

Computers and the Internet in sensory quality control

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Abstract

Computer technology is changing rapidly as is the scope and use of the Internet. These tools are being applied to a broad range of quality control activities, including sensory evaluation. The main areas of impact of this technology are in test design, collection of data, tabulation, storage, statistical analysis and reporting of the data in real time over great distances. Effective quality systems can be constructed using anything from the simplest spreadsheet programs through to sophisticated integrated quality control systems operating over corporate networks. This article provides an overview of the tools that are available and discusses a specific case as an example of a starting point for computerizing sensory quality control. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Currently in the sensory analysis field, most research facilities have automated their collection of sensory data and have connected it to rapid statistical analysis accelerating the entire process. The reduction in cost of hardware and the widespread acceptance of personal computers has contributed to the growth of computerization. In addition, rapid turnaround has made sensory analysis a timely tool that can be used to make management decisions. However, we must remember that computers are merely tools, not a solution in themselves. Automation of accounting systems improved good accounting practices, but never created good accounting by itself. Computerizing sensory systems has had a similar effect. It is only when good sensory practices are in place that you can derive a benefit. We can say the same thing about sensory quality control.

2. The role of the Internet

To discuss how the Internet can be applied to sensory quality control we must first understand a little bit about how the worldwide web works. First, it is a global

system of computer connections that has become known as the information superhighway. At its simplest, the Internet is like the string that connects the two tin cans of a child's play telephone, a computer at each end and wire in between. Messages can be sent electronically to any other connected device on the planet. The routes that messages take as they move from server to server have become enormously complex. It is not unusual to have a message sent to the other side of the continent and return to a physical destination literally next door. At each relay point on the journey, the message is open to interception by a third party, raising great concerns over privacy.

The use of electronic mail, e-mail, has become universal. It is not perfect and not everyone has it, but access to e-mail has been growing at a dizzying pace. When it takes days or weeks to send conventional or "snail" mail, the immediacy of e-mail is stunning. Entire documents can be edited and developed by a team of contributing writers from all over the world. The documents are attached in a common file format that permits all users to work with the same document. This presents a convenient method for distribution of standard quality control documents and the movement of data between remote locations. It is unfortunate that many of the most aggravating computer viruses have been spread as e-mail attachments. As a result of this problem, Microsoft have released the current version of Outlook[®] that has a quarantine location for attach-

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ments and will not permit attachments of the types that can carry viruses. This may also prevent the distribution of self-executing programs that could be used for data collection.

Another aspect of the Internet is the web sites that are operated by thousands and thousands of organizations. No self-respecting company of any size can survive in a global economy without a web presence. Some are simple electronic billboards, advertising the wares of the site owner. Others are dynamic and interactive, permitting interaction and downloads. The cable television and telephone companies have created a bidding war for the consumer marketplace, making it easy to acquire and connect to the web. The speed of connections has increased in leaps and bounds to the point where web television is now a reality. This brings the Internet right into the living rooms of the world. This increased rate of data transfer, or bandwidth, is an enabling technology. Many applications can be run on remote servers from local computers that are essentially terminals. This reduces the cost for each workstation but increases the network dependency. Like so many aspects of the computing world, it is difficult to find a benefit that does not have commensurate risk attached. It is an aspect of the constant battle between efficiency and simplicity on one side and complexity and comprehensiveness on the other. Simple systems are usually inflexible, because they are limited. Comprehensive systems are complex and require more maintenance and learning to operate. To make matters worse, the environment of computing is changing constantly.

The only way to make sense of using computerized methods is to identify the tasks that we want done and understand what a software program can do to either save time, reduce cost or provide value-added information. A list of a dozen functions that software can provide for sensory quality control may be found in Table 1. Almost all of these functions can be successfully implemented over the Internet. However, cost and security issues make most of them more practical on an intranet,

local area network, or even on stand-alone desktop computers. Most of these items are self-explanatory and encompass four types of software applications: spreadsheets, databases, statistical analysis programs and communications. Combinations of these four may accomplish the more sophisticated tasks (Fig. 1; these applications are discussed further below).

