. Moerman
TNO Nutrition and Food Research Institute
P.O. Box 360
3700 AJ Zeist - The Netherlands

Introduction
The application of gas sensor arrays is focussed on different areas in which there is a strong need for an objective and instrumental quality control method. One of these areas is measuring freshness/contamination of meat products.
Quality control of meat products is now being performed amongst others, by microbiological analyses and panel tests (smell/taste). A product can be rejected on basis of microbiological test results, on basis of panel test results or on both test results. In practice however, there is a discussion on products which are microbiological approved, but rejected on basis of sensory evaluation.
This can be the case in situations where a small amount of deteriorated meat is mixed with fresh meat. The part of the meat that is deteriorated has an off odour, but because of the dilution with fresh material no microbiological problem exists.

Methods
Equipment
Commercial samples of porksausages (raw pigmeat, spices and salt) were tested sensorically, microbiologically and the headspace of these samples were measured with a gas sensor array, integrated in the FOX 3000, provided by Alpha M.O.S. The sensor array consisted of twelve metal oxide sensors with different sensitivity to different groups of volatiles. Because of the different origin of the samples the amount and composition of the spices is different between the sausages.

Because of expected low concentrations of the compounds responsible for an "off odour", the configuration of the FOX 3000 was changed to a closed loop system by adding three additional valves (valves 2, 3 and 4 in figure 1). In the initial phase (purging the sensorroom) the valves are positioned in such a way (according to figure 1) that the conditioned air is flowing only through the sensorroom and then leaves the FOX through the outlet. In the second phase (purging the headspace) the valves 1 and 2 are switched 90° clockwise. In the third phase (measurementmode) valve 2 is turned back and valve 3 is turned 90° clockwise and valve 4 is turned 90° anti-clockwise. Furthermore a conditioning unit for the carrier gas, using purified air, was added. By adjusting the relative humidity (r.h.) of the conditioned air to a higher level than the r.h. in the headspace the influence of changes in relative humidity (r.h.) was minimized.

It should be noted that r.h. also has an influence on the measurement characteristics of the whole system, caused by interactions on the sample surface, during transport from sample headspace to the sensor array and on the sensor surface. In order to obtain reproducible results, the flowrate has to be relatively low (50 ml/min), especially with higher r.h.. A higher r.h. will increase the heat transfer of the air, especially in combination with a relatively high flowrate. This can cause a decrease in temperature of the sensor surface and as a result the sensor characteristic will be affected.

According to figure 1, at step one the sensor array is purged. Purging starts with a high flow rate (500 ml/min) for 10 minutes in order to speed up the diffusion process. After stabilization of the sensorvalues, the flow is decreased till 50 ml/min for another 10 minutes in order to allow the sensors to restore their temperaturelevel. At step two, with a flow of 50 ml/min the tubes and the headspace of the vial are purged (valve two is turned one step clockwise). Just after placing the sample in the vial, the headspace contains a sample of laboratory air. This step provides in eliminating environmental odours, inclosed during handling of the sample. At step three, the headspace is recirculated from the vial through the sensor room and back again by returning valve two to its initial state and by turning valve three one step clock wise and valve four one step anti clock wise. Measurement time (5 minutes) was determined by the stabilisation time of the sensor array.

Samples
From the sausages a sample of 50 grams was equally distributed on the bottom of the measurement vial. The samples were quickly conditioned at +25 °C by placing the vial in a temperature controlled waterbath.

Data processing and presentation.
The dataset was analysed with the internal FOX Statistics Software (V4.0b). 10 samples of each lineplot were taken in order to include the slope and Principle Component Analysis (PCA) was used to represent the results (figure 2).

Results
The results of the experiment are depicted in figure 2.

The FOX 3000, in the configuration used, distinguishes three areas:
1. Approved on the basis of microbiological criteria and by the panel (APPROV).
2. Rejected on the basis of microbiological criteria *or* by the panel (MICR OR SENS).
3. Rejected on the basis of microbiological criteria *and* by the panel (BOTH).

