Guidelines for sensory evaluation of food packaging

CONTENTS

1. Foreword
2. Purpose, scope and application of this procedure
3. Analysis principle
4. Assessors
5. Analysis conditions and study design - general information
6. Analysis equipment
7. Test media
8. Sample preparation
9. Sensory analysis
10. Evaluation of results
11. Reporting
12. Quality assurance of the analysis work
13. References
1. FOREWORD

Food packaging is a wide concept and comprises a variety of different materials or combinations of materials, designs and functions. Furthermore, the nature and characteristics of the packaged food itself, which may be intrinsically different, are highly important factors to consider when aiming to achieve a well-functioning packaging. The fundamental function of packaging is to protect the packaged food in many ways, such as mechanically, microbiologically, chemically and sensorially. Two other important aspects of packaging are design and appearance, as the packaging constitutes the interface between consumer and product, and thus plays a significant part in how the packaged food is assessed by the consumers.

It is important to be aware of the fact that the sensory aspects that are dealt with in this procedure, are often a part of a larger whole, and this may mean that compromises have to be made in order to achieve a product that is as well-functioning as possible. Nevertheless, one should always strive to perform the sensory measurements with the appropriate degree of sensitivity. There will always be a certain degree of interaction between the surroundings, the packaging and the food. In many cases, manufacturers focus on minimising this interaction, and therefore seek packaging which interacts with the food to such a small extent, that it may be considered insignificant in sensory terms. On the other hand, some types of packaging try to utilise and encourage a form of interaction between packaging and food - this is called active packaging.

Various possible interactions between environment, packaging and packaged food.

The packaging of food is also dealt with in official rules and regulations: Within the EU, food packaging is regulated by "Regulation (EC) No. 1935/2004 on materials and articles intended to come into contact with food" (13.8). This directive states that materials and objects which may
come into contact with food, shall not emit substances to the foods so that they may become a
danger to health, or may cause an unacceptable change in the properties of the foods, e.g. their
odour and taste.

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2. PURPOSE, SCOPE AND APPLICATION OF THIS PROCEDURE

The guidelines in this NMKL Procedure are based on national as well as international recommendations and standards, and also on experience gained over many years. The document provides a number of different procedures which may be applied in the sensory evaluation of food packaging, and points out critical aspects and potential pitfalls of this work. It focuses mainly on the sensory aspects of packaged foods relating to odour and taste evaluation, and consequently does not deal with issues such as the design and practical usability of the packaging. The field of application is wide, and covers issues such as continuous production control of incoming materials, evaluation of storage conditions for packaged goods, and controls to ensure compliance with applicable rules and regulations.

3. ANALYSIS PRINCIPLE

The nature and structure of the packaging, and its relevant applications will, of course, govern the choice of method and how it is performed. The packaging may either be assessed in itself (for example in terms of odour), or it may be evaluated by assessing a test medium which has been in contact (indirectly or directly) with the packaging. It is very important to be aware of the fact that odour from the packaging does not necessarily have an impact on the test medium - and vice versa. The packaging material may have a strong odour without this affecting the test medium, or it may have no or only a slight odour, but still have a sensory impact on the test medium.

In cases where the packaging material will have direct contact with the test medium, it is ensured that favourable conditions are provided for the medium and packaging to interact, by placing them in direct contact with each other (preferably with a large contact surface). If necessary, conditions are adapted so as to stimulate the interaction. When there is indirect contact between the test medium and the packaging, the interaction takes place through volatile substances being emitted from the packaging material and/or test medium, and then being absorbed by the packaging material and/or test medium. This process is obtained by placing both the packaging material and the test medium in a closed vessel without allowing them to be in direct contact.

A sensory evaluation is then performed to assess odour and taste. Sometimes other factors are considered, such as visual appearance and consistency.
Reference samples are used in practically all sensory evaluations, thus allowing comparison between the tested samples and the reference samples.