The simplest and most profound computer application for quality control is the electronic spreadsheet. These pieces of software are ubiquitous. The Microsoft[®] Excel program dominates this market, but Lotus[®] and others have remained strong suppliers of similar product functionality. The ability to create a record of responses by product, to accumulate data over time and to analyze the data for trends and report the results graphically is almost intuitive. For anyone with a science education, the spreadsheets allow step by step inspection of all mathematics. It is easy, even for a neophyte, to create a template into which new data is entered and the results are automatically calculated and charted. For anyone who has delved deeper into the use of spreadsheets, it is relatively simple to create macros that will perform multiple steps in calculation and reporting. For any completely repetitive task, this level of computation is more than sufficient. The next step up is the use of a database program that prompts the user to enter the data, then has the ability to perform a range of reports based upon information in the database. There are many user-friendly desktop programs on the market. Microsoft Access[®] is very easy to connect to an Excel spreadsheet, so that it is possible to move older data from spreadsheets into the database. It is also easy to send database output to the spreadsheet for analysis and graphing.

Table 1
Functions of computers in quality control systems

1	Tabulate information and collect data
2	Perform routine calculations
3	Graph data and produce routine control charts
4	Run statistical analysis and analyze trends
5	Maintain historical records in a database
6	Permit electronic communications by network or Internet
7	Feedback quality data to adjust manufacturing conditions
8	Monitor the training of judges
9	Provide a framework for standardization of procedures and documents
10	Operate a laboratory management information system (LIMS)
11	Provide a web site for customer complaints
12	Correlate with instrumental measures and process variables

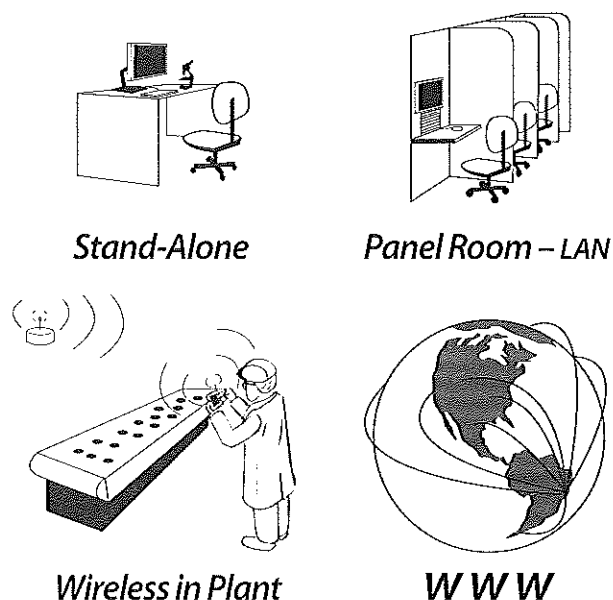


Fig. 1. Configurations for computer systems for quality control.

Statistical programs are widely available and even come as web-based applications. A search of the Internet or consultation with the sensory E-groups will help most users find a suitable choice (sensory@yahoogroups.com).

The software for communications is usually a corporate decision and the functionality of the product chosen dictates the tasks that can be performed. E-mail programs that maintain calendars and group scheduling are very powerful. Lotus Notes[®] and Outlook[®] both have great GroupWare capability. However, to implement these systems is a major endeavour that goes far beyond the scope of this review.

3. What software is commercially available?

The Internet is a reality, and consequently there are many applications that have been developed to utilize its strengths. Although there are no specific tools that have yet been built for sensory quality control using the Internet, there are many programs for quality that are web-based. The following products are reported here with no intention of endorsement or critical evaluation. The field is changing so rapidly that new products are being introduced and old ones becoming obsolete almost daily. Web addresses have been included and a Google[®] search is recommended if you wish to pursue software system information.

There are two general comments that are useful to help the potential user ask the right questions. It is typical that the applications that are inexpensive or are “freeware” either are so limited in their features that they are not very useful, or they have poor documentation and require a full time computer programmer to implement and operate. The expensive applications are well documented and are frequently customized to meet end user specifications. Since all software requires maintenance and updating, the task can become very expensive and difficult over time. Many companies produce an “in-house” solution. These programs are usually purpose built by internal IT programmers or contractors. They operate well as long as the original programmer is around to make the changes needed to keep the system operating. If the individual leaves, there is usually a void left in the organization that makes system maintenance untenable. So it is important for potential end users to ask the questions “Who will maintain this system?” “Who is responsible for its routine upkeep?” and finally “How will the system be upgraded in the future?”

