OVERVIEW PAPER

Analytical and sensory monitoring of food products – needs for achieving quality competence

Annan N.T.
Faculty of Agriculture, Dalhousie University, Truro, NS, B2N 5E3, Canada,
E-mail: Nana.Annan@Dal.ca

ABSTRACT

Analytical and sensory methods for monitoring foods are among the most essential tools needed to ensure food quality. Post harvest changes in food products result in changes in volatiles and flavours that are often associated with characteristics such as ripening, spoilage and storage. Food processing methods often help to provide intermediate products with limited shelf-life or finished products with much longer storage stability. The quality of foods after post-harvest is an important consideration in marketing and achieving food security.

INTRODUCTION

Fermented foods date as far back to 6000 BC and the civilization of the Fertile Crescent in the Middle East (Fox, 1993). The original primary purpose of fermenting foods has been to preserve them and the added effect, in most cases, is the development of a more desirable and organoleptically pleasing finished product. Fermented foods in Africa include beer in Ethiopia, sour dough bread and wines in the Sudan and sour dough porridges throughout south of the Sahara. The fermentation technologies are however, often small scale traditional processes that are unstandardized leading to wide variations in quality and short shelf-lives.

One way to evaluate and monitor the quality of fresh or fermented foods is to characterize the aroma profile of the food by identifying and quantifying the components that contribute to sensory properties using gas chromatography and ‘gc-sniffing’ techniques. A correlation between the instrumental and sensory methods serve as useful tools in standardizing food quality as well as determining spoilage thresholds of foods during storage. Targeting the key aroma components of foods helps in the determination of critical control points (CCP) for product specification monitoring under a Hazard Analytical Critical Control Points (HACCP) system.

Sensory monitoring in post-harvest management

Monitoring in post-harvest management involves sensory testing to evaluate product quality. Sensory evaluation is defined as a "scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, taste, touch and hearing" (Stone and Sidell, 1993). Controlling conditions to minimize bias is an important step in evoking sensory responses. Sensory responses can then be measured using quantifiable parameters such as grading scales or numerical scoring points. The quantified data responses must be evaluated statistically to find variation and then an interpretation of the statistical results provides the basis for drawing conclusions about a product. Interpretations are made based on the limitations of the study.

What is Product Quality? The quality of products can be defined based on quantifiable attributes or based on consumer needs, perceptions and expectations. Sensory monitoring using tools oriented mainly towards product quality often presents a bias towards more readily quantifiable attributes which do not always correlate with consumer expectations and market trends. Consumer-oriented product evaluation is important for predicting market response as well as measuring acceptability or inclination to purchase. The diversity in consumer groups such as culture and demographics are some of the undefined reasons for acceptability or rejection of products.

Shelf-life and food quality. Shelf-life quality and duration are the most important concerns in post-harvest management. A longer shelf-life and good appearance are essential for product-based quality. These factors however, tend to reduce the importance of other quality attributes such as flavour in post-harvest handling. Consumers are, however, found to be more oriented towards flavour and texture of foods and this emphasizes the need to incorporate consumer expectations in post-harvest handling (Shewfelt, 1999).

Food quality control. Quality standards must be defined in order to monitor products in sensory testing. Product conformity evaluation includes physical, chemical, microbiological, toxicological, nutritional and sensory methods. Consumers are driven first to appearance and texture, however, food flavour tends to be the most important factor for acceptance and inclination to purchase (Shewfelt, 1999).

Food flavour is an indicator of freshness, health safety and nutrition (Kader, 2001). Flavour quality is compositely influenced by sweetness, acidity, and aroma. These qualities can be monitored by measuring sugar, organic acids, phenolic acids and volatile compounds (Kader, 2001).

Analytical techniques in flavour analysis

Historically, food flavour analysis focused on identifying all compounds in the volatile fraction of a food. Recent studies have shown that only a small fraction of volatile compounds contribute to flavour or are considered flavour active. The majority of volatile compounds are detected using gas chromatographic methods, however, sniff detectors are essential for differentiating between odour-active and non-odour active components. Analysis of food flavour involves three major steps of isolation, characterization and quantification of volatile compounds. Sensory requirements must guide analytical testing and are powerful when used together. Isolation techniques for volatile compound analysis generally involve solvent extraction, steam distillation, supercritical fluid extraction and headspace extraction.

Liquid-liquid extraction, solvent distillation and extraction: Odours in extracts obtained by solvent extraction or distillation may be different from odours that are perceived when smelling (orthonasal) or chewing (retronasal). Highly volatile and important contributors to odour are often lost during solvent extraction, distillation and concentration methods.

Steam distillation: Simultaneous distillation extraction methods allow a high release of stable volatile compounds as well as the release of volatile compounds bound to the food matrix. Steam distillation methods can be described as simulating cooked aroma flavours. The cooking temperatures used however, result in the formation of artefacts and the degradation of compounds.

