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Chapter 14

Sensory Evaluation and Consumer Acceptability

Mian Kamran Sharif, Masood Sadiq Butt, Hafiz Rizwan Sharif and Muhammad Nasir*

Abstract

Sensory appraisal is a discipline of measurements strongly allied with precision, accuracy and sensitivity to avoid from wrong assenting results. Sensory assessment is comprised of techniques that involve psychology, statistics, food science, physics, engineering, ergonomics, sociology, mathematics, humanities and various other biological sciences. Imprecisely sensory evaluation is categorized into objective and subjective testing. In former method, hedonic response of a product is determined by skilled evaluators whereas in second method, consumers are involved in the evaluation process. Hedonic assessment is the economical and ideal method to find out the influence of variations in ingredients, manufacturing, wrapping, or shelf life. The successful sensory evaluation in food industries is achieved by linking sensory properties to physical, chemical, formulation and process variables which enables manufacturing food products with maximum consumer acceptance. This chapter briefly describes the field of sensory evaluation,

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sensory perception, principles of good sensory testing, sensory evaluation methods and application of sensory science to product development. An effective sensory program is helpful in meeting end-user expectations and ultimately getting large market share.

Keywords: Sensory evaluation; discriminatory testing; difference testing; descriptive testing; affective testing; sensory perception; panelist considerations; sensory evaluation in the food industry.

14.1. The Field of Sensory Evaluation

14.1.1. Sensory Evaluation

The discipline of hedonic response flourished swiftly in 20th century along with the growth of food processing industries. It encompasses a set of techniques required for the precise measurements of human reactions to foodstuff ultimately persuading the consumer perceptions. According to the Institute of Food Technologists (IFT), sensory evaluation is a scientific method used to evoke, measure, analyse and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell and taste (Stone and Sidel 1993; IFT 2007). Since its advent in 1940s, sensory assessment has been established as an exciting, dynamic and continually evolving discipline that is now renowned as a scientific field in its own right. The sensory professionals are regularly challenged with problems which call upon widespread skills derived from array of disciplines, like bio-sciences, psychology, statistics and often required to work with other experts from these areas. Furthermore working with a human as 'measuring instrument' is challenging due to great variability. Today's lifestyle is entirely different; hypermarkets are offering consumers a great range of food products. The competition between food processing industries is escalating for more space in superstores; hence sensory analysis has become vital part of food production. Sensory evaluation has emerged as an essential component of food product development and standards for setting up, testing, analyzing and interpreting sensory results are now at an advanced stage. Moreover, innovations and advancements in electronic devices have further simplified the evaluation process.

14.1.2. Role of Sensory Evaluation

There has been tremendous change in the role of sensory evaluation over the years. In partnership with research and development as well as marketing departments it helps in the formulation of profitable strategy. In the early stages of product development, sensory testing can help to pinpoint the imperative sensory characteristics driving acceptability. It can be useful to ascertain target consumers, product competitors and assess the new ideas. Now a days, chemical and physical properties of the product driving sensory attributes are ascertained by combining data obtained from sensory and instrumental testing. Sensoric evaluation can determine the impact of scaling up pilot samples to large-scale manufacture. Sensory evaluation give assurances that inferior products are not released in the

market. In most of the cases, sensory evaluation is used to estimate shelf life of the food products as sensory characteristics of the product depreciate ahead of microbial quality. Customer evaluation is extensively employed in the investigation arena. It explores new technologies for product development and understanding the consumer behavior.

14.1.3. Successful Sensory Testing

Sensory analysis involves the inspection of a product by the senses *i.e.* sight, smell, taste, touch and hearing for various quality attributes like appearance, flavor, aroma, texture and sound. These characteristics of a food product are briefly described below:

14.1.3.1. Appearance

Appearance is the first characteristics perceived by the human senses and play an important role in the identification and final selection of food. This is the visual perception of food comprised of color, shape, size, gloss, dullness and transparency. The appearance of a meal have shown impact on appetite stimulation or depression resulting in pleasure or total depression. The look of a food or beverage impacts craveability and acceptance, before the product touches the lips. This is because we eat with our eyes before we ever smell or taste.

14.1.3.2. Flavor

It is sensory phenomenon which is used to denote the sensations of odor, taste and mouthfeel. Flavoring substances are aromatic compounds which are conceived by the combination of taste and odor and perceived by the mouth and nose. Odor improves the delight of eating *e.g.* aroma of freshly cooked rice and most of the baked products. Taste helps in identification, acceptance and appreciation of food. It is perceived by the taste buds on the tongue. There are four types of taste perception: sweet, salty, sour and bitter. Sour and bitter are often confused. Lemon juice has a sour taste whereas coffee has a bitter taste. In case of mouthfeel, nerves present inside the mouth are enthused by chemical or thermal responses *e.g.* coldness of ice cream or the fiery impression of pepper.

14.1.3.3. Aroma

Aroma is the first cousin of taste. These are volatile compounds which are perceived by the odor receptors of olfactory tissues of the nasal cavity. Aromatic compounds are released during the mastication process. Smell appraises the aroma of food that is important in the gratitude of flavor. A pleasant smell makes food delicious. To provoke a sensation of smell, the stuff must be in a gassy state. Furthermore, aroma is valuable in perceiving fresh, rancid or intermittently poisonous food.

14.1.3.4. Texture

Texture is perceived by a combination of senses *i.e.* touch, mouthfeel, sight and hearing. It is one of the most imperative feature of a food. If a customer bites a soggy biscuit or eats ice cream with sandy texture, it is improbable they will be back. Texture is prerequisite in the acceptance of numerous foodstuffs *e.g.* tenderness of meat and softness of bread. It also include the consistency, thickness, fragility, chewiness and the size and shape of particles in food. Texture analyzer is helpful to guarantee the target texture from the laboratory to the user's kitchen.

14.1.3.5. Sound

Hearing deliberates the sounds made by food during preparation and ingesting *e.g.* the crackle of fried food, the effervescence of drinks, the cracking of hard biscuits. So, in sensory analysis, the senses are used to measure, analyse and interpret the organoleptic or sensory properties of food.

14.2. Sensory Perception

14.2.1. Human senses

Sensoric attributes of the food products are perceived by the sensory organs like eyes, tongue, nose, ear etc. by interacting with food components (Kemp et al. 2009). The biological mechanisms involved in perception are discussed below:

14.2.1.1. Vision

It is first food attribute which is critical in the selection or rejection of food. The appearance of any product is accessed through the vision. Actually light waves after striking with food stuff fall on the eye retina which is comprised of rods and cones. Light energy after transforming into neural impulses reaches to the brain through optic nerve. Rods respond to white light and communicate info regarding the lightness of the color. Cones are receptive to diverse wavelengths of light concerning to 'color'. The brain deduces these indicators and we notice the appearance (shape, size, color, etc.) of the product.

