THE ROLE OF SENSORY ANALYSIS IN QUALITY CONTROL

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Foreword

This publication on the sensory evaluation function within manufacturing quality assurance/quality control (QA/QC) programs was sponsored by ASTM Subcommittee E18.07, a subcommittee on Quality Assurance, of ASTM Committee E-18 on Sensory Evaluation of Materials and Products. The scope of the subcommittee was to identify and recommend procedures for using sensory analysis in QA/QC functions.

Many people have contributed ideas for this manual from their actual work experience. Sensory programs vary with the diversity of products, size, and needs of individual plants and companies. Because there are few "standard procedures" for sensory testing in QC programs, the information presented in this document is intended to be used as reference material for developing sensory test programs appropriate to the ideas and needs of individual QC groups. Supplemental references related to QA procedures and sensory methods are listed in the bibliography.

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Related ASTM Publications

Manual of Sensory Testing Methods, STP 434 (1968), 04-434000-36

Guidelines for the Selection and Training of Sensory Panel Members, STP 758 (1981), 04-758000-30

Physical Requirement Guidelines for Sensory Evaluation Laboratories, STP 913 (1986), 04-9130001-36

ASTM Manual on Presentation of Data and Control Chart Analysis, MNL 7 (1990), 28-007089-34

Preface

This manual on *The Role of Sensory Analysis in Quality Control* describes general procedures and gives background information regarding the use of sensory testing as part of a quality control function in a manufacturing plant. Chapters 2 through 4 are intended to help those readers who are new to the sensory field, with a need for background material on establishing sensory testing in a plant. Those experienced with plant quality control may wish to go directly to Chapter 5 for sensory testing applications.

TERMINOLOGY AND DEFINITIONS USED IN THIS PUBLICATION

1. *Quality Assurance*—All those planned or systematic actions necessary to provide adequate confidence that a product or a service will satisfy given needs [*1*].

   Discussion

   - As a function of corporate management, quality assurance sets the policies, systems, programs, and procedures to be carried out by quality control.
   - Quality assurance defines the function of quality control and its programs and procedures.
   - Historically, quality control has permitted certain percent defectives. QA aims at achieving lower defect levels.

2. *Quality Control*—The operational techniques and the activities that sustain quality of product or a service that will satisfy given needs; also the use of such techniques and activities [*2*].

   Discussion

   - Quality control, as a function closely aligned to the manufacturing process, implements the quality specifications for raw materials, intermediate products and finished products as established by quality assurance.

3. *Sensory Evaluation*—The analysis of a substance(s) through the use of any or all of the senses [*3*]. A scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing.

   Discussion

   - Sensory evaluation measures perceived product characteristics, using one or more people as measuring devices.

REFERENCES

[1] ANSI/ASQC Standard A3–1978, American National Standards Institute, Inc., 1430 Broadway, New York.
[2] American Society for Quality Control, 230 W. Wells St., Milwaukee, WI.
[3] "Minutes of Sensory Evaluation Division Business Meeting at 35th Annual Meeting," Institute of Food Technologists, Chicago, IL, 1975.

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INTRODUCTION

Consumers are becoming more aware of taste as well as nutritional qualities of the foods they consume. As a result, perceived quality has had a growing influence on product marketing in recent years. The responsibility for creating highly acceptable flavorful foods is being transferred from the person doing the meal planning to the manufacturer of the food, as more prepared microwavable meals become available. The person doing the cooking is now part food preparer and part purchasing agent for the family meals.

Branded food and personal care products are often differentiated on the basis of certain sensory product characteristics, and these characteristics may determine whether or not a product is repurchased. Extensive and expensive market research and consumer testing is sometimes conducted before introducing a new product on the market. Predictions of market share are based on the acceptance results of the product that was tested. All of these factors make it is easy to understand why maintaining key product characteristics of manufactured products has been gaining in importance in the past few years. As a result, finished product specifications may now or may in the future include sensory characteristics in addition to chemical and physical measurements.

The quality assurance (QA), marketing, and research and development (R&D) groups in most successful companies know the sensory characteristics of their products. They also know which of these characteristics are important to their customers. Key product characteristics are usually identified during the development, testing and marketing of a new product. With the increased emphasis on knowing customers' wants and needs, defining the important characteristics of manufactured products is an ever growing responsibility of management, marketing, market research, and R&D.

