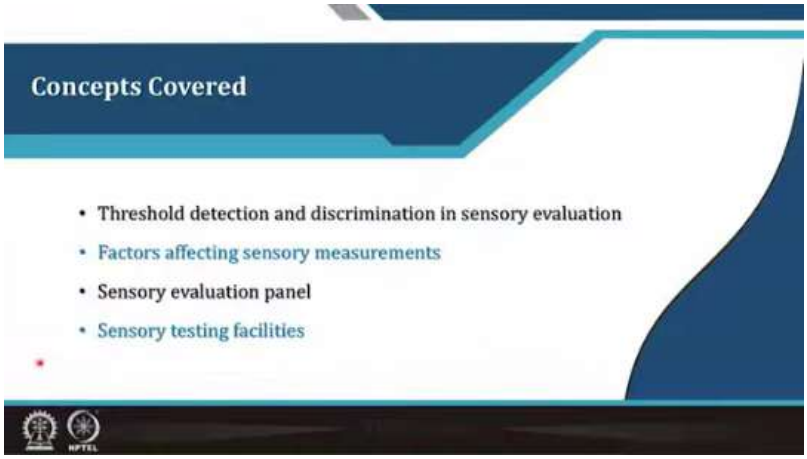
**FOOD SCIENCE AND TECHNOLOGY**

**Lecture19**

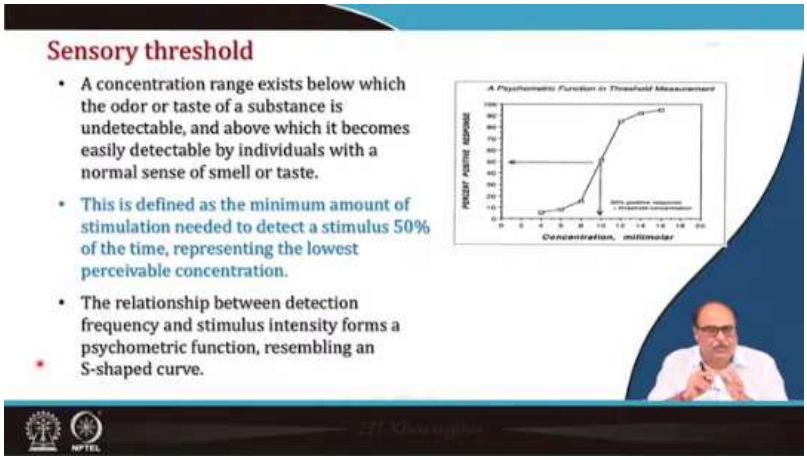
**Lecture 19: Psychophysics of Sensory Perception**

Hello everyone. Namaste. In the last class, we studied the sensory evaluation methods. What are the various methods that are used to analyze food organoleptically?

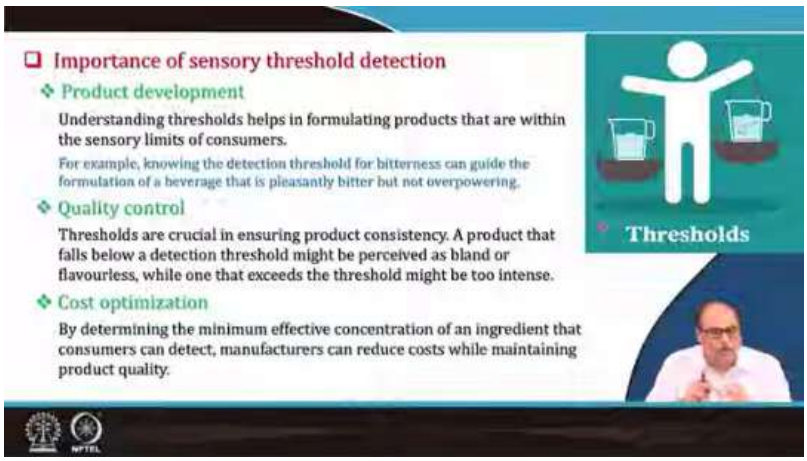

In today's lecture, that is lecture 19, we will talk about the psychophysics of sensory perceptions.