WebSPC[®] is a secure web application designed to share statistical process control information across the Internet. This program relies on a central installation of another SQL database application that accumulates data from a wide array of inputs. Primarily designed for the manufacturing industries the main advantage of this system is that it permits remote locations, suppliers,

customers and plants to have controlled access to a consistent data source. It also encourages standardization of reporting that makes interpretation of results and corrective action easy (<http://www.hertzler.com>).

QualTrend[®] is positioned as a plant floor portal that lets users get at any quality data from diverse locations. The software is designed to transform critical data into key performance indicators that can be updated and distributed automatically. Production from several plants can be compared and controlled simultaneously. Confidential reports can be e-mailed and incidents can be responded to in real-time through pager notification (<http://www.winspc.com>).

NWA Quality Analyst Web server provides statistical quality control data through standard web browsers. A wide range of users may view the SQC charts since the content is tailored for each end user’s need. The data remains secure while the information is provided in a timely and useful manner. This system also relies on the data being entered into its database from other systems. Typically, the Quality Analyst gets its information from a laboratory information management system (LIMS) and a manufacturing computer system and processes the data into several tiers of reports which it makes available through the web site (<http://www.nwasoft.com>).

Quality Navigator (QN) is an integrated suite of programs that attempt to address the entire quality chain. Included in the QN is a vendor monitoring system that tracks raw material supplies that also addresses the reliability of each supplier. This way, the level of monitoring can be reduced for consistent suppliers but increased sampling applied to new or less reliable suppliers. The Inspection System maintains all the on-line documents and forms related to the product test protocol. Results can be used immediately for feedback to the plant floor. The specifications can be customized to fit individual needs. Data input can be achieved manually, by bar code or directly from a LIMS system. The Internet can be used to integrate the supplier’s results directly into the system. This way, incoming materials can be simply monitored for compliance to confirm supplier data. In addition to all of the usual SQC reports, this system allows complete tracing of all products back to their ingredients. Systems like this are very comprehensive and have tools that address non-conformance management and customer complaints and actions. The ability to respond to customer complaints is an essential verification of any quality control system. For sensory quality control, it is important to anchor our standards on consumer evaluations. The feedback from customers is an excellent tool for validating the meaningfulness of the sensory standards. This entire system is web enabled and consequently makes the communication across the supply chain quite economical. Suppliers can be using the same system for their own tests. It is clearly in the interest of both parties

to have products that meet specification. By the use of the Internet, virtually any enterprise in the world can be given access to this type of system (<http://www.guardess.com>).

Statware provides a web-based product Statit® e-QC for performing SQC functions over the Internet. This application gives the user the ability to customize the type of analysis and reporting they need. The application has the ability to acquire data from any spreadsheet, database, or web site, through any network portal. It can monitor the data sources and update reports automatically, providing data reporting almost in real time. The ability to publish web forms and accept queries from browsers makes the system easy to implement and operate. This class of Internet tools is designed for larger organizations that have the infrastructure in place to get the benefits from it (<http://www.statware.com>).

ENet SPC offers a more user friendly statistical process control program. This web-based program allows users to perform real-time analysis on line, rather than viewing static report views. Each user gains entry through a password system and has access to a predetermined set of data and tools. So suppliers, customers and a range of functions within the company can all use the same system. The program is menu driven, making it relatively easy to program. Like all software applications, it helps to have an administrator who is highly skilled in web management (<http://www.qa-inc.com>).

4. Development of a sensory quality program

Before discussing an example of computerization, it is essential to define the process that should be followed to establish a sensory quality program. There have been several excellent publications that address sensory quality including the landmark publication of Munoz, Civile, and Carr (1992) and the textbook chapter by Lawless and Heymann (1998). They share a similar systematic approach and provide a set of guidelines that establish good standards of practice for sensory quality control. There are several excellent examples of the application of these principles in other articles in this Special Issue of *Food Quality and Preference*. It's easy to make a list of steps that are generic and even somewhat academic, but how do we put sensory quality control into practice? A presentation by Marianne Gillette and Jacqueline Beckley at the Institute of Food Science meeting in New Orleans in 1992 (Gillette & Beckley, 1992) emphasized the practical aspects of In-Plant Sensory Quality Assurance. The details of the proposed requirements are listed in another article in this journal (King, Gillette, Titman, Adams, & Ridgely, 2002). It is clear that they recognized that for a sensory quality program to work at the plant level it must, in addition to meeting the sensory objectives, be acceptable to the management of the