Headspace methods: Static or dynamic headspace methods help to detect highly volatile compounds. Adsorbent traps such as Solid Phase Micro-extraction (SPME) and tenax columns help to concentrate the often too low odour threshold samples.

Analysis of odours

The human nose is the most effective evaluator of odour and odour recognition is found to be dependent on memory and previous experience and is thus a subjective analytical tool. Instrumental methods such as the 'electronic nose' offer objectivity while gas chromatography-olfactometric techniques combine objective and subjective analysis.

Electronic nose: According to Gardner and Bartlett, (1994) the 'electronic nose is an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognizing simple or complex odours'. The electronic nose is programmed for specific odour testing and may not identify specific odours. It will however, identify groups of compounds. Character impact compounds are not differentiated by the 'electronic nose' unless programmed to detect them. One of the important areas of application of the electronic nose is in the food and environmental industry for monitoring air and food quality.

Gas-chromatography-Olfactometry (GC-O): Gas-Chromatography-Olfactometry also referred to as 'GC-sniffing' uses the human nose as detector by sniffing and recording the quality and potency of volatile compounds as they elute the column of a gas chromatograph. This combination of the subjective nose with the analytical gas chromatograph provides the means to identify compounds that contribute to odours. These compounds are referred to as 'character impact compounds'. The human nose can detect odour and flavour components at parts per trillion ranges. Analytical techniques are often not sensitive enough to detect such low thresholds.

Several factors influence the performance of humans on the gas chromatograph-olfactometric method. They include, fatigue and reduced alertness as eluting compounds are sniffed, interference from extra odours such as contact with smoke, food or perfumes before sniffing as well as differences in olfactory sensitivities between individuals. Comfort and the ability to sniff without being distracted are important for obtaining good olfactometric results from the gas chromatograph. The heat carrying compounds to the sniff detector or 'human nose' often causes the drying out of the nose. This can however, be mitigated by supplying humidified air as make-up carrier gas to deliver eluate to the nose. Repeated olfactometric analysis of the same sample by the same human evaluator can result in error of anticipation so that compounds are detected where they do not exist. Lack of concentration and differences in breathing cylces of individuals have been found to impact detection responses and results of the same sample (Hanaoka *et al.*, 2001). The efficiency of the human nose in detecting odour compounds is dependent on the ability of the gas chromatograph to effectively separate eluting compounds. Co-eluting peaks are not differentiated by 'gc-sniffing'.

Aroma and flavours in African fermented foods

Changes in aroma volatiles are associated with ripening, spoilage and storage. Food processing and preservation are essential in post-harvest management. An important food preservation tool that contributes the added effect of desirable organoleptic characteristics is fermentation. Fermented foods in Africa have a long history and were often not documented. Sour milk, the most documented, dates as far back as 1068 when frequent references were made by Arab authors (Odufa and Oyewole, 1998). In many African countries small scale fermentation technologies contribute to food safety, food security, and nutrition. However, a lack of standardization of processing techniques results in variations in quality which become limitations to product development, food security and health. Acquisition of the aroma profile of foods is a powerful way to monitor and standardize the quality of fermented foods.

The aroma profile provides a fingerprint for an odour in food products which characteristically have unique patterns of volatile compounds. By obtaining the aroma profile, qualitative and quantitative comparisons for different foods can be determined. Primary aromas are natural odours from raw materials and help to determine product authenticity based on geographical origin or the presence of adulteration. Secondary aromas, on the other hand, relate to odours from food production, processing and storage such as thermal processing, fermentation, chemical and microbiological processes, packaging, pesticides, food additives and pollutants. The aroma profiles obtained from secondary aromas are essential for control, monitoring and optimization of food processing and storage techniques. They also help in detection of changes in organoleptic quality and onset of spoilage in foods.

Food fermentation may be desirable or undesirable. Spontaneous fermentation of food substrates is uncontrolled and may lead to undesirable effects. Standardized fermentations result in consistent and desirable effects such as is observed in cheese and yoghurt. A total of 91 compounds were detected in 'kenkey' a cooked dumpling from spontaneously fermented maize dough using simultaneous distillation extraction methods (Annan *et al*. 2003a). Only 46 compounds were found to have an odour-impact by method of GC-sniffing. The dominant microorganisms in Ghanaian maize dough fermentation were isolated and cultured and used as starter cultures singly and in combinations to standardize the fermentation of Ghanaian fermented maize (Annan *et al*. 2003b & c). The standardized dough fermentations were subjected to sensory evaluation to compare acceptability with the traditional spontaneously fermented dough. Highest acceptability scores were obtained for samples fermented with all three combinations of yeast and lactic acid bacteria cultures while fermentations with only yeast starter cultures were least acceptable (Annan *et al.*, 2003c). The study demonstrated that spontaneous fermentations can be controlled and the aroma profile monitored to correlate with sensory acceptability.

CONCLUSIONS

Quality control programs require sensory panels, analytical techniques and computer technologies. Aroma profiling comprises all three factors. Human or sensory direction is however, essential for chemical and computer analytical monitoring of foods.

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