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Review Article

New Approach to Advanced Technique Used in Food Inspection

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Abstract

The Electronic noses are devices able to characterize and differentiate the aroma profiles of the various foods, especially the meat and the meat products. During the recent years advanced method the Electronic noses have been widely used in the food analysis and proved to provide a fast, simple, non expensive and non destructive method of the food assessment and quality control. The aim of this review article is to summarize the important characters of the analytic technique and to present basic fields and the typical areas of the Electronic nose use as well as the most commonly used sensor types and the patterns for the Electronic nose design. The Prospects for the future development of this technique are presented. The Methods and the researches may be a guideline for the practical Electronic nose use.

Key words: electronic nose; sensors; gas chromatography; odor.

Introduction:

The most important factors affecting freshness and quality of the poultry and the fish are the color, the texture and the flavor. The Meat flavor quality is determined by composition of the VOC as its critical factor. The factors must be qualified through the electronic nose in the same way as the human senses, because these modalities are the basis for the human perception of the freshness and quality. The odor of the meat is formed by a complex mixture of the different volatile organic compounds, originating from various reactions. It is often stated that the fresh meat is almost unscented and the only the odor that can be detected by the consumer is described as bloody. Within the storage or the thermal processes, the precursors of the aroma constituents undergo the oxidation and decomposition reactions leading to a number of products which can then react further providing the organic compounds of low molecular mass and usually these secondary products are responsible for the odor development (1,2,3,4,5,6 and 7). The characteristic aroma of the meat usually originates from the thermal processes like the cooking, the roasting or the frying. The Chemical reactions occurring during the heat treatment involve degradation of the amino acids, the peptides, the sugars, the ribonucleotides, the lipids and the vitamins. The key process in the aroma formation is Maillard reaction that occurs between reducing sugars and amino acids derivatives. The characteristic compounds for the cooked meat are the aldehydes, the ketones, the alcohols, the hydrocarbons, the pyrazine derivatives and the Sulphur compounds. A specific effect is the warmed over flavor (WOF), which develops during the storage in the meat after the cooking. It comes from the lipid oxidation induced by the iron released from the myoglobin and hemoglobin during the cooking. The unpleasant odor is described as the metallic, the musty and the pungent and the secondary oxidation products responsible for it are hexanal, 2,3-octanediol, pentanal, 2-pentylfurane and 2-octenal (8,9,10,11,12,13 and 14) Another process connected to the odor development apart from the heat treatment of the meat is spoilage. During the storage the bacterial activity leads to the production of the volatile organic compounds of the unpleasant odor, most of which are easily identifiable (the methanol, the ethanol, the dimethyl sulfide, the methyl thioacetate, the toluene, the nonane, the 2,3-butanediol and others). The Alcohols, the hydrocarbons, the aliphatic the ketones, the volatile acids and the benzenic compounds are the compounds typical for the physicochemical changes generated as a result of fat decomposition and the lipid oxidation. The aroma profile of the meat can be influenced by different factors like the fat content, the animal diet, the breed, the pH, the storage condition or the heat treatment method. This subject is still not fully explored despite of many discussions. Assessment of the meat freshness can be done by analysis of mixture of volatile organic compounds. The Classical methods of analysis of the meat aroma profile involve the gas chromatography (GC) and the olfactometry (O). The fusion of these two techniques, GC-O, combines the ability of the chromatographic unit to separate different compounds and the capability of the olfactometric system to characterize them (24,25,26,27,28,29,30,31 and 32). The chemical methods, the sensory descriptive analysis is still of great significance. The aroma profile is difficult to analyses and characterize in the laboratory since the human sense of the smell does not distinguish individual components but rather identifies the specific mixture of volatiles as a whole. The Classical methods of the chemical analysis based on the gas chromatography result in the identification and the quantification of the particular compounds which can be considered the most important odor indicators. Often the single compounds present in meaningful quantity in the aroma profile are not noticeable by the human sense of the smell. The practice shows that there is not always a simple correlation between the concentration of particular compounds and the odor perception. The Electronic noses are analytical instruments designed to mimic the work of the human sense of the smell. In this technique the analytic process does not concentrate on the identification and quantification of the components of the mixture of volatile compounds but rather on the quantitative description of the complete aroma profile, including the relationships between its components. In many researches the time change of the profile or the profile change in relation to standard profile is important. The volatile profile is a fingerprint typical for certain test. The most important issues are presented below (33,34,35,36,37,38,39,40 and 41). The standard Electronic noses equipment is based on a series of the gas sensors able to collect the chemical parameter coming from the headspace and to transmit it to the electronic devices. The Different types of sensors can be used for different applications, among them the most popular are electrochemical sensors like the metal oxide semiconductors (MOS) or the conducting polymers (CP) and the piezoelectric sensors like the quartz microbalances (QCM). The Optical, calorimetric and biosensors can be also incorporated into the Electronic noses system. Those innovative types of the advanced method Electronic noses based on the gas chromatography (GC) or gas chromatography with mass spectrometry (GC/MS) have been introduced recently and their high utility has been demonstrated. the detection each peak from a mass spectrum or a chromatogram acts as a “sensor” providing also information about the chemical structure of the corresponding compound. It is a standard to couple the Electronic nose with multivariate software equipped with the software tools for the chemometric interpretation of the sensor signals. The data collected from the sensors are analyzed using various statistical tools in order to create a numerical model of the aroma profile of the sample. When having a quantitative description of the aroma profile of the samples one can then compare the unknown samples with the reference materials or study the influence of different factors on the odor. The most effective statistical methods used in these types of investigation include principal component analysis (PCA), partial least squares regression (PLSR), The linear and canonical discriminant analysis (LDA and CDA) or the artificial neural networks (ANN). The Electronic noses are rather an unreliable tool for the determination of specific chemical compounds constituting the aroma profile, the advantages of this method over the traditional ones are conspicuous. The analyses are fast, simple and low cost, what makes the Electronic nose a gratifying analytical method for quality control applications. The Electronic nose requires specific and time consuming training for the staff. This review article aims to present diversity of types of the Electronic noses used for the evaluation of the meat and the meat products. The Prospects for the future development of this technique are presented. The Methods and the researches which discussed may be a guideline for the practical Electronic nose application (12, 13,14,15,16 and 17).