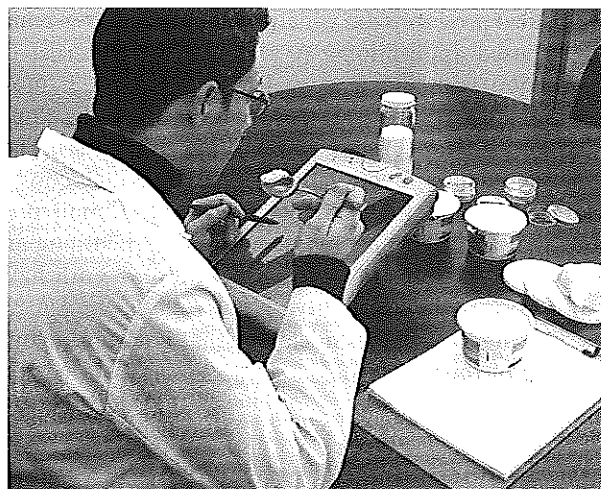


Fig. 2. Collecting sensory quality control data over a wireless tablet computer.

company and its suppliers. Their practical approach was also extended to a list of additional desirable features. Many of these points are of key strategic importance in planning the implementation and extension of a basic sensory QC program into other areas of quality. In particular, the ability to relate to other QC methods, transfer to an instrumental method (Weller & Stanton, 2002) and permit on-line corrections are the cost saving activities that make the program self funding.

5. Implementing a sensory qc system

Although it's easy to agree that any company needs a sensory quality program, where do you start? You can go to the literature and research what others have published and then try to develop your own approach. This Special Issue of *Food Quality and Preference* contains several excellent case studies that serve as good starting points (Pecore & Keeler, 2001; King et al., 2002; Weller & Stanton, 2002).

A Sensory Quality Assessment system was developed in the United Kingdom by the Campden Chorleywood Food Research Association (CCFRA) to enable suppliers and retailers to develop a standard, objective approach to product sensory quality measurement. Their training course is intended to develop an objective approach to product quality measurement using the human senses, to understand how to achieve valid sensory information and to practice setting up the quality attribute scoring system. Over the last 3 years, both CCFRA and the Leatherhead Food Research Association have trained hundreds of companies, both large and small, how to develop sensory quality systems tailored to their needs. Since the training program provides the framework it is up to the company to work with its customers to implement a system that monitors

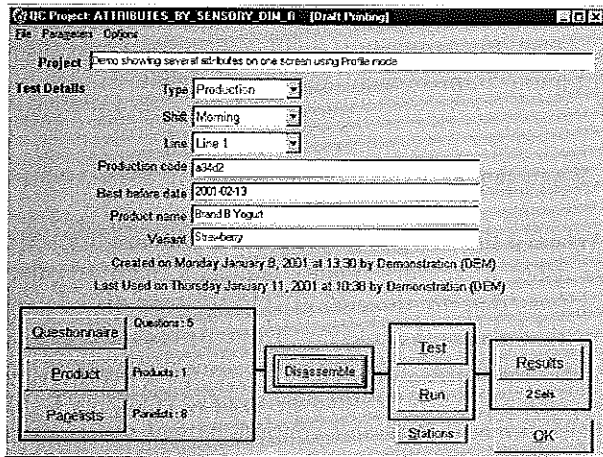


Fig. 3. The project design screen for sensory quality assessment scoring.

results and provides a method for measuring improvement and compliance. It is very much in the interests of both parties to have sensory standards that are meaningful and achievable. That way, the customer gets what their consumers want and the manufacturer can be confident that they are producing the right product.