4. ASSESSORS

4.1 Selecting assessors

The selection of assessors is one of the most decisive factors for how sensitive, accurate and stable a sensory analysis will be. The available general guidelines and standards for selecting assessors
Guidelines for sensory evaluation of food packaging

for the sensory panel, apply just as much to this type of evaluation, as they do to others (13.5). The recommended general tests should, however, be supplemented by selection tests that are more closely related to the actual products and tests with which the panel will work. Samples with various typical defects can be presented, and it is also possible to use test media that are relevant to food packaging. It should be emphasized that the production of food packaging aims to ensure that the packaging does not affect the sensory characteristics of the food. Thus, the expected effect of the packaging is often very slight, and this places great demands on the sensitivity of the method as well as the assessor.

In cases where it is expected that certain substances or combinations of a small number of substances may cause sensory related problems, the ”prospective assessors” may be tested for their sensitivity to these particular substances. NOTE! In such cases, it is essential to ensure that the assessors are not exposed to any health risks.

An overall evaluation of the results of all these tests should then form the foundation on which to base the selection of the panel members.

### 4.2 The number of assessors

It is always difficult to recommend an accurate number of assessors, as this depends on various circumstances such as how competent and experienced the assessors are, the purpose of the evaluation and how many assessors it is practically possible to locate. For economical and practical reasons, production control often has to be performed with only a few assessors who are thoroughly familiar with the relevant products. In cases of doubt, such evaluations should be verified by other assessors in order to increase their credibility. Other sensory assignments, such as assessing the difference between products packaged in various packaging materials, require far more assessors. Statistical tables should be consulted to estimate the statistical certainty of the results as well as to form an opinion of how many assessors are required to achieve a satisfactory significance level (13.5).

It is also possible to perform repeated assessments with a limited number of assessors, and treat this as a single evaluation by several assessors. However, in such cases, it is essential to ensure that it is possible to obtain equivalent replicates of the samples. Furthermore, such a procedure places additional statistical requirements on the design and results of the study, and it is necessary to make sure that these requirements are complied with, so that the treatment of the results will be correct.

### 5. ANALYSIS CONDITIONS AND STUDY DESIGN - GENERAL INFORMATION

Usually, the whole of the packaging is tested. Depending on the purpose of the testing, this may be supplemented by exposing parts of the packaging more or less to the surroundings, e.g. by welding together packaging material, or by separating laminated materials in order to expose parts that are
known to be critical to the sensory effect of the packaging. Laws, regulations, conventions or common practices may impose requirements on analysis conditions, and govern the choice of parameters such as temperature and contact time.

Age and storage conditions of the packaging material before the analysis takes place, may be critical, and should be considered when planning the study.

The analysis conditions can intentionally be made more extreme than the realistic conditions, for example by changing the air temperature, air humidity or atmospheric light conditions, or choosing extra sensitive test media. In this context, it is vital to know the correlation between results that have been generated under such modified conditions, and results obtained in more realistic conditions. Quite often, the correlation is more complicated than it may seem. For example, raising the temperature may increase the content and modify the composition of volatile substances that are emitted from the material. At the same time, the increased temperature will cause less absorption of these volatile substances by a test medium. These factors counter-act one another, and the direction to which the balance is shifted by the change, must be examined experimentally.

In this type of analysis, it is quite common to use reference samples to which the examined samples are related. An example of such a reference sample may be: A sample of the relevant medium that has not been in contact with the packaging, or packaging material which has been approved and/or has an acceptable effect on the test medium.
6. ANALYSIS EQUIPMENT

Equipment for use in sensory analysis, must be sensorially inert, practical to use and preferably washable and reusable (13). Glass is generally very neutral, but can also be rather fragile, impractical and awkward to handle. In most cases, plastic equipment is both light and practical, but may cause problems with odour and taste transfer and memory effects, which means that the equipment absorbs odour/taste from previous samples, and then contaminates samples that are stored in the equipment in later analyses.

Generally, polystyrene, polyethylene terephthalate (PET) or possibly polypropene is preferred over polythene, but all equipment should be checked and compared to a sensorially neutral alternative, in order to ensure that the analysis equipment itself does not affect the results. If the analysis requires higher temperatures, the selection of equipment material is further limited.

Good washing routines are extremely important, but at the same time need to be practical. Quite often, a dish washer using odour-neutral and taste-neutral dishwashing liquid provides an efficient and satisfactory way of cleaning the equipment. Equipment designated to sensory testing should be washed, handled and stored separate from other equipment in order to prevent contamination.