14.2.1.2. Taste

It involves the perception of constituents after being dissolved in saliva, oil or water by taste receptors in the taste buds found superficially on the tongue and other parts of the mouth or gullet. The consequential discernments can be divided into 5 various taste qualities – sweet, salty, sour, bitter and umami.

- Sweet: sucrose, glucose, fructose, saccharine, aspartame
- Salty: sodium chloride, potassium chloride
- Sour: phosphoric acid, citric acid
- Bitter: quinine, caffeine
- Umami: Chinese salt

14.2.1.3. Smell

The aroma or odor associated with food products is sensed by olfactory receptors present in nasal epithelium. Hence, for the detection of aroma or odor, volatile molecules must be shifted to the nasal cavity. These compounds further move in the nose during inhaling or breathing or during eating through the back of the throat. A specific odor is the outcome of numerous volatile compounds, but sometimes particular volatiles can be associated with a specific smell, *e.g.* Iso-amyl acetate.

14.2.1.4. Sound

It is detected by tiny hair cells in the ear stimulated by the sound waves. The noise produced by food during eating contributes to the perceived texture of a food, *e.g.* effervescence of a carbonated drink, crispness of an apple or puffed rice. The sound waves produced during the consumption of food products are conducted by the air and/or bones in the jaw and skull known as intra-oral perception.

14.2.1.5. Touch

Texture is a complicated phenomenon and it can be divided into categories including mechanical (hardness and chewiness), geometric (graininess and crumbliness) and mouth-feel (oiliness and moistness). Generally these are professed during biting, chewing after swallowing.

Kinesthesis: Nerve fibers in the tendons, joints and muscles sense tension and relaxation, allowing the perception of traits such as hardness or heaviness.

Somesthesis: Human skin including the tongue, surfaces of the oral cavity and lips encompasses numerous tactile receptors to detect sensations related to touch, *e.g.* particle size.

Chemesthesis: Some food constituents can arouse the trigeminal nerves situated in the skin, mouth and nose to give hot, burning, tingling, cooling or astringent sensations, *e.g.* capsaicin in chilli, piperine in pepper and carbon dioxide in carbonated drinks. When sensed in the oral cavity, these are communally known as mouth-feel.

14.2.2. Factors Affecting Sensory Measurements

Contrary to sensory gadgets, psychological or physiological factors can easily affect human decisions. In order to diminish or eradicate such biasness, panelists should pick right protocols and experimental design (Hough 2010). The possible sources of error and recommended approaches for tumbling associated effects are discussed below:

14.2.2.1. Psychological Factors

i) Expectation Error

The information about the samples to be assessed or objectives of the investigation can influence the decision of the panelists because assessor inclined to find what is desirable. Try to avoid including such persons in the panel who are familiar with the product. Furthermore, minimum possible information should be shared with the judges and don't reveal info concerning the samples unless it is indispensable due to religious integrity especially while using innovative ingredients. During sample coding, use random 3-digit numerics rather colors or alphabets. Numbers like 15, 911, 1122 have specific links, hence should be avoided. Similarly, Codes such as 'A', '1' or round numbers (e.g. 100, 250) can be related with a higher score.

ii) Suggestion Effect

Sensory evaluation should be carried out in designated facility in order to avoid the influence of commentaries or sounds on the judgment. There should be separate sensory booths for sample evaluation and judges should be discouraged for any discussion related to samples before or after assessment except instructed to do so.

iii) Stimulus and Logical Error

Logical error happens when the stimulus is rationally allied with one or more of the attributes under appraisal. This occurs when evaluators use extra info while making a decision about the samples. For examples, food products with intense color are supposed to be more intense in flavor. Similarly, a thin cream layer is assumed as poorer quality. Sometimes conducting sensory evaluation at an unusual time, may prompt evaluators to think about a manufacture problem. Similarly use of costly containers may lead appraisers to think that foodstuffs is of superior quality. Try to disguise irrelevant variations and ensure that sample characteristics are consistent using suitable colored illumination, coverings and ear guards.

iv) Distraction Error

Stimuli like radio, chatting and personal obsessions in the evaluation area can easily influence the panelists. Use of electronic as well as communication devices should be prohibited in the test area in order to create noise free environment. Furthermore, create an atmosphere that inspires professionalism amongst the evaluators.

v) Attribute Dumping

While designing sensory performa, efforts should be made to include all possible attributes for optimum evaluation. It has been noticed that if judges are not given the chance to rate all the traits they observe in the foods under assessment, they still exhibit their opinion using existing attributes. For example, if samples are varying in sweetness but no sweetness characteristic included in the performa, panelists record this variation on a flavor intensity scale.

vi) Order Effect

This hedonic response of preceding sample can influence the attribute of the next sample *e.g.* a sample is considered less sweet if next one is with greater intensity. Furthermore, the sample position may affect the scoring *e.g.* sample placed at first position is generally assigned higher scores in hedonic scale. Order effect can be reduced through randomization or balancing the order of sample presentation. Use a mock sample at position one is suggested for effective evaluation.

vii) Acclimatization

This happens where judges evaluate similar stuff repetitively. In order to diminish the influence of adaptation, present spiked samples from time to time or vary products.

viii) Halo Effect and Proximity Error

This usually happens while judging numerous traits in a single run especially by the untrained assessors. In this case, scoring one attribute may influence the assessment of other characteristics *e.g.* sweet sample may be regarded as stickier. Wherever possible, assess one, or at least a limited number of qualities at a time. Furthermore, try to use trained panelist and randomize the order of characteristic when evaluation of several traits deemed necessary at once.

ix) Contrast and Convergence Effects

To reduce the contrast and convergence effects, randomize or balance the order of presentation of samples and consider eliminating outlying samples from the sample set.

x) Motivation Error

An interested judge perform sensory evaluation more consistently. Usually assessors rate the samples based on their feeling about the food manufacturer or team leader. This can be a concern especially if evaluation is being carried out by the company employees. To minimize this error, try to do the sensory analysis in a professional manner by giving regular feedback and due respect to the judges.

xi) Central Tendency Error

This is more likely to happen with untrained evaluators or when they are not conversant with the product range. When using scales, judges mostly give scores to the middle of the scale. Encourage them to use broad scale to differentiate between the products and this is especially important when using unskilled assessors. There is need of panelist training in the use of the scale and exposure of a wide range of products in order to cope with central tendency error.