6. An example of a computerized sensory quality control system

A collaborative project between CCFRA and Compusense has resulted in the development of a quality control software system. Using the wealth of practical knowledge CCFRA had accumulated in sensory quality, Compusense created a general solution that can automate the sensory quality control process. Compusense[®] QC (2001) allows users to perform sensory quality control on products using trained QC assessors (Fig. 2). The main Compusense[®] QC software can be installed and run from a network server, although it also works on a stand-alone computer. Each QC project contains one product with a set of attributes related to that product, and ranges specifically defined to characterize the target quality of each attribute. Since the quality control process involves repeated testing instances of the same product, it is necessary to first create a project template for each product type. This template includes the questionnaire, product, panelists and quality ranges for each attribute. When all results are collected, the data is analyzed, and a QC grade is determined for each attribute according to a pre-set quality target range. Quality ranges are set when the project is made. The branching option helps to further qualify an attribute such as an off-flavor or defect. If the panelist scores the attribute in an unacceptable range, they can automatically be presented with a comment question in which they provide further description, or a multiple choice question in

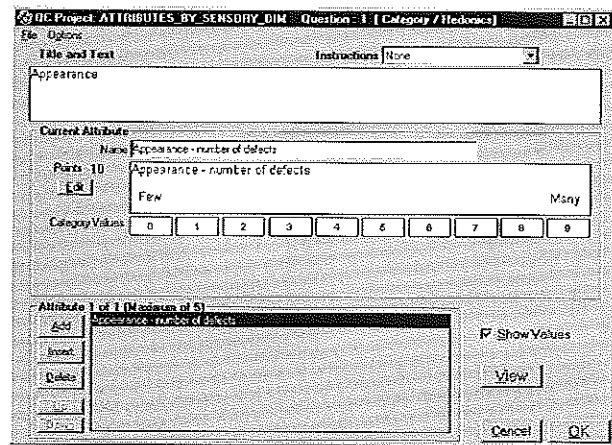


Fig. 4. Designing an attribute question.

which they select a descriptive term from a list or lexicon. The main task of Compusense[®] QC is to analyze the panelist data according to the defined quality ranges, and render a quality decision or grade for each attribute. The QC Manager's role is to review the individual attribute grades, evaluate which attribute grades have more weight in the overall product quality and enter an overall QC decision for the product.

The main project window shows the workflow that is followed to create and run a project (Fig. 3). All of the pertinent data about the product is entered on the main screen. Then the remaining steps are in a logical progression. A questionnaire is created to collect QC data that may be branched to additional comment or multiple-choice questions to further qualify specific product attributes. (Fig. 4). Product and judge information is obtained from their respective databases. The project is assembled and quality ranges are set for each attribute (Fig. 5). The range may be set as a target value (green), acceptable (amber) or unacceptable (red). The questionnaire is presented to panelists over the network or on non-networked data collection stations. The panelist is not made aware of the range settings and simply scores the attribute on the scale. In this manner, the same scale may serve for products that have quite different targets. Once the test is finished the results are provided in a formatted report. This report charts attributes, ranges, panelist scores, an attribute consensus (median) score, attribute grade, panelist grade and panelist distance from target. The Summary Report provides an alternative format that does not show individual panelist scores and grades (Fig. 6). The data can be exported to other programs. Finally, a decision to Pass, Hold/Retest or Fail the batch is recorded. The ultimate decision to release a product is a business one. This system assures that the data collected for each of the attributes by each of the panelists is kept as a record of the sensory evaluation.

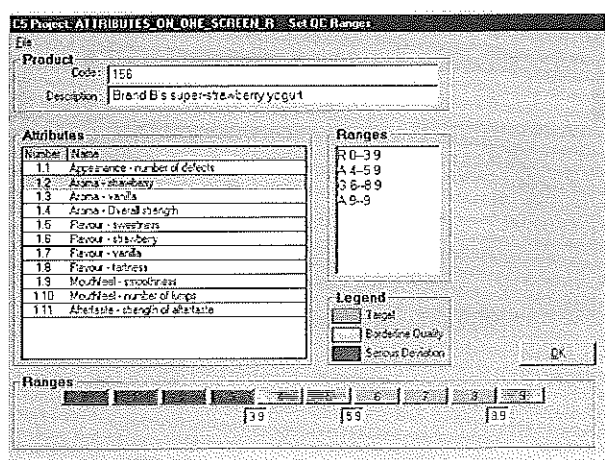


Fig. 5. Setting the target range for specific attributes for sensory quality assessment scoring.