Once these characteristics have been established, they must be maintained. The maintenance of product quality and uniformity is the responsibility of the quality assurance/quality control (QA/QC) groups within a company. These groups have mainly dealt with physical or chemical testing or with product safety in the past. The idea of tasting or smelling incoming ingredients, intermediates, and finished products is relatively new to manufacturing quality control. The idea of using procedures for measuring perceptions by human subjects may also be foreign to people accustomed to chemical or physical testing. Once these hurdles are overcome, the value of sensory testing in a QC program can be appreciated by the QC manager.

The sensory testing part of a QA/QC program will vary with the manufacturing process. It might cover only incoming and stored raw materials. It might also include in-process and finished goods. Like any other objective physical or chemical measurement, it can be useful

in identifying problem areas and averting or coping with product recalls. It can also contribute to profitability by avoiding manufacturing costs of products in which off-flavored, or otherwise unacceptable raw materials, are used.

This manual is intended for use in planning and implementing a plant sensory analysis program oriented to providing data appropriate for QA/QC applications. It is not intended to be a sensory methods or statistics manual. Rather it is a guide to adapting sensory methods to every day quality control situations. Procedures that might be appropriate for a large manufacturing facility producing the same product for weeks or months on end will be quite different from procedures used by small plants making short runs of multiple products.

Information on starting a sensory program where one does not exist is presented in Chapters 2 through 5. Chapters 6 through 8 contain information for the reader that already has a sensory test program that only needs reorientation so numeric data become part of the QC format.

PROGRAM OBJECTIVE

The primary objective of a sensory program included as part of the QA/QC function should be to measure the degree of conformance of sensory characteristics of products to target sensory specifications or quality standards. In other words, how does the product meet the company expectations with respect to sensory qualities?

A secondary objective of a sensory program included as a part of some QC programs might be to assist in total quality management (TQM) programs, so that products in nonconformance can be detected in-process, not as finished products. Along with the TQM programs, the sensory group may also participate in product trouble shooting.

BASIS OF A SENSORY PROGRAM FOR QA/QC WORK

An effective sensory program for QA/QC work in manufacturing plants should be based upon the following:

1. Sampling programs and test procedures that are cost effective, feasible within personnel and time constraints, and integrated with other QC sampling.
2. Test methods that measure critical product attributes and provide results that can be presented in a QC format.
3. Product attributes identified in well-written, clear sensory specifications.
4. A clear understanding of the product attributes by the personnel testing them.

Note the emphasis on the word "attribute." Using product attributes and having attribute target levels identified takes the sensory quality test program out of the realm of subjectivity to judging whether the product is "good" or "bad." It is important to position sensory testing for QC as an objective scientific measurement, similar to moisture or sugar analysis, with appropriate care taken in performing the test.

The sensory test program should provide actionable sensory test results presented in an easily understood format, reported in conjunction with other QC analyses and production data if possible. The test results may or may not have statistical support, depending on the test program, size of the plant, and decisions made with the results.

There are often two levels of sensory evaluation in a plant situation, especially when

online evaluations are conducted. Online evaluations are usually done by one or more people who have been trained to look for key product characteristics and are familiar with the product because they see it on a daily basis. This online evaluation is a "safety net" resulting in a similar to target, OK/not OK, place on hold, or reject type of decision.

When a product is placed on hold, there are more decisions to be made. Quite likely, it will be looked at by a larger group of people. If the problem involves a large quantity of product, or even a small quantity of high-value product, it may ultimately be tested by a larger group of judges or by a sensory panel at the corporate research center. The results of retesting, either at the plant or elsewhere, will be used to decide whether the product is to be sold, re-worked, or scrapped.

For online testing, efforts should be made to record the results in some numeric form. Recording results, whether in numeric form or as verbal comments, can provide the following benefits:

1. More care in evaluation is usually taken if the results are logged into some form of record.
2. Retention of online evaluations can be useful in providing information on product quality "drifts."
3. Examining evaluation results can provide a record of the performance of the personnel judging the products, providing motivation to the line people.

Providing a check form can serve as a reminder to test the product and as a guide for key characteristics to be evaluated.

Whether obtained from line personnel or taste panels, numeric sensory data form the basis for making decisions on how far a product is from target and whether or not it should be sold. QC formats usually require quantitative data, and moreover if sensory analysis is to be part of a QC program, the tests should be designed to provide some form of quantitative numeric data.

In considering numeric data from plant sensory testing as part of a QC program, it is important to remember that the values are often the results of evaluations by as few as four to six people. As a result, sensory data will differ from engineering data or even chemical analysis data, which often include multiple measurements of many samples. The results of the chemical and physical analyses will often have relatively smaller standard deviations than the results of small sensory test groups. The size of the sensory panel and other available resources must be considered before attempting to adopt recommended practices in QC reference books, especially as they relate to statistical sampling procedures and sample numbers.