14.2.2.2. Physiological Factors

i) Adaptation

There is a strong association between reduction in sensitivity with the continuous exposure of a stimulus and reduction in response to other stimuli. Subsequently, sensory assessment is affected by the adaptation to a stimulus. These are known as carry-over effects. To decrease the adaptation impacts, first confine the number of samples to be evaluated. Then ensure sufficient time interval before proceeding to the next sample to recover the sensory system. This duration ranges from a few seconds to hours, contingent with the stimulant *e.g.* cooling can take 10 minutes to retreat. The panelists should be provided appropriate palate cleansers in order to ensure cleaning of oral cavity, *e.g.* milk may be desirable for some spicy compounds.

ii) Physical Condition

Sensory evaluation is strongly influenced by the age, health, nutritional disorders, hormonal state, stress level and mood of the assessors. Additionally, uses of medicines further aggrieve the situation. In this situation, assessor's screening is suggested prior to testing or eliminate data of the panelist if medical conditions affect the sensory performance. Sensory sessions should be schedules around a similar time each day preferably between 10 and lunch. Furthermore, ask evaluators to restrain from eating for at least an hour before evaluation.

iii) Perceptual Interactions between Stimuli

Certain stimuli can interact to cause suppression (existence of one ingredient diminishes the perceived concentration of another, *e.g.* sourness reduces apple flavor), potentiation (occurrence of one element surges the intensity of another, *e.g. Chinese* salt accelerates the meat flavor) and synergy (intensity of a mixture is greater than the intensity of the sum of the individual components, *e.g.* sweetness and sourness impact on strawberry flavor).

14.2.2.3. Cultural Factors

This is especially important when working with assessors from diverse regions or cultures. In some cultures, specific product codes may have significant associations; eating in public is considered as a social offensive; religious limitations may influence sample selection. In addition, the use of a scale can differ across the cultures, *e.g.* some inclined to score lower than 'average' or much higher while using the hedonic scale. For effective sensory evaluation, be aware of cultural tendencies as these strongly influence many aspects of sensory testing such as products, protocols, scale use and feedback.

14.3. Principles of Good Sensory Testing

Sensory assessment requires various kinds of controls which influence the sensitivity of the tests. The major environmental controls include elimination of psychological distraction, irrelevant odor and light stimulation. The ultimate goal is

to provide conducive environment. Preferably sensory testing must be done using specially designed facilities. However, where such facilities do not exist, researchers should create comfortable environment as closely as possible (Chambers and Wolf 1996; Hough 2010).

14.3.1. General Requirements and Conditions for Sensory Testing

14.3.1.1. Testing Facility

The sensory facility should be situated close to potential panelists in odor and noise free area. The location should be conveniently accessible to the assessors with minimal disturbance in normal routines. Inconvenient testing facility adversely affects the motivation and performance of the judges. The laboratory should be away from heavy flow of traffic in order to avoid confusion and noise. In a food industry, this facility generally should not exist next to a lobby or cafeteria, due to possibility of disturbing the evaluation process. However, this requirement may appear to conflict with accessibility. Sensory laboratories may be near those areas for accessibility purposes without compromising testing conditions if special procedures to control noise and confusion, such as sound-proofing and waiting rooms, are used. Sensory booth area must be easily accessible to the assessors and there should be sufficient space for parking. The preferred place for sensory laboratory is ground floor of a building. Furthermore, the traffic pattern of the assessors should also be considered and access to the facility should bypass food preparation and administration areas. A well-equipped and specially designed sensory laboratory should have the following areas:

i. Waiting room area
ii. Briefing area
iii. Sample preparation area
iv. Evaluation area
v. Discussion area

i) Waiting Room Area

This area has long lasting impact on the panelist's perceptions about the facility. It should be comfortable and well lit. To reduce tediousness associated with waiting, this area should have some light reading. In some facilities, a child care area is available for the care of kids during the evaluation process. However, efforts should be made to prevent the noise and interruption from this area to evaluation area. Additionally, facility manager should try to curtail the waiting time by aligning the evaluation process.

ii) Briefing Area

This area should be nearby to waiting room or placements can be done in the waiting room itself by making seating arrangements in rows or semi-circle. This type of organization will further be helpful for briefing the panelists about the

procedures, protocols and instructions before entering the test area. Additionally any ambiguity can be addressed and assessors facing problems can be further coached.

iii) Sample Preparation Area

This area is generally meant for food preparation and is usually equipped with equipments commonly used in the preparatory operations and storage purpose. The assessors should not have physical and visual access to this vicinity. Sample preparation area usually differ depending upon the product lines being evaluated in a particular facility e.g. there is no need of cooking utensils and ovens in a facility designated for the evaluation of frozen products however freezers are required for storage of the stuff. Similarly, a facility intended for meat evaluation would need refrigerators, stove etc. Microwave ovens is generally required for heating of samples before serving. Space is also required for the storage of samples under various storage conditions, reference standards, utensils, rice cookers, tea pots, serving trays, serving dishes, computer printouts etc. The counter space should be sufficient to set up multiple sessions simultaneously. For the purpose, food service trays and vertical carts can be used as a holding space. Food preparation facility should be constructed with easy to clean materials. Ensure sufficient supply of clean water for washing of dishes and trays as well as panelists for rinsing of mouth between the samples. Additionally, trash cans should be available in the preparation area. Above all building codes should be followed to avoid from fire hazards and sewer issues in this area.

iv) Evaluation Area

Sensory testing can be carried out in a simple room large enough to accommodate sensory booths. If these booths are not available, facility manager should atleast arrange tables in a way that assessors may not interact with each other to avoid from any influence on sensory evaluation. Preferably isolate the judges with temporary booths which can be made using economical plywood. Additionally, environment of the evaluation area should be noise free to avoid from any type of disruption. Modern sensory facilities have computer screen in sensory booths and space for placement of samples. Some companies prefer to use classroom style for testing of products. This arrangement is especially meaningful when vocal instructions have to be communicated to whole group instantly. Overall sensory testing area should be isolated and comfortable with professional look. Use of neutral or non-distracting colors is advisable. The number of booths in a facility may range from 3-25 depending upon the space available. Ideal booth size is 1x1 meter. These booths should be divided with opaque separators about 1 m above the counter top to prevent interaction and concentration of the panelists. There should be enough corridor for the movement of the assessors. Furthermore, for disabled persons instructions regarding width of the corridor, seating arrangements and counter top height should be observed. The booth counter is usually 2.5 to 3.0 inches high and should be spacious to accommodate samples, score sheets etc. This is usually 45x40 cm however it depends on the size of serving trays used in the facility. These hatches are mostly sliding door style with the advantage of less space occupied in the serving counter. The chief drawback of these doors is chance

of visualizing the preparation area. The fitting of sinks in the booth should be avoided due to source of odor contamination and difficulty in maintenance. It is better to use disposable water glasses rather than sinks.

v) Discussion Area

This is also called as conversation area. It should be simple and easily approachable to the assessors. The final results of the sensory testing are mainly reliant on assessors as they are sensory instruments hence foremost duty in the sensory assessment is sufficient screening and training of the assessors. In consumer acceptability studies, efforts should be made to provide conducive, pleasant and quiet environment so that they may perform product evaluation without interfering each other.