In this, the various topics that we will cover include threshold detection and discrimination in sensory evaluation, factors affecting sensory measurements and we will also talk about how we should select, what should be the type of sensory evaluation panel, and the sensory testing facilities.

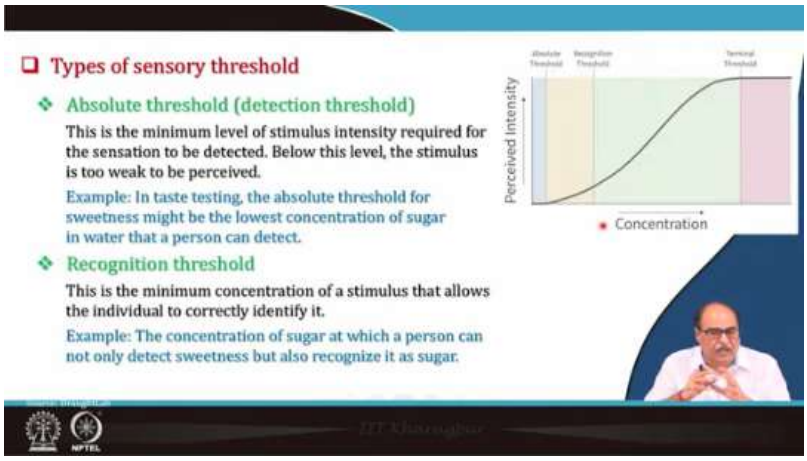



So, let us first talk about the sensory threshold. Now, a concentration range exists below which the odor or taste of a substance is undetectable and above which it becomes easily detectable by individuals with a normal sense of smell or taste. This concentration range is known as the threshold value, that is the minimum amount of stimulation needed to detect a stimulus 50 percent of the time, representing the lowest perceivable concentration. The relationship between the detection frequency and a stimulus's intensity forms a psychometric function, resembling an S-shaped curve which you can see here and this is the 50 percent positive response threshold concentration you can see here. That is the 50 percent threshold concentration.

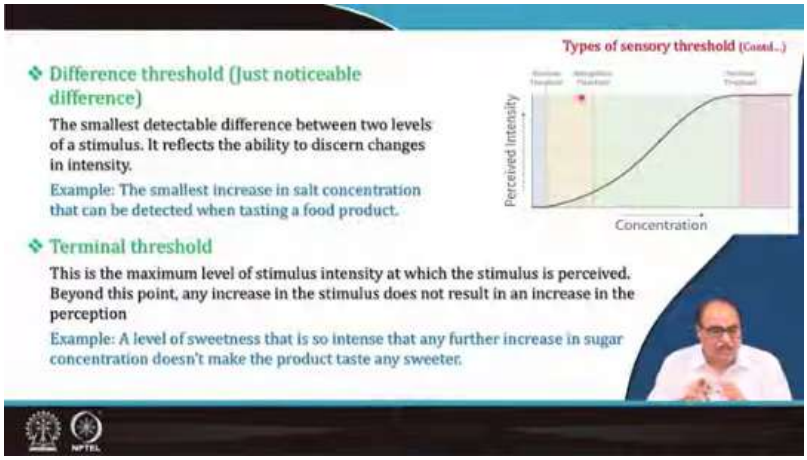



So, the importance of sensory threshold in the detection methods: It is used for various purposes like product development. Understanding the threshold helps in formulating products that are within the sensory limits of consumers. For example, knowing the detection threshold for bitterness can guide the formulation of a beverage that is pleasantly bitter but not overpowering. Similarly, this threshold limit can be used for quality control. It is crucial in ensuring product consistency. A product that falls below the detection

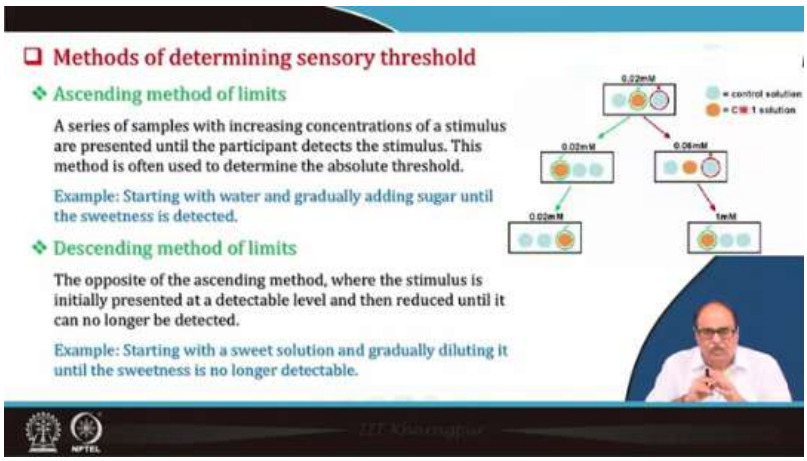
threshold might be perceived as bland or flavorless, while the one that exceeds the threshold level might be too intense. Then, this threshold also helps in cost optimization by determining the minimum effective concentration of an ingredient that consumers can detect, manufacturers can reduce costs while maintaining product quality.



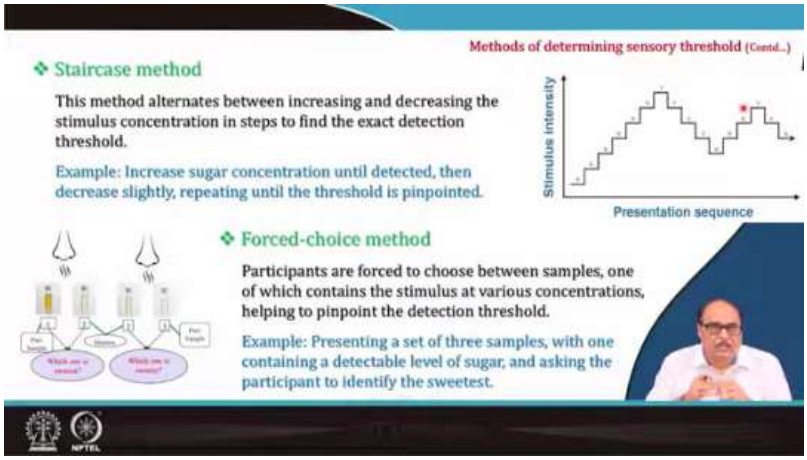

The types of sensory thresholds you can say are absolute thresholds, also known as detection thresholds, you can see here in the figure. This is the minimum level of a stimulant's intensity required for the sensation to be detected below this level. The stimulant is too weak to be perceived, for example, in the testing. That is for the taste in determining the absolute threshold for sweetness, it might be the lowest concentration of sugar in water that a person can detect. Then the second threshold is after the absolute threshold; it comes the recognition threshold. This is the minimum concentration of a stimulus that allows the individual to correctly identify it. Like, for example, the concentration of sugar at which a person can not only detect the sweetness, but they can also recognize that it is sugar. So, that is known as the recognition threshold.



Then comes the difference threshold or just noticeable difference. The smallest detectable difference between two levels of a stimulus. It reflects the ability to discern the changes in intensity. Like, for example, the smallest increase in the salt concentration that can be detected when testing a food product; that is the difference threshold. Then, finally, comes the terminal threshold; you can see in the figure here and this is the maximum level of stimulus intensity at which the stimulus is perceived. Beyond this point, that is beyond the terminal threshold point, any increase in the stimulus does not result in an increase in the perception, like, for example, a level of sweetness. That is so intense that any further increase in the concentration does not make the product taste any sweeter, more sweeter like that. So, that is called the terminal threshold.