The objective of sensory testing in a plant is to provide a range of information to meet the needs of the QC program. This information can include accept/reject results and data from many kinds of sensory tests on raw materials, intermediates, and finished products. The data can be presented in tables or graphs, either as a separate sensory report, or included with other chemical or physical test results. Because plant situations vary greatly, the person responsible for sensory testing must consider his or her own situation in selecting sampling and test methods. Chapters 6, 7, and 8 address QA/QC sensory data product specifications for plant sensory testing and suggest ways to adapt sensory test methods for plant QC purposes.

2 Background Information for Setting Up New Plant Sensory Programs

WHERE A PLANT SENSORY PROGRAM FITS WITHIN A COMPANY

The information presented here is a summary of several discussion groups comprised of ASTM members working in plant sensory programs, either as sensory test leaders in manufacturing plants or as coordinators of plant sensory as part of corporate sensory or QA. Actual experiences and practices were shared with the objective of helping someone starting a new program in a manufacturing plant.

Company structures vary greatly, both in size and numbers of plants manufacturing different products. As a result, plant sensory programs may have several different reporting relationships. Examples of some groups to which plant sensory programs might report are as follows:

1. Quality Assurance/Quality Control (QA/QC).
2. Research and Development.
3. Corporate Sensory.
4. Operations/Plant Management.

Each of these reporting relationships are discussed below.

Reporting to QA/QC

The scope of quality assurance and quality control varies in different companies. In large companies they are two separate units. In smaller companies the two functions are often combined into one group. To clarify where plant sensory might fit into these groups, QC and QA are defined.

QC is responsible for executing procedures to measure the specified quality of raw materials and in-process or finished products. These procedures are part of the written product specifications. QC is responsible for rejecting or placing on hold those products and materials that are not in compliance with established specifications. Sensory quality may be part of the product specification and may be a basis for rejecting or placing on hold. The sensory specifications and test procedures may be written by R&D or QA. The plant sensory group implements the test procedures and may have input into the writing of the test procedures.

QA is responsible for developing policies and programs to assure that the product is manufactured to a standard of uniformity and sets compliance standards for the uniformity

of the target or standard. QA, or QA in conjunction with R&D, often identifies the target and acceptable ranges for key product characteristics. The QC test procedures may be written by QA or by other groups, such as R&D.

QC in a plant is generally responsible for the physical, chemical, and if appropriate, the sensory testing of raw materials and finished products. The size of the QC staff, or the specific sensory group if there is one, generally determines the extent of sensory testing of ingredients and finished products. The sensory test activity within the QC group will also vary relative to the sensitivity of the ingredients and how they affect the finished product. Another influencing factor is the extent to which sensory attribute variation affects consumer acceptance.

The QC group within the plant may also be active in training TQM teams in spot testing for chemical, physical, and sensory attributes. This work is also often coordinated between the QA and QC groups.

Summary of Advantages and Disadvantages of Reporting to QA/QC

Having sensory testing as part of QC in a plant has several advantages. The reports on a product can combine all chemical, physical and sensory test results in a single document, which can facilitate communication of results. Sampling can be more efficient if both chemical, physical, and sensory samples can be collected at one time. Often QC personnel are assigned to a product rather than a specific chemical or physical test. In these cases, the sensory testing can be coordinated with the other QC tests on the product. As part of QC, sensory tests can be effectively used with other testing in trouble shooting.

Sensory testing as part of QC can have disadvantages. It is generally less well understood than chemical and physical test procedures and can be relegated to the last test performed. With limited time, this can result in the testing not being done at all. QC labs are generally small and can be crowded with instruments for chemical and physical testing. Size limitations can impose severe limits on space for serving samples to panelists.

Plant Sensory Reporting to Research and Development

The sensory plant QC program may relate to R&D in the areas of new product development, scale-up to production, cost reduction, and process optimization. This is especially true if R&D is located in close proximity to the plant. Feedback to R&D and purchasing regarding ingredient variation or performance can be valuable as a follow-up to an initial plant run, which is usually manufactured with a single ingredient sample. Sensory evaluation of ingredients at the plant may be useful in revision of specifications if needed.