The washing process may well be combined with drying at relatively high temperatures to vaporise any remaining volatile, smelling substances.

7. TEST MEDIUM

The choice of test medium should not be treated lightly, and is governed by a number of circumstances. This choice is one of the most decisive factors for the sensitivity of the method, and must be aligned with the purpose of the study.

When choosing one or more test medium/media, the food is often divided into different categories. Suitable test media for each category are suggested in various standards (such as ISO 13302). This classification into categories differs somewhat in various standards. The table below contains some examples taken from several standards (13).
Examples of different food categories and suggested test media:

<table>
<thead>
<tr>
<th>Food category</th>
<th>Suggested test media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatty foods with a significant water content</td>
<td>Cream, homogenised whole milk</td>
</tr>
<tr>
<td>Fatty foods with a low water content</td>
<td>Margarine, butter, coconut butter, shredded milk chocolate</td>
</tr>
<tr>
<td>Lean foods with a low water content</td>
<td>Taste-neutral biscuits, icing sugar, lactose</td>
</tr>
<tr>
<td>Lean foods with a significant water content</td>
<td>Water* + citric acid + sugar (in proportions matching the food)</td>
</tr>
<tr>
<td>Beverages</td>
<td>Water*</td>
</tr>
<tr>
<td>Alcoholic beverages</td>
<td>Water* + alcohol (in proportions matching the beverage)</td>
</tr>
<tr>
<td>Dairy products, fermented</td>
<td>Milk, water* + lactic acid</td>
</tr>
<tr>
<td>Dairy products, non-fermented</td>
<td>Cream, homogenised whole milk</td>
</tr>
<tr>
<td>Meat, meat based products</td>
<td>Sausages with a mild taste, cream, homogenised whole milk, margarine, butter</td>
</tr>
</tbody>
</table>

*taste-neutral and odour-neutral water

The characteristics and properties of the test media are extremely important. Firstly, they affect the degree to which interaction between media and packaging takes place, and secondly they have an effect on how clearly such interaction can be detected. Their inherent odour and taste may for example to a varying degree mask different types of defects caused by the packaging, and the differing appearance of the media may capture packaging related discoloration to a varying degree. As regards odour-neutral and taste-neutral water, this is not the same as ultra clean water in a chemical sense. Treatments such as distillation and reversed osmosis are efficient ways of obtaining clean water, but this water may be perceived as "poor" and unnatural in a sensorial sense. For sensory evaluations, treatments such as adsorption with active coal (coal filtration), which removes organic taste substances from the water without taking out substances such as natural salts, may be a considerably better option. This issue is often related to the available water quality, and should be tested by experiment.

The intended use of the packaging must be taken into consideration, particularly the following factors:

- The characteristics of the food to be packaged
- Which type of packaging is available
- Whether there are any previously known problems of a sensory nature

It might be possible to use the relevant food as test medium. For this to be feasible, the food must be stable and of good quality, so that a whole test procedure may be performed on the same sample or sensorially equivalent samples. Among the problems that may be encountered, are the following: that the food itself has a nature which makes small sensorial differences difficult to measure, that the food is inhomogenous and it is not possible to obtain identical samples for several tests, that several different types of foods, each with different characteristics, have to be
packaged in the same type of packaging, and/or that it is necessary to choose analysis conditions that do not work well for the type of food in question.

If the persons performing the analysis do not have previous experience with the test medium/media intended for use in the analysis, this medium/these media should be tested before the real study is carried out.

By using a test medium which is significantly more sensitive to effects from packaging materials than the actual food(s) for which the packaging will be used, it is possible to test the packaging under more extreme conditions than the real application will involve, and thereby obtain a safety margin to ensure that questionable materials will not be approved. In such cases, it is important to acquire the necessary knowledge about this increased sensitivity, e.g. by using reference samples, in order to be able to interpret the results correctly.

### 8. SAMPLE PREPARATION

The prevailing conditions for the real application should be known and taken into consideration when preparing the test samples. The age of the materials which make up the packaging, is often a critical factor. Furthermore, it is important to be familiar with the applicable transport and storage conditions (e.g. the length of the transport or storage period, the temperatures the samples may be exposed to, and whether the materials will be exposed to light or a chemically aggressive environment), as these too are factors that may influence the process and choice of conditions.