14.3.1.2. Sensory Laboratory Layout

One objective in designing a laboratory is to arrange the test area to achieve efficient physical operations. A second objective is to design the facility to avoid distraction of testers by the operation of the laboratory equipments/personnels or by outside persons. A third objective is to minimize mutual distraction among respondents. The testing area should be divided into at least three parts; one for sample preparation and storage, second for briefing and discussion and third for actual testing (Fig. 14.1). These areas must be separated adequately to eliminate interference if preparation involves cooking, odorous, and visual materials. For most types of tests, individual panel booths (Fig. 14.2) are essential to avoid mutual distraction among testers. However, they should not be built so that respondents feel completely isolated from others. It is important to provide a separate space where test respondents can wait either before or after the test without disturbing those who are testing. Briefing and discussion area can be used for this purpose. This place also serve for social interaction, payment of stipends, or other business that should not take place inside the actual room(s) used for testing.

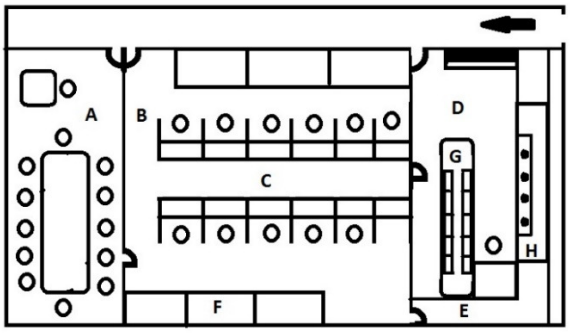


Fig. 14.1 Layout of an ideal sensory testing facility (A: Briefing area; B: Testing booths; C: Distribution and serving area; D: Preparation area; E: Store room; F: Cup-boards; G: cooking ranges; H: Refrigerators & deep freezers

Fig. 14.2 Modern sensory panel booths

14.3.1.3. Climate Control

Sensory facility particularly evaluation and discussion areas should be odor free and temperature controlled. There should be excellent arrangements for proper ventilation. The use of disposable filters in the ventilation system pipes is encouraged. Odor transfer from the food preparation area can be minimized with slightly positive pressure in these areas. Overall these should be noise interruption free. Signs necessitating calmness during testing times in the lobbies around these areas are helpful. Furthermore, the noise created by nearby mechanical systems including refrigerators, freezers, air conditioners and processing equipment should also be curtailed. The temperature (20–26◦C) and relative humidity (50–55%) in evaluation and discussion areas should be maintained. Efforts should be made to make the environment comfortable for the testers. Lighting in these areas should be comparable to intensity in workplaces and controllable with a regulator.

14.3.1.4. Odor Control

The testing area must be kept free from odors. Although it is very difficult to attain, an air temperature and humidity control system with activated carbon filters could be helpful in odor control. As suggested earlier, a slight positive air pressure in the evaluation area is recommended to decrease invasion of air from the preparation room and other areas. Air from the sample preparation room should be vented directly outside the testing facility. Fresh air should not come from high odor production areas such as manufacturing exhaust vents or garbage dumpsters. Furthermore, all equipments and materials inside the room should either be odor-free or have very low odor level. If extremely aromatic foodstuffs are to be examined, dividers to help control odor transmission are indispensable. Air in the testing facility may become tainted from the samples themselves, hence protocols must be established while testing such materials so that odorous samples are exposed for a minimum time and the atmosphere of the room can be reverted to normal before the analysis of other samples.

14.3.1.5. Lighting

Overall illumination of the laboratory should be with luminous uplighters as these are comparable to daylight in brightness and do not produce too much heat. Colored lights are usually optional in testing facilities to disguise color variations among the food products *e.g.* minced meat has tendency to change color and develop odor during the storage. If odor is the critical descriptor, then the evaluator has to disguise the color differences. In case of strawberry flavored yoghurt, if panelist has to decide which sample has a stronger flavor? The sample with higher red color intensity, can create doubt and biasness which can be eliminated by keeping all samples under a red light. In consumer testing studies, it is very difficult to create atmosphere and lightening conditions just like in laboratory setup. In this regard, the serving samples can be placed in a particular sequence in order to minimalize appearance comparisons. Furthermore, consumers can be requested to consider only flavor or odor rather color of the product.

14.3.1.6. Time of the Day

Sensory tests should preferably be performed in the morning or afternoon. However, trained panelist can do this job any time. Preferably try to avoid tests after meals by better results.

14.3.1.7. Carriers

These are required for some food products to form a base for the food being tested *e.g.* cream fillings in pastries. In sensory evaluation, the main goal is to make the test more sensitive to find out product differences. However, use of carriers minimizes assessor's capability to distinguish difference due to alterations in the flavor, texture and mouthfeel characteristics. Hence, carrier are not desirable in some situations due to decrease in test sensitivity for perceiving sensual variations. However food products which are frequently consumed along with other food stuff, use of carrier is advisable. Similarly, in some situations it is suggested to do the test both with and without carrier if time and capital permit. The sensory expert should discuss with the customer whether the degree of realism in the test is a concern and then decide about the use of carriers.

14.3.1.8. Serving Temperature

In sensory evaluation, samples should be served at temperature these are usually consumed *e.g.* soup should be served hot and carbonated drinks must be cold. However, in case of trained sensory panel temperature sometimes vary from normal eating temperatures. Liquid milk can be served warm or cold depending upon the objectives of the evaluation. International Dairy Federation recommends a temperature of 16°C for liquid milk and 20°C for reconstituted powdered milk. It's better to serve milk at 16°C rather at 4◦C to boost the perception of volatile flavors. If sensory evaluation is carried out at room temperature then sensory specialist should record temperature during each session. Furthermore, holding time at the specified temperature should be elaborated in the test protocol for the safety of the product under assessment.

14.3.1.9. Sample Size

It depends upon the test objective however sample should be sufficient (about 30 g or adequate for 2-3 sips) for the overall assessment of the product. In consumer tests, this quantity is usually doubled. The sensory specialist specifies the sample size keeping in view the objective of study, normal portion size and mouthfeel of the product and number of characteristics to be evaluated. In some cases a minimum amount to be eaten may be specified. This is especially significant in consumer tests where some assessors may be timorous about tasting novel products. Overall, sample size is decided keeping in view the factors like cost associated with the product, its preparation and storage.