Advantages and Disadvantages of Reporting to Research and Development

There are advantages to having the sensory program in the plant reporting to R&D. By reporting to R&D, especially with a new product, the plant sensory team can develop an understanding of the product by working with the research group. The plant sensory group can become familiar with the product as it was originally manufactured under R&D supervision, which will ensure that the sensory characteristics will be maintained. The plant sensory team can also track ingredient variations and report these to the R&D and purchasing teams.

There are also disadvantages to having the sensory program in the plant reporting to R&D. Unless there is a close relationship between R&D and plant operations, the sensory

group reporting to R&D but located in the plant may inadvertently not be included in the total picture.

Plant Sensory Reporting to Corporate Sensory Group

The plant sensory group might report to the corporate sensory group, especially in large multiplant companies. The corporate sensory group can provide technical support, training, and new methods research for the plant group. Especially in multiplant situations, the corporate sensory group can coordinate testing among plants to improve uniformity in testing among plants manufacturing the same product.

Advantages and Disadvantages of Reporting to the Corporate Sensory Group

There are advantages of having the plant sensory person/group reporting to a corporate sensory group. A person hired to conduct sensory testing in a manufacturing plant can feel overwhelmed or lost with limited reference material or technical support. Having a group to call when quick answers are needed is helpful. It is also an advantage to have the same tests conducted on products manufactured in several plants to facilitate summary of information by corporate QA.

There are also disadvantages. Unless the coordinator in the corporate sensory group has had experience in plant sensory work, there can be resentment on the part of the plant group being told what to do by someone who is "going by the book." The corporate sensory group must be conscious of the possibility of being viewed as "high and mighty," especially by a relatively junior person in an entry level QC position in the plant.

Plant Sensory Reporting to Operations/Plant Management

A plant sensory program might report to plant management or operations, especially in small to midsize companies. This reporting relationship is especially effective when sensory characteristics are key factors in product quality and test results are used by operations on a continuing basis. Being part of production, plant sensory can play a useful role in product troubleshooting.

Advantages and Disadvantages of Reporting to Operations/Plant Management

A reporting relationship to operations and plant management can be very effective, provided that a "team" relationship is maintained. If the sensory group is differentiated from the QC group by reporting directly to plant management, there is a better chance of establishing sensory testing as part of manufacturing and not being put into the background of a larger QC program.

There are disadvantages to the sensory program reporting to Operations or Plant Management. As with any QC activity, there are usually pressures placed on groups reporting to Operations to approve the shipment of products that are of marginal quality.

In summary, the ideal reporting relationship will result in the plant sensory group being independent and able to present unbiased test results. Companies and people managing QC/QA, R&D, and plant operations vary greatly. Where plant sensory will best fit and how it can be successful is difficult to generalize.

HOW SENSORY TESTS CAN FIT INTO CURRENT QC PRACTICES

Sensory testing can play an important role in maintaining product quality, but it may be one of the last programs to be established for QC. It is often initiated because a product problem has occurred or a need has arisen for control of a critical flavor or other product characteristic. In any case, objectives and ways of achieving them must be identified before a sensory program is initiated. For example, a critical flavor or texture may have to be controlled to maintain either customer (in the case of the product being an ingredient sold to a manufacturer) or consumer acceptance. To establish a control program, methods of measuring the characteristic must be identified and limits of variability around the target level must be set. If sensory testing is being done in response to a product problem, it is important to establish what product problems exist and what kind of information is expected from a plant sensory program. Sources of this type of information are plant, marketing and sales personnel, company management, and possibly customers (especially review customer complaint letters if available).

It is important to remember that sensory testing differs from chemical or physical testing and is often poorly understood by people responsible for overall quality control. Unless specific objectives and priorities are set, the role of sensory testing can disintegrate into casual like/dislike tasting by plant management personnel with minimal sensory science input. It is also important to remember that sensory testing must be cost justified and reported in an easily understood manner to plant management.

CONSIDERATIONS IN SETTING UP A SENSORY QC PROGRAM

Assessment of Existing QA/QC Practices

A review of QA/QC practices currently used for chemical/physical testing is essential in setting up a sensory program. Such a review might include the following:

1. What sampling procedures exist for raw materials, in-process products, finished products, and packaging materials.
2. How priorities are established for sampling and testing critical materials.
3. What conformance and testing criteria have been established between the company and raw material suppliers.
4. How references and product retain samples are maintained.
5. What criteria and procedures exist for rejection of raw or intermediate materials or placing finished products on hold.
6. What critical time has been established for the rejection/on-hold decisions resulting from Step 5.
7. How many product specifications exist, and how many of these have sensory specifications.
8. What sensory testing has been conducted in the past, how were data reported and recorded, and how were the data used.