Summary Report

Project: REPORT_EXAMPLE

Product Details

Product Code	155
Product Description	Brand B's super-strawberry yogurt

Test Details

Type	Production
Shift	Morning
Line	Line 1
Product Code	33329
Production Date	2001-02-13
Product Name	Brand B Yogurt
Variety	Strawberry

Results [Summary Report] (5 Panelists)

Attribute Number	Range	Range 2	Range 3	Range 4	Range 5	Consensus	Grade	Panelists on Target	Panelists on Amber	Panelists on Red	Total
STRAWBERRY AROMA											
1	R 0-3.9	A 4-6.9	G 7-9			7	G	3	2	0	5
SWEETNESS											
2.1	R 0-1.9	A 2-3.9	G 4-5.9	A 6-7.9	R 8-9	4	G	3	2	0	5
STRAWBERRY AFTERTASTE											
2.2	G 0-2.9	A 3-5.9	R 6-9			3	A	2	3	0	5

Annotations: Median of panelist, Quality range result, # panelists scoring attribute in green range.

Fig. 6. An example of a sensory quality control report.

Table 2
Future development on the Internet^a

1	Short range wireless voice/data—Wireless LAN within a facility with security
2	Voice recognition—the now power exists
3	Background Internet—e-devices—Virtual Private Networking
4	Unique Com number—voice/data/net
5	Continuous real time connection
6	Multiple dedicated devices—e-appliances
7	Enforcement of Privacy Legislation for the Web
8	E-tags replace address system—unique chips will be recognized—device to device

^a From *Exchange Magazine* (2000).

The data from individual batches are accumulated in a database to be able to analyze trends over time. Any tendency to drift may be tracked. It is also easy to track the proficiency of our panelists by submitting blind calibration samples that are either known defects or are gold standard products. The information on the panelists can be used to improve training and determine any limitations they might experience. This system is efficient,

economical and may be implemented in stages. It may be scaled for large and small enterprises and allows continuous improvement and development.

7. What can we expect in the future?

Where is the web going in the future and how does all of this relate to sensory quality control? There are many initiatives that are directed at solving some of the problems that plague the Internet. Table 2 presents a number of the anticipated changes in the way the Internet and e-devices will work. Of greatest significance to us are the wireless units that permit continuous real time connections. These new devices will have secure communication and unique identification. The results of our sensory assessments will be part of the data flow that controls manufacturing processes. These systems will be able to run sophisticated software in an easy to use environment. Since they will be inexpensive, all of our personnel will be able to use them. The increased bandwidth available in digital communications, including wireless, has led to the ability to run applications from the same server across a continent and even globally. The good news is that with rapid communication, security and powerful new computing devices the software developed for internal uses, like Compusense[®] QC, can now be used over the Internet. For those concerned with reliability of connections and stability of networks, new software is available that permits on-line communications and off-line operation. So if the connection cannot be continuous, there will be no difficulty in routine operation. The future looks very exciting. There are very few barriers to companies implementing global systems and having the ability to maintain sensory quality control systems at the same level universally.

References

- Compusense[®] QC. (2001). Compusense Inc. Guelph, Ontario, Canada.
- Exchange magazine for business*. (2000). Volume 17, No 6. November/December 2000.
- Gillette, M. H., & Beckley, J. H. (1992). In-plant sensory quality assurance. Paper presented at the Annual Meeting, Institute of Food Technologists, New Orleans, LA, June 1992.
- King, S., Gillette, M., Titman, D., Adams, J., & Ridgely, M. (2002). The sensory quality system: a global quality control solution. *Food Quality and Preference Special Issue: Sensory Evaluation in Quality Control* (submitted for publication).
- Lawless, H. T., & Heymann, H. (1998). *Sensory evaluation of food: principles and practices*. Aspen Publishing.
- Munoz, A. M., Civeille G. V., & Carr B.T. (1992). *Sensory evaluation in quality control*. Van Nostrand.
- Pecore, S. & Keeler, L. (2002). A consumer-focused QC/sensory program in the food industry. *Food Quality and Preference Special Issue: Sensory Evaluation in Quality Control* (submitted for publication).
- Weller, J. N. & Stanton, K. J. (2002). The establishment and use of a QC/analytical/descriptive/consumer measurement model for the routine evaluation of products at manufacturing facilities. *Food Quality and Preference Special Issue: Sensory Evaluation in Quality Control* (submitted for publication).