14.3.1.10. Serving Containers

It depends upon the circumstances and protocol established in sensory facilities. Sometimes it is economical and time saving to use disposable containers and sometimes dishes can be washed if number of samples are limited and sufficient time is available. Additionally, in some testing facilities, use of disposable dishes is discouraged due to environmental and financial restrictions. The choice of container should not negatively affect the sensory attributes of the product. Mostly cups and plates made from Styrofoam are preferred due to convenience in use, easy labelling and economical nature. However these containers can badly affect the flavor of hot drinks.

14.3.1.11. Number of Samples

The number of samples depends upon the nature of samples and test. In case of hot and spicy foods, only 2-3 samples should be assessed in a sitting due to carryover effects where as in case of bakery products 8-10 samples can be evaluated simultaneously. In hedonic test a single sample may have to be tested for atleast 4-5 times and if 8-10 samples have be evaluated, sensory evaluation will be too difficult. In a paired preference test there is little tiredness as judge tastes a sample once for liking or disliking so the number of samples can be more. As a general rule it must be considered that panelist can lose his or her motivation and evaluation ability if too much samples are offered for evaluation in a session.

14.3.1.12. Coding and Order of Presentation

Generally samples are coded with arbitrary selected 3-digit numbers to avoid biasness and order randomly to avoid artifacts associated with order of presentation. Order of presentation can be random or balanced depending on the test. In consumer tests the mostly the order of presentation is balanced whereas randomized order of presentation is suggested for descriptive tests and order of presentation is balanced in discrimination tests such as paired comparison or triangle tests.

14.3.1.13. Procedure for Sample Preparation and Serving

Efforts should be made to standardize sample preparation techniques and serving procedures except the variable(s) under appraisal e.g. if the effect of dietary fiber incorporation in bread formulation is to be evaluated, all bread samples must be

baked under identical conditions. Cutting cheese samples into cubes by two different technicians can impact the size slightly and ultimately appearance may lead to biasness. While using carriers or combinations of products timing of this process must be consistent. If breakfast cereal are evaluated by pouring in milk, the time between pouring and tasting must be the same for all samples. The sensory specialist should kept in mind the container type, sample size and shape, visual appearance, serving temperature, use of carrier, number of samples in a session and rinsing mouths between the samples.

14.3.1.14. Palate Cleansers

Trained evaluators generally use a palate cleanser during sensory evaluation to reduce the residual materials from previous samples. The most frequently used palate cleansers in sensory evaluation laboratories include water, bread, apples and saltless crackers. Sensory standards recommend use of milk for products with garlic or spices and warm water for products that leave an oily residue. Sometimes carryover effects can be diminished by extending time duration between the samples. During training sessions, assessors are offered a variety of palate cleansers to find out the most suitable one for the product under consideration. Generally, crackers, bread and apples are escorted with water. In consumer testing only water serve the purpose as it has been observed that serving all these things make the process more complex. Additionally, it has been noticed that in spite of instructions it is difficult for them to remember eating a sample and then a piece of palate cleanser followed by rinsing with water.

14.3.1.15. Swallowing and Expectoration

Swallowing is evaded in most of the sensory assessments and usually samples are ejected except in some products and flavor systems *e.g.* throat burn is vital in pepper samples. This is expected to provide less carry-over effects one product to the next. Additionally consumption of product rich in fat and sugar can add needless calories to evaluator's diets. Obviously, swallowing can affect consumer's opinions on the products especially in studies where acceptability is to be measured. However, the main benefit of ingestions in sensory evaluation is the stimulation of receptors in the throat.

14.3.1.16. Instructions to Panelists

It is often necessary to give the instructions to the assessors on how to perform the sensory evaluation both verbally before entering the evaluation area and in written form on the score sheet. The instructions to panelists should be very clear and short. These guidelines should be pre-tested one before the project attempts to follow them. Furthermore, the instructions to the support staff should also be very clear and preferably should be written in order to avoid any ambiguity among the sensory specialist and technician. It is a good practice to develop standard operating procedures available in the laboratory.

14.3.1.17. General Comfort

For concentration of the judges, the atmosphere of the sensory testing facility in general and particularly testing room should be relaxed and comfortable.

Temperature and humidity of the testing area should be controlled to deliver steady coziness. Besides selecting and installing fixtures, efforts should be made to provide other facilities like coat closets, lockers and rest room so that evaluators can perform the task with more concentration.

14.3.2. Panelist Considerations

14.3.2.1. Incentives

This is an effort to motivate the people to volunteer. Sensory specialist should be ready to answer the question from a panelist "What is in it for me?" In academic settings usually staff members and graduate students participate in sensory testing on volunteer basis due to many reasons including positive feelings from helping out in the testing program. In some cultures, the motivation will be sense of social responsibility and desire to support group effort. Similarly in industry sensory panel participation should be a volunteer activity. However with the passage of time, the motivation for participation in sensory testing just only on volunteer basis is declining in academia as well as industry leading towards the concept of the token incentive. This incentive should be enough to motivate the person for participation in the activity but not too much that it become the only reason for the participation. Usually overpaid individuals may have no motivation during the session and they are just in the activity for the money. In consumer testing where there is little or no fidelity and long term concern and commitment, the payment is of primary apprehension. In case of employees, snacks can be served at a social break time. Here chance for social communication may become a motivating factor. Free company products and small gifts are mostly used as common incentives. However to ensure maximum participation of the assessors larger gifts and social gifts like parties can be arranged. Sometimes appreciation form the management considering panelist contribution towards research & development also serve the purpose. Support for sensory evaluation must extend through all levels of management from supervisors to top management.

14.3.2.2. Use of Human Subjects

The health and safety of the panelists should be the primary consideration and sensory expert should follow the following guidelines while using human subjects:

- It is vital to get voluntary consent of the assessors for participation in the project.
- The investigator must ensure that there will no health related risk associated with the study.
- The assessor should be taken in confidence if any risk is associated with the study.
- The subjects have the right to exercise their free choice in the evaluation.
- The results of the study should be useful for the society.

Most of the sensory studies pose no risk above the normal risks of everyday life. However, in some cases physical risks may occasionally be present *e.g.* during

product development, various ingredients and food additives are tested before these have achieved generally recognized as safe status. In this situation, the panelist must be informed about the possible risks allied with the product under consideration and their participation in this activity should be voluntary. In advanced country Human Subjects Institutional Review Board approve the protocol of the study regarding responsible use of human subjects in the research and development.