#### 8.1 Sampling

As for all analytical work, the importance of a well-planned and accurate sampling process cannot be overrated. The extracted samples shall represent e.g. a type of packaging, a batch of packaging or a portion of a packaging that has been transported in a certain manner. It is important to consider this when sampling, so that the extracted samples for instance include the variations that are typical for the batch, while at the same time make it possible to separate between the phenomena the analysis aims to examine. To obtain this, it is recommended to apply common sense combined with guidelines for sampling (13.2). The details of the sampling procedure are determined, among other things, by the type of packaging. For packaging materials in the form of stacked sheets, for instance, the outermost sheets should be avoided. The sampler's personal hygiene can also be a critical factor. It is important that the sampler does not use perfumed hand soap and hand lotion. Gloves may be used, but certain types which may emit odour and/or taste, and gloves with talcum powder, should be avoided.

As a rule, larger test portions are needed for odour evaluation of materials, than for the evaluation of their effect on the test medium, as materials for odour evaluation often have to be prepared in separate vessels for each of the assessors.
8.2 Handling and storage of samples

Samples should be handled with care so as not to introduce tastes/odours which do not correspond to reality. The details of how this should be done, depends on the type of packaging and area of application. When it comes to sheet packaging, for example, it is important to ensure that there are enough sheets to make it possible to take samples from the middle for analysis, and leave the outermost sheets. If aluminium foil is used to prevent contamination of samples, the foil must be free of pollutants and thick enough to allow handling.

Quite often, the storage process itself is included as a factor for analysis (e.g. storage studies), in which case the realistic storage conditions should be examined and recorded. The storage conditions for the samples should then either be adjusted to reflect the realistic conditions, or be made intentionally more or less critical.

It is important to retain all the characteristics of the samples during storage, and therefore it is quite common to protect the samples to some degree, for instance by shielding them from contamination from the surroundings, and preventing the evaporation of volatile substances. The admission of air and light can, in many cases, initiate and promote reactions in the packaging materials which may affect their sensory properties.

The storage temperature can be adjusted so that it corresponds with the actual conditions of the area of application. If this temperature is unknown or variable, room temperature is an appropriate option. Sometimes low temperatures provide the best conditions for storing samples, but can also introduce unintentional changes which should be tested experimentally. No matter how carefully the storage is planned, it can be assumed that the sensory properties of many materials do change with time, despite being stored in the most suitable manner. It is essential to gather sufficient knowledge of these changes for all relevant sample materials, and to take them into consideration in the planning of analyses and studies.
8.3 Preparation of samples for odour evaluation

In some cases, e.g. when evaluating the interior odour of sealable packaging materials, the materials may be sealed without using sample vessels. However, most accurate analyses of packaging materials require that the material for odour evaluation is transferred to a suitable sample vessel. It may be necessary to cut or otherwise split up the material, but it is important to realise that by doing this, more of the interior parts of the material are exposed (through the edges of the material). For this reason, the volume of the vessel should not be too small (it is assumed that approx. 500 ml is needed for a sensory evaluation, and for sheet packaging, the equivalent volume is 1 sheet of A4 format). The sample vessel must be sealable, and should be protected from light until the odour evaluation is to be performed.

In most cases, it is important to prevent the assessors from seeing the sample, as knowing which sample is being evaluated, may influence their assessment. This can be arranged by using non-transparent vessels, applying foil to transparent vessels or using coloured lighting during the evaluation.

8.4 Preparation of samples for evaluating the effect on test media (taste etc.)

Direct contact
For cases in which the real application of the packaging is to be examined, and the actual food is used at the test medium, the preparation is very straightforward. The filled packaging is simply stored for the required period of time and under the appropriate conditions, before the test medium is evaluated. If special test media are to be used, these are packaged in an equivalent manner. The ratios between the amount of material/test medium varies significantly for different applications, and should be adjusted so that they are as relevant as possible for the purpose of the evaluation.