The Applications of the Electronic nose in the meat analysis

The Spoilage monitoring Traditional methods of the meat spoilage

The monitoring is based on measurements of chemical or biological spoilage indicators. The Standard tests include total bacterial count (TBC), rancidity measurements with thiobarbituric acid reactive substances assay (TBARS), determination of the VOCs by GC-MS and total volatile basic nitrogen (TVBN) measurements. The Colour evaluation and sensory descriptive analysis can be also useful in the detection of spoiled samples. The methods are rather costly, time consuming and require specialized staff, what makes them difficult for on line applications. The spoilage process is strongly connected with the odor changes, the most of studies investigate the possibilities of employing the Electronic nose to this purpose. The standard procedure in this type of the study involves choosing the storage conditions (the type of the packaging and the temperature), usually mimicking storage in typical household or industrial conditions and analyzing samples after different periods of time. The importance to ensure careful preparation of the samples in order to preserve the headspace composition during storage and analysis. The sensor types used for this purpose include mainly the metal oxide semiconductors or conducting polymers. During last years a few applications using colorimetric sensors could be noticed (81,82,83,84,85,86,87,88 and 89). The statistical tools employed for data analysis involve multivariate statistics and artificial neuron networks. The obtained results are then confronted with data from reference methods based on the microbiological evaluation, the sensory descriptive analysis or the chemical determination of the spoilage indicators. A number of fully successful attempts to employ the advanced method Electronic noses for the meat spoilage monitoring prove the utility of this analytic technique. The Electronic nose found application as a laboratory tool, yet no in industrial practice. The prospects of the method development involve further investigation of the value of information coming from particular sensors and constructing new portable instruments with reduced number of sensors in order to minimize costs and simplify the analysis (18, 19, 20, 21,22,23 and 24).

The Differentiation between types of the meat

The Animal nutrition has a potent influence on the meat quality. The Different types of dietary regimes can be applied for specific purposes, among them supplementation of functional ingredients such as vitamin E, selenium, conjugated linoleic acids or omega 3 fatty acids gained a special interest over last years. The Evaluation of the relationship between the animal diet and the meat attributes is an important feature. The investigation of the animal diet influence on overall the antioxidant power in the meat and its connection with the aroma profile. The Crossbreed steers were either live in pasture or feed on the grain and in both groups a part of the animals obtained an additional vitamin E supplementation. The Electronic nose with 32 conducting polymer sensors was used to analyze the aroma profile of the fresh beef samples from all the four groups. The Antioxidant capacity tests were also performed. The relationship between the Electronic nose data and the antioxidant status related variables was analyzed while the linear discriminant analysis of the Electronic nose measurements was employed to investigate the meat samples grouping as a function of feeding. The Electronic nose distinguished correctly grain and pasture produced meat as well as supplemented and non supplemented with vitamin E grain produced meat. These results show that the aroma profile of the meat is strongly related on the antioxidant status which affects the lipids oxidation influencing the consequent production of volatile short chained aldehydes. The Electronic nose proved therefore to be a useful tool to discriminate the aroma profile of the fresh meat samples with different antioxidant potential. The influence of the animal dietary regimes on the lipid oxidation can manifest in the change of volatile compounds profile of the meat and this effect was also investigated with the use of the Electronic noses. The pigs were divided into four feeding groups with the different diets: the control diet, the supplemental vitamin E and organic selenium diet, supplemental organic selenium diet and supplemental vitamin E diet. The samples were analyzed using the electronic nose equipped with ultrafast gas chromatograph with the flame ionization detectors. The Electronic nose data were analyzed by using the AroChemBase database and the ANOVA. The measurements performed by the Electronic nose showed that the addition of the antioxidants to the pigs feed prevented the formation of the Sulphur compounds in the raw meat. The electronic nose successfully allowed to determine seventeen specific volatile compounds in the supplemented meat (31,32,33,34,35 and 36).