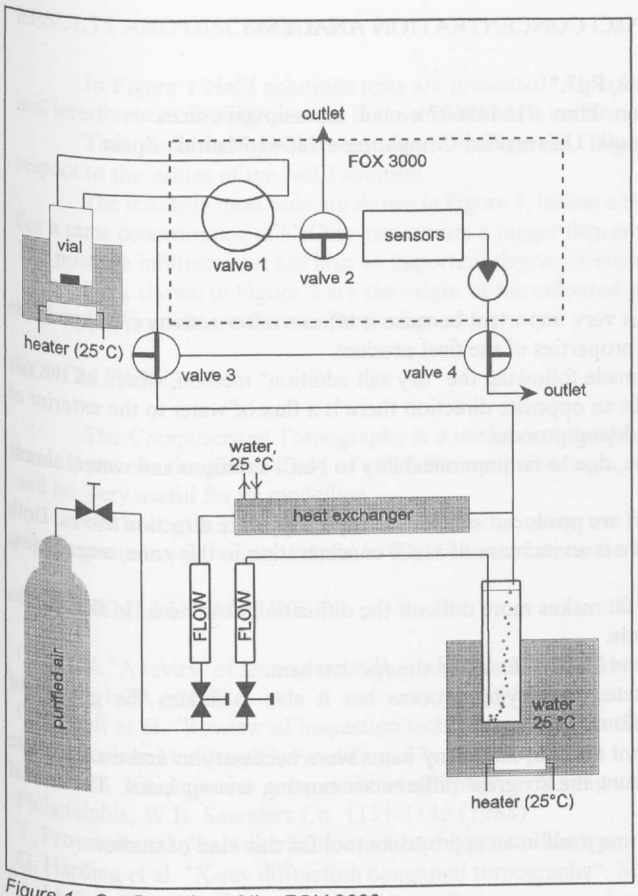

Figure 1. Configuration of the FOX 3000

Comparison of the FOX 3000 with a trained panel shows interesting results, but the discrimination is not yet optimal. However, by adding special sensors, tuned on certain compounds, the discrimination could be improved. These sensors can be obtained by coating of acoustic transducers like Bulk Acoustic Wave (BAW) or Surface Acoustic Wave (SAW) transducers with carefull selected, modified or developed materials like stationary GC-phases, lipids, polymers, cyclo-dextrines, etc..

Relevant to our findings it should be noted that a panel is never consistent and completely reliable. An extensive panel test might give results which are more consistent with the results of the FOX 3000.

Conclusions

It seems to be possible to use an electronic nose like the FOX 3000 with a standard sensor array for quantitative measurements of microbiological deterioration of meat. However, for practical applications it is necessary to tune the FOX 3000 on the specific application. This can be done by adding extra acoustic sensors with special coatings, use of filters, optimize temperature of the sample and the carrier gas, etc.

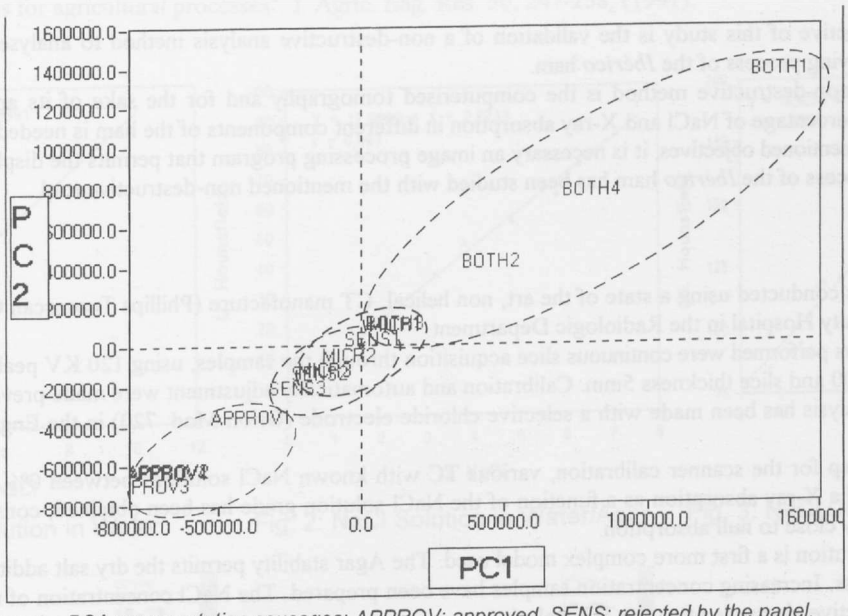

Figure 2. PCA representation sausages; APPROV: approved, SENS: rejected by the panel, MICR: microbiological rejected, BOTH: rejected by both

Literature

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