If it is considered necessary to increase the contact between the test medium and the packaging or the materials making up the packaging, it possible to make special arrangements. One example is submerging the material in liquid test media. However, this is not suitable for sandwich materials, or when the test medium may be expected to be absorbed by the packaging material. Flat materials can be arranged in "sandwich models" where the packaging material and solid test medium are layered and light pressure is applied. Examples of preparation methods can be found in standards (13.6).

Indirect contact
Here, the packaging material and test medium are enclosed in a suitable sample vessel without being in direct contact. The interaction takes place as the volatile substances evaporate from the material, and are subsequently captured by the relevant test medium (or vice versa). It is therefore essential to choose the right temperature and other factors, such as air humidity and indirect contact time. If the volatile substances have a strong "attraction" to the test medium, the method can become quite robust and less sensitive to variations in the volume of the vessel and the amount
of sample/medium. Examples of preparation methods can be found in standards (13.6).

9. SENSORY ANALYSIS

Sensory analysis usually concentrates on differences between the actual sample and a reference sample. This involves carrying out comparison tests based on the reference sample. The test methods for this may be "multicomparison tests", ranking tests, difference tests (e.g. paired or triangular), or profile tests adapted to the used test medium (13.5).

The most appropriate method(s) are chosen based on the nature of the problem for evaluation, which type of result is necessary to illuminate this and other circumstances such as access to samples, number of available assessors and previous experience with methods. It is often necessary to have an open dialogue with the persons ordering the analysis, in order to fully understand the purpose of the evaluation and thus choose the right method. It is also important to recognise that results from different sensory methods are not always directly comparable. It may be useful to include samples with expected sensory impressions (control samples) in the analysis, for example a blind negative control sample or a duplicate of one of the samples. However, it is important to consider the use of such control samples carefully, in order to maintain the assessor's focus on the actual samples for evaluation. Assessors often have a tendency to look for patterns, and therefore they may easily start focusing on revealing the control samples (i.e. identifying a blind negative sample or a duplicate), instead of concentrating on the samples themselves.

A quantification of the intensity and, if possible, a description of the characteristics of the packaging effect, should be indicated when the method allows this. The quantification is stated by means of intensity scales. There are a great number of different scales for this purpose (13.4 - ISO 4121). When the test material is presented to the assessors, it is important to consider the sample identification and sample sequence. The "true identity" of the samples is withheld from the assessors through coding, often with randomly chosen three-digit numbers. The sequence of the samples is randomised so that the samples are presented to each assessor in a different order.

9.1 Odour evaluation of packaging

A preliminary "screening", i.e. a quick, rough determination, may well be performed directly on the material (for example by smelling a stack of sheets, opening a sealed package), and can provide valuable information. A more accurate and controlled evaluation is made by smelling the vessel in which the sample has been enclosed (or inside a sealable packaging material). The assessor opens the vessel, and smells the air inside it. It is important to smell the air immediately after the vessel has been opened, as many odour substances are present in very small quantities, and are quickly diffused when the vessel is opened. It is very rarely possible to repeat the smelling
after a short while, as a large part of the odour substances will then have been aired out almost completely. Quite often, however, a repeated analysis may be made after waiting a little longer, but it is not possible to assume that this is the case without checking. For this reason, it should be ensured that the test portion in the vessel is not too small. Each of the assessors should have a separate vessel for every sample.

9.2 Evaluation of the effect of packaging on test media (taste etc.)

How a test medium is evaluated is to a great extent dependent on the nature of the medium, and which parameters are of interest. Often it is possible to obtain valuable information by evaluating media using several different methods, for instance visual inspection, smelling and/or tasting, and evaluating consistency.

Exactly how this should be carried out, is closely linked with the purpose of the evaluation, and the subsequently chosen method. Usually, it is appropriate to transfer small portions of the test medium to suitable equipment, which is subsequently presented to each of the assessors. For example, water may be poured into jugs with lids, and shredded chocolate may be placed in cups while waiting to be evaluated.

It is important to know how stable the test medium is, in order to decide the tolerance levels that are acceptable in the practical work (e.g. how long a test medium may be stored pending evaluation, how large temperature variations may be tolerated, or how tightly the packaging material needs to be enclosed). It is equally important to gain experience to later be able to decide how long the assessors need to wait between evaluations, in order to recover and thereby avoid adaptation.