14.3.2.3. Panelist Recruitment

The recruited subjects must be aware of their role in the evaluation and what is expected from them during the study. The sensory specialist should provide maximum information regarding time commitment and product categories before their commitment for participation in the project. Information related to incentives should be clearly shared. In academia, the sensory expert must obtained signed consent form the assessors regarding volunteer participation in the study in order to get approval from the institution's Human Subjects Institutional Review Board. In industry, sensory specialist must ensure approval of the panelist from their supervisors.

14.3.2.4. Panelist Selection and Screening

Sensory expert has to screen assessors regarding sensory perception. For the purpose, the sensory specialist carry out a variety of tests related to products under investigation and some general tasks required by the panelist. However it is suggested that screening test should be simple and not to over-test judges before performing true product assessments. Too many screening tests could reduce the motivation and eagerness of the assessors at the time of actual evaluation. In some situations, medical screening is required before participation in the study.

14.3.2.5. Training of Panelists

It depends upon the level of sensory evaluation as in-depth training is required for descriptive tests whereas only minimum training is prerequisite for discrimination tests. During the training the panelists must realize that sensory evaluation is a difficult task which requires full concentration and attention. For training purpose, sometimes fresh assessors have to work with experienced judges who have been trained for other product categories. Appreciation form the top management is a source of motivation and encourage to the panelists.

14.3.2.6. Panelist Performance Assessment

Most of the food industries have panelist assessment and reporting programs in place. Use of trained panelists over extended periods results in less motivation and participation during evaluation sessions. The performance of trained assessors who do not participate in sensory evaluation over extended period of time due to leave, transfers and vacations may deteriorate and need re-training.

14.3.3. Test Location

Generally test locations include laboratory, central location, and home use; each has associated merits and demerits:

14.3.3.1. Laboratory

In this case, employees or local citizens are the main participants for sensory evaluation in a company or institution. The main advantages of sensory laboratory include easy accessibility, carefully controlled atmosphere, prompt analysis of results and evaluation of relatively large number of samples in a session. This type of setup is helpful for shelf life studies where consumer have to taste six or seven samples with different storage times. This procedure is easily accomplished in a laboratory setup. A consumer can taste half of the samples followed by fifteen minutes break for palate cleansing and then taste the leftover samples. The main disadvantage of the laboratory location is that the site reflects that the products are from the company and can thus create prejudiced results. Likewise, standardized preparation procedures and product handling protocols might not impressionist consumer experience and behavior at home.

14.3.3.2. Central Location

Sensory evaluation at a central location is generally carried out in a rented setup probably unused portion of a restaurant. Assessors are captured when they are on the way to shopping malls or street pavements. After initial screening thorough some questions, selected ones are requested to contribute in a consumer testing. Customarily they are incentivized with gifts after performing the tests. The main advantage of central location tests is that subjects are true representatives of the target population. For effective assessment, the number of questions and the products should be limited due time limitations of the respondents. Generally, nobody is ready to spare more than 15-20 minutes to perform these tests. These type of tests can also be useful for shelf life studies (SSL) where usually 6-7 samples have to be evaluated which require about 15-20 minutes. However, efforts should be made to keep the questionnaire very brief. In most of the SSL studies the only answer we need from a consumer is whether he or she accepts or rejects the sample. In this situation, a central location test would be suitable. The main disadvantage of central location is that conditions are artificially compared to real product usage at home, in a restaurant, or at a party.

14.3.3.3. Home Use Tests

These tests are performed to evaluate the real usage of the product at home and usually carried out at the end of food product development stage. The main advantages of home use tests are that the products are manufactured and consumed under natural conditions of use; hence more elaborated information about the general use can be gathered. Likewise, info can be collected over recurrent use of the product rather than first imprint only. The drawbacks of home use tests include more time consuming, poor sanitary control, testing of limited number of samples usually 2-3 samples and little control over preparation and ingestion of samples. Sanitary control is also of importance.

14.3.4. Selecting Consumers

Selection of the consumer is the heart of sensory assessment as results drawn from a limited number of assessors have to be applied on target population. During product development, huge amount is spent in conducting consumer tests. It is always difficult to convenience the top management to devote resources for the conduct of consumer acceptability tests; hence low cost solution are sought by involving local residents or even workers of the industry. However, it is suggested that certain guiding principles should be followed in this regard.

14.3.4.1. Number of Consumers

The number of consumers is linked with the panelists either they are trained or untrained. In consumer acceptability studies, considering the average standard error and a difference between sample means of 10% of the sensory scale, atleast 112 panelists are required for a particular set of parameters. In some cases, if product acceptability has to be determined at three different locations in a country, total 336 consumers and 112 at each location would be required to compare the samples within each location.

14.3.4.2. Frequency of Product Consumption

In most of the sensory assessments, researchers prefer heavy users while determining frequency of product consumption. If the product is a certain brand of snack bars, heavy uses means individuals consuming this brand every day. To determine frequency of the consumption, it is suggested to take a survey of 40-60 company employees or local residents in the neighborhood of institution and inquire them how often they consume that brand of the snack bars. The result may by 1 out of 40. Hence if total 100 heavy users are required then nearly 4000 consumers will have to be interviewed. This requires huge cost and time; hence, the idea of heavy users is dropped and generally moderate or light users are interviewed for selection of assessors to find out significant differences between the samples.

14.3.4.3. Gender

In sensory self-life studies, gender differences have insignificant influence now a days. Earlier it was assumed that women consume zero calorie or reduced calorie products due to more weight conscious nature. Likewise, men were targeted for alcoholic drinks. These types of differences have been diminished with the passage of time as most of the products now a days are equally liked by the consumers without gender discrimination.

14.3.4.4. Income Status

Income of the users is an important issues in some cases. For example, children of high income families prefer chocolate based food bars while these item are not so much liked by the children of low-income families. But it is always difficult to screen out rich and poor families especially in countries or societies people are not ready to confess how much they earn. In these situations, indirect questions are asked like what type of car they have in their family and in what type of schools

they sent their children for education. The purpose of this activity is get rough idea about the income status and to find out target assessors accordingly.

14.3.4.5. Employees and Local Residents

Food industries often use workers or local residents in product development process due to associated high costs and time limitations. This type of sensory evaluation could by biased due to existing information of the product sensory properties leading towards possible rejection of the product even with small changes in the sensoric attributes. The normal or target consumers are unable to find out such small changes. Furthermore, factory workers usually find all samples acceptable due to loyalty to their company. Hence, employees and local inhabitants should be used in sensory assessment with cautions.