Assessment of Product Quality Records

A history of the kind of product defects and their frequency may help to target the proposed sensory program. Suggested information sources are as follows:

1. Past customer complaint records.
2. Plant reject experience with raw materials and finished products placed on hold, including why they did not comply with current QC specifications.

The customer complaint records can tell the sensory person whether there might be a pattern or trend with sensory problems, such as seasonal variations in water sources, or a humidity change in the packaging room. Information on what raw materials may have been rejected in the past, and for what reasons, can help in establishing priorities regarding what should be reviewed first. If raw materials have been rejected for broken containers, then the issue is not directly related to sensory, even though the material may have had off flavor characteristics. If the raw materials are within chemical and physical specifications, but the finished product still does not taste or smell right, then there is a need for a sensory test to be identified and implemented. Sensory testing is most successful for QC programs when it can provide answers not readily available from physical or chemical tests.

Assessment of Manufacturing Process

A review of the manufacturing process will provide necessary background information for starting a sensory program. Some questions to serve as a guide in this review are as follows:

1. Are the processes batch or continuous?
2. What are the control capabilities of the processes?
3. How are incoming raw materials planned, purchased, and delivered?
4. How are incoming raw materials recorded, stored, and rotated?
5. What are the possibilities for contamination or changes caused by physical conditions, such as odor transfer or heat/cold conditions, during storage before use?
6. How are in-process intermediates handled and stored?
7. How is the finished product tested and certified before shipment?

An understanding of the manufacturing process is essential to a person responsible for plant sensory testing. Testing ingredients is important, but equally important is how they affect the final product, and how the process changes the ingredients. An understanding of the sensory properties of the final product manufactured at target and at the outer limits of the process can provide suggestions to the sensory person as to whether the incoming ingredients or in-process products should be given priority in the test program.

Examining the history of the use of ingredients, assuring that they have been rotated properly and not damaged by freezing/thawing or overheating, is another important area to review. Looking at an ingredient warehouse may not show obvious problems, but an understanding of routine handling and storage of raw materials can be helpful if a problem does arise. An example of this is odor transfer from printed packaging materials, or the use of old raw materials because of a mistake in stock rotation. The manufacturing process has many random variables, and the more known about it, the more effective a sensory person can be, especially in trouble shooting.

Assessment of Current Sensory QC Program Dimensions

There may have been a sensory program in the plant at one time, or one may exist at the present time. In reviewing a program, the first thing to determine is whether the size of the

program matches the requirements for sensory testing in the plant. The size of the program will depend on many factors, some of which are as follows:

1. The sensitivity of the raw materials used, including packaging materials.
2. Intermediates produced or received from another supplier.
3. The production schedule, which may need testing over three shifts for a critical product, especially one with continuous production of intermediates.
4. The number of stock keeping units (SKUs) of finished goods produced at the plant.
5. Space and personnel available.

With current emphasis on being competitive and reducing manufacturing costs, the space and personnel available will usually be limiting factors, without even arguing the need. There are never enough resources to do everything that is needed. As with most other testing programs, the sensory testing will be expected to provide a payback in decreased reject product, and expansion of testing will have to be cost justified.

SUMMARY

The information gathered on the raw materials, manufacturing, and QC practices should form the context for the development of a sensory program. Some key questions to ask while developing the program are as follows:

1. Is there a physical or chemical test that answers the same quality questions? If so, use it instead of a sensory test. Why? Because more samples can be tested within a given amount of time and generally the testing will be less costly. For example, if an incoming batch of oil is darker than the color specification limit, there is little point in setting up a panel to taste it. However, gas chromatography cannot always point out small peaks that might be from flavors that could alter product quality. These could be noted by a sensory panel.
2. Is there a reasonable way to maintain a standard that is representative of expected quality of either an ingredient or finished product? If so, by all means use it to anchor the sensory test results to something that everyone understands. Written descriptive sensory specifications are meaningful to the person writing them. There must be a good understanding of those written descriptors by the person at the plant for plant sensory testing to be effective. To avoid misunderstanding, participation in the writing of the descriptors or providing a physical standard to the plant sensory person can be helpful. Standards are mainly useful if the product is reasonably shelf stable, such as dry packaged mixes, canned products, and cereal products. One example of using a standard with a target color and flavor and with acceptable ranges is a product such as chocolate ice cream topping.
3. Is there a way that the sensory person can become familiar with how quality management decisions are made? If so, give serious consideration to producing test data that will be useful to these decisions. Understanding how the data will be used is a key factor in designing the sensory test program.