The Production process monitoring

There are rather few examples in the literature of direct use of the Electronic nose for production process monitoring. The Electronic nose usedd to identify the spoiled Iberian hams during the curing process. They discussed use of the Electronic nose for recognition of different Iberian ham ripening times. The sensors with the tin oxide semiconductor thin films were used for the tests. The sensors were doped with metal catalysts. The PCA was used for results analysis together with artificial neural network. The Electronic nose can be applied to study dynamic processes occurring during production of sausages. The investigation of the seasoning processes for the dry cured meats was performed with an electronic nose containing 12 metal oxide sensors. The Fresh pork sausages were subjected to the manufacture's protocols and 5, 7, 10, 14 days seasoning. The Research included monitoring of presence of the ochratoxin A producing and non producing Penicillium strains during the seasoning process. The Food contamination with the ochratoxins is very dangerous for the humans and is considered as possibly carcinogenic by The International Agency for Research on Cancer in 1993. The Electronic noses data were analyzed using the DFA. The Proposed research technique was successfully applied for the rapid prediction of the ochratoxin A. These mentioned applications of the Electronic nose are satisfactory examples of successful use of the Electronic nose based systems for quality control (37,38,39,40,41,42 and 43).

The Specific purposes:

The boar taint and the WOF evaluation the Boar taint and the WOF are the sensory defects in the meat flavor. The Boar taint is characteristic for pork derived from the non castrated male pigs.

The boar taint is connected to the presence of the androstenone and the skatole but it was shown that the sensory evaluation of the 'boar taint' level does not always agree with the absolute concentrations of these two compounds. The need to the developing a system able to efficiently discriminate between the different intensities of the undesirable odor. The Used Electronic nose and sensory panel to measure the intensity of the boar taint in the entire male pigs. The electronic nose based on ion mobility spectrometry was employed to mimic the responses given by the sensory panel. The data from the Electronic noses analysis were calibrated using canonical correlation with the sensory measurement and a discriminant function for separating levels of the boar taint in the pork by the Electronic nose was developed . The Sensorics research affirmed stronger correlation of the boar taint with the androsterone than with the skatole. The research showed that the Electronic nose technique based on the ion mobility spectrometry may have a potential for a rapid sorting of boar fat at the slaughter line. The warmed over flavor develops in the meat which has been pre cooked, chill stored and reheated. The sensory analysis of volatile compounds on the meatballs derived from the pigs fed with standard diet supplemented with the addition of rapeseed and palm oil using solid state based gas sensor array system (the Electronic nose) and the gas chromatography/gas spectrometry together with measurements of the thiobarbituric acid reactive substances (TBARS). The Obtained data were analyzed using partial least square regression modelling (PLSR). The MOS sensor responses showed to be significantly related to WOF characteristics detected by both the sensory and the chemical analysis. This shows the potential of using gas sensor technology to monitor WOF in the pork. The simple and rapid method of prediction of WOF in the cooked chicken by colorimetric sensor array. The Data from colorimetric sensor array was classified using principal component analysis and hierarchical cluster analysis. The Research showed that colorimetric sensor array may be successfully used to predict WOF development in the cooked chicken meat (44,45,46,47,48 and 49).

Conclusions:

The electronic noses provide a fast, simple and non destructive method of the meat analysis. The Electronic noses were successfully employed mainly in the quality control of the meat being able to monitor spoilage or adulterations and the obtained results were in accordance with the sensory evaluation, offering a reliable tool for on line analysis. The ability of the Electronic nose to determine the antioxidant status of the meat samples was also proved. It can be stated that every factor that influences the aroma profile of the meat, could be potentially indirectly analyzed with the Electronic nose system and this field still seems to be insufficiently explored. The development of new types of advanced method Electronic noses, based on gas chromatography, opens new perspectives for analysis of the aroma profile of the meat. Despite of many scientific works proving usefulness of the Electronic nose based on different types of sensors or GC techniques for the meat quality appraisal or spoilage detection, use of the Electronic nose in industry practice is insufficient. There was not found any description or report on large scale industrial application of Electronic nose. Almost every paper describes potentially large possibilities of use of Electronic nose in industrial practice, but none reports real life implementation. This may be explained by sensor vulnerability (sensor time drift), relatively the high Electronic nose costs and effort consuming staff training. The above does not mean that the Electronic nose will not be used widely in future in industrial practice. There is still lack of effective application, although the potential of the Electronic nose approach was proven.

Conflicts of Interest:

The author declare no conflicts of interest

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