10. EVALUATION OF RESULTS

How the results are evaluated, depends on the purpose of the analysis and the used method. Common for nearly all evaluations, however, is that the results for the samples in question are in some way compared to the results for corresponding reference samples. Statistical evaluations, using tables, variance analysis and other relevant tests (such as t-tests and multiple difference tests), are often necessary to find out with which certainty such differences may be determined. The important thing here, is that the design of the study matches the conditions that apply to the statistical evaluation.

11. REPORTING

The general rules for reporting also apply to sensory analysis reports, which should include the following information:
  • Name and address of the laboratory who has performed the analysis
• The relevant packaging and reference material as well as an unambiguous identification of the tested sample(s)
• The test medium and the prevailing conditions such as evaluation temperature, evaluation lighting, storage period, storage temperature, etc.
• The analysis method used, which should refer to a relevant standard or to the laboratory's own documented, internal methodology.
• Method specific information (such as information on amounts of test medium and packaging material, how the contact has taken place (directly/indirectly), how long the contact has lasted, relative humidity and practical details).
• Choice of sensory test as well as number of assessors and their qualifications.
• Results with corresponding statistical evaluations.
• Conclusions, comments and any recommendations based on the purpose of the analysis and the current situation.

The design of the report should match the context in which it will be used, thus making it as easy to use as possible.

12. QUALITY ASSURANCE OF THE ANALYSIS WORK

A well-functioning panel of assessors, combined with careful and accurate sample preparation and evaluation, is vital to achieving good quality results. The guidelines presented by NMKL and other applicable standards (13) are recommended to this end.

Control samples (samples which are not interesting in themselves, but which are used for controlling and improving the reliability of the analyses), in which typical defects have been intentionally created, may well be used for training assessors, and also occasionally during testing. Furthermore, calibration samples (samples with an expected, known sensory intensity and character) may be an appropriate supplement. However, as the odour and taste related properties of many samples change with time, these are not easily obtained. In this context, synthetic, simplified calibration samples may be worth a try (13.9).
13. REFERENCES

13.1 General guidelines
NMKL Procedure No. 6, 1998 (or later edition): Generelle retningslinier for kvalitetssikring af sensoriske laboratorier / General guidelines for the quality assurance of sensory laboratories. (available in Danish and Finnish)
EN ISO/IEC 17025, 2005: General requirements for the competence of testing and calibration laboratories.

13.2 Sampling

13.3 Selection and training of assessors
ASTM STP758. Guidelines for the selection and training of sensory panel members.

13.4 Instructions for indirect sensory testing and usage of scales
ISO 5497 Sensory analysis - Methodology - Guidelines for the preparation of samples for which direct sensory analysis is not feasible. (1982)

13.5 Method specific standards
ISO 5495 Sensory analysis – Methodology – Paired comparison test (2005)
ISO 6564 Sensory analysis – Methodology – Flavour Profile Methods (1985)

13.6 Packaging specific standards
13.7 Estimation of detection thresholds
ISO 13301 Sensory analysis - Methodology – General guidance for measuring odour, flavour and
taste detection thresholds by a three-alternative forced-choice (3-AFC) procedure. (2002)
ASTM E679 Standard Practice for Determination of Odor and Taste Thresholds By a Forced-
Choice Ascending Concentration Series Method of Limits. (1997)

13.8 Laws and regulations
Regulation (EC) No. 1935/2004 on materials and articles intended to come into contact with food.
(2004).

13.9 Calibration
CEN Technical Document (Draft): Calibration of off-flavour of food in contact with paper and
board.
Additional References to chapter:

13.6 Packaging specific standards
ASTM E2609 Standard Test Method for Odor or Flavor Transfer or Both from Rigid Polymeric Packaging. (2008)

13.9 Calibration
SIS-CEN/TR 15645-1 Paper and board intended to come into contact with foodstuffs - Calibration of the odour test - Part 1. (2008)
SIS-CEN/TR 15645-2 Paper and board intended to come into contact with foodstuffs - Calibration of the off-flavour test - Part 2: Fatty food. (2008)
SIS-CEN/TR 15645-3, Paper and board intended to come into contact with foodstuffs - Calibration of the off-flavour test - Part 3: Dry food. (2008)