14.4. Sensory Evaluation Methods

Sensory evaluation plays significant role in quality control and marketing of the products. It is frequently used in food industries for new product development and recipe modification of the products. It is carried out to find out differences among the products, nature of difference and possible acceptance or rejection of products on the basis of differences. Sensory characteristics of food products can be assessed by using discriminatory, difference, descriptive and affective methods (Kilcast 2010; Lawless 2013). Within each category there are various sensory tests that can be carried out. Generally two types of sensory tests are common in practice. Objective tests are usually conducted by the trained panelists and provide objective data on the sensory properties of products. These are further divided into two classes i.e. discrimination and descriptive tests. Discrimination tests are useful in the assessment of sensory differences among the samples whereas descriptive tests further elaborate the nature or magnitude of sensory differences. Likewise, subjective tests deliver subjective data on the acceptability, liking and preference of the products. These are generally carried out by inexperienced judges. These are also famous as affective or consumer tests. The brief description of each type of tests is given below:

14.4.1. Discriminatory Testing

These tests are mostly employed in sensory science to determine differences among two or more samples. These tests are frequently used when differences among the samples are not obvious but need to be explored. These tests are commonly employed for screening and training of panelists, preliminary assessments, probing sensitivity thresholds, quality assurance and quality control, screening raw materials for consistency and inspecting the effect of ingredient/process changes, e.g. for cost reduction or supplier change. For appreciation of primary tastes, sensory evaluators are provided numerous coded samples which characterize primary tastes (sweet, salty, sour, bitter) and is enquired to ascertain the taste of each sample. In some cases, threshold tests are conducted to determine absolute threshold (the lowermost concentration of an ingredient that can be perceived) or recognition threshold (the bottommost concentration of a constituent vital for

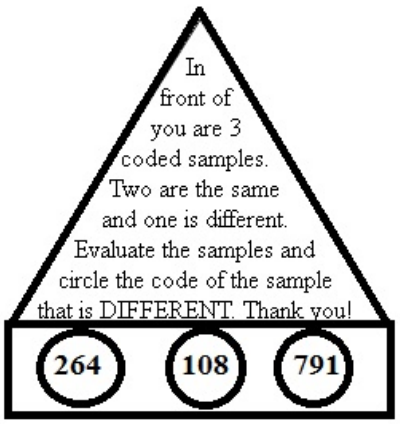
identification of the material or taste). For the purpose, numerous coded samples with different concentrations of a taste substance are offered to the judge to specify point he/she can notice the taste. Likewise, judges are asked to taste the coded samples having varying concentrations of a primary taste and rank them in order of increasing concentration of that taste. Overall, discriminatory tests are swift and can be performed by both simple and skilled evaluators. However, it is suggested that sensory panel should not be a blend of both simple and skilled assessors.

14.4.2. Difference Testing

These tests are used in food industries to perceive minor differences in the samples but not the size of the difference. These are usually carried out to find out differences among the samples and how peoples notice and describe the difference. Additionally, these are frequently used for screening and training of taste assessors. These tests can be accomplished by skilled as well as unskilled panelists. Difference testing is further classified into triangle test, paired comparison test, duo-trio test, multiple comparison test and ranking. The brief description of each is given below:

14.4.2.1. Triangle test

This test is valuable in quality control to detect ingredient substitution results and odd product from various manufacturing lots. Triangle test can also be used for screening panelists who are able to perceive a difference. These tests does not customarily specify degree of amount of difference. For the purpose, the assessor should be requested to postulate dissimilar attribute. In triangle testing, each assessors gets three coded samples, two are identical and one is different. The task is to pick out the unusual sample. If the judge isolates the odd sample correctly, then the answers to questions 2 and 3 can be analyzed. If not, they are disregarded.



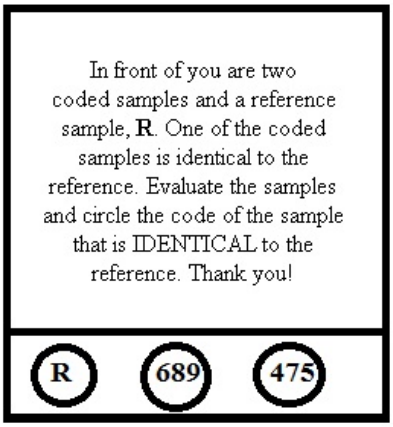
14.4.2.2. Paired Comparison Test

This test is also recognized as the 2-AFC test (2 samples, alternate forced choice test). In this case, each evaluator is provided with two coded samples and the task is to select the sample with the highest concentration of a pre-defined descriptor such

as sweetness. This test is only meant for a detectable difference and did not specify the degree of difference. The likelihood of choosing the right sample by chance is 50%; hence, paired comparison test is more authoritative in finding differences than triangle test. A paired comparison test is suitable for use in quality control; nevertheless, the exact characteristic evaluated is clearly stated must be known earlier.

14.4.2.3. Duo-Trio Test

In this case, 3 samples are provided to the judge; one is reference (labeled R) and other two are coded. One coded sample is a duplicate of reference and other one is dissimilar. The assessor is enquired to isolate the odd sample. This test is mostly used with strong flavor products due to less tasting required. This test is less effective than the triangle test because the probability of selecting the correct answer by chance is 50%. Additionally, duo-trio test is less sensitive compared with triangle test as it is easier to conjecture the right one.



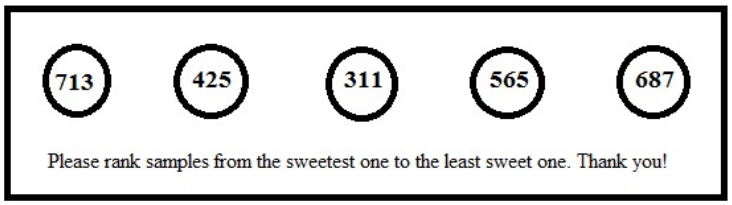
14.4.2.4. Multiple Comparisons Test

This is just like paired comparisons test. In this case, a reference sample (labeled R) is presented to the evaluator with numerous coded samples and each one is compared with the reference sample on the basis of a specific attribute.

14.4.2.5. Ranking

This is a quick technique for evaluating numerous samples at once and is frequently used for screening of 1 or 2 of the best samples in a group. The assessor is provided

with 3 or more coded samples and is asked to rank them for a specific trait. This test is similar to ranking for a primary taste but uses food samples rather than pure solutions.



14.4.3. Descriptive Testing

Descriptive tests are used in the food industry to elaborate the perceived sensory traits of foods. These are meaningful in assessing differences among the samples, their perceived sensory attributes and impact of variations in processing, packaging and storage situations on the sensory characteristics of the respective product. Descriptive testing is suitable for understanding the basis of product acceptability, probing the influence of changes in recipe or process on sensoric attributes, appraising critical parameters significant to quality control or shelf-life studies and supervising research and development of food products. The following methods are usually employed in descriptive testing:

14.4.3.1. Scoring Methods

These tests are also called as scaling methods and are used to find out the intensity of some traits. The assessor uses a structured or unstructured scale to express his/her decision. Scaling methods are helpful in establishing the size, intensity and direction of the differences for a particular trait; hence these tests should be executed by the skilled or trained personal. Usually a single attribute is rated on a structured scale, labeled with numerics and/or descriptive terms like very sweet, sweet and not sweet. The specific intervals on the scale are then transformed to figures for analysis. In contrary, unstructured scale have verbal anchors at the ends and/or the midpoint. The assessor marks the position of each sample on the scale which is converted to a numeric value by the sensory specialist commonly by gaging distance on the line. Scoring or scaling methods are mostly used in the food industries for quantitative descriptive analysis.

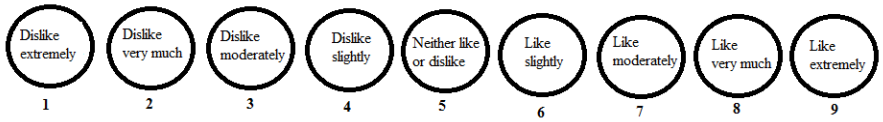
14.4.3.2. Other Descriptive Methods

Quantitative descriptive analysis, flavor and texture profiles are usually determined by highly skilled evaluators. Being the most sophisticated sensory methods, these demand training and practice.

14.4.4. Affective Testing

These tests are mostly used to establish the consumer acceptability or preference for a particular product through liking and disliking. Affective tests are employed in the food industry to determine liking and disliking of consumer, preference of

one product over another and consumers intention to use a product. Generally a fresh product is preferred over foodstuff close to end of shelf life. A rusk is expected to lose some of its crispness and slight change in flavor. Consumers are generally enquired whether they still consider these rusks acceptable in spite of changes in sensoric attributes during the storage. The most commonly used affective methods include paired preferences, ranking for preference and 9-point hedonic scale. In paired preference the assessor is enquired to point out sample of his preference among the two samples. A judge may choose one of the samples but find neither one desirable. This test is quiet simple and easy to perform especially when the desirability of one sample is known. In ranking for preference, the assessor is requested to rank 2 or more samples for being favorite. In hedonic scale, degree of liking for a specific product is assessed. The most commonly used hedonic scales are 7-point hedonic scale and 9-point hedonic scale with expressions stretching from dislike extremely to like extremely. By using hedonic scale, the evaluator can compare the acceptability of numerous products. 9-point hedonic scale is most commonly used in English speaking countries as well as in Pakistan.



14.5. Application of Sensory Science to Product Development

14.5.1. Sensory Evaluation in the Food Industry

Sensory testing is used substantially in the food industry for product development, recipe modification and the evaluation of products. It also plays a key role in quality control and in the marketing of products. Product development is a continuous process in the life cycle of foodstuff. Each year hundred thousand products are manufactured. It has been estimated that 75% of new products fail within a short duration after inception resulting in huge loss of financial and human resources. This usually happens due to discrepancies between the consumer expectations and sensory characteristics of the products. Sensory and consumer testing during the product development process usually permits cost effective distribution of satisfactory products diminishing the risk of product failure. Sensory testing is usually carried out by the food industries using their own testing facilities or sometimes sensory testing facilities of private companies or teaching and research institutes. Sensory evaluation results are either calculated manually or by using computer programs. Furthermore statistical analysis is carried out to ensure the reliability and validity of the results.

Food industries frequently develop products to taste like another, e.g. own label foods to taste like the brand leader. If a food is intended to taste like another, then a difference test is used. This may be followed by a preference test to find out the acceptability of the newly developed product among the customers.

Preference tests are used to find out the positioning of a company's product with its competitors. A ranking test may be done and if the results of are favorable to the company, this may be offered to the retailers to persuade them to allocate more shelf space to the company's product. Cost and quality are important factors in the food industry. A company may consider changing the supplier of one of the ingredients in a product for economic reasons. It is important that consumers do not detect that the product has been changed in any way. In this case the company may use a panel of trained assessors to carry out difference tests to determine if the testers can detect a difference from the original product. Companies may anticipate changes to their existing products based on consumer demand e.g. healthy eating, by replacing salt with a low sodium alternative. It is important that food companies are attentive to the demands of the consumer in order to retain their market share.

14.5.2. Product Development in the Food Industry

Increased competition in the food industry has led to the development of new products. There is also constant re-appraisal of existing products, leading to improvements *e.g.* in flavor or packaging. Product development may involve making a completely new food product - developing ideas for a new product by drawing up the product profile *e.g.* shape, size; modifying an existing food product - making changes to an original recipe *e.g.* adding or removing an ingredient to improve flavor or changing the size or shape of a product and matching an existing food product - copying other popular branded products of similar types. The process of product development involves a series of complex stages, requiring the combined talents of many specialists to make it successful. The main stages in product development include conceiving an idea followed by its small scale testing, product modification, consumer acceptability testing, fixing final specification, large scale production and finally its launch. At the initiation, ideas are developed for the new product and a specification is produced. Then this idea is tested on a small scale. Research is carried out to formulate a number of recipes and specify the ingredients to be used. Several versions are made, altering ingredients or processes. In other words the products are prototyped, often by a professional chef or food consultant. These developed products are evaluated by the trained panelist to ensure that it exhibits the desired characteristics. The recipe may need to be modified and further testing is carried out. The product is then tested on large scale to determine consumer acceptability. The final product specification is then agreed detailing the exact ingredients and methods of production. Food scientists work together in a pilot plant to determine the best method of producing large quantities of the product. The product is then produced on a large scale. This is done under controlled conditions to maintain consistent product quality. Appropriate packaging is chosen bearing in mind shelf-life considerations. Labelling is designed to meet legal requirements. Finally the product is advertised and then launched. Sensory analysis testing is carried out at many stages as the product is being developed.

14.6. Conclusions

Sensory evaluation encompasses a set of test methods and recognized techniques for product presentation, statistical methods and strategies for elucidation of results. Accurate application of sensory technique involves correct corresponding method to the objectives of the tests followed by good communication between sensory experts and end-users of the test results. In food industries, sensory evaluation department not only interact with product development department but may also deliver info to quality control, packaging, marketing and many other groups throughout a company. The main advantages of sensory information includes development of food products in an economical way by lowering risks in decisions about product development and strategies for meeting consumer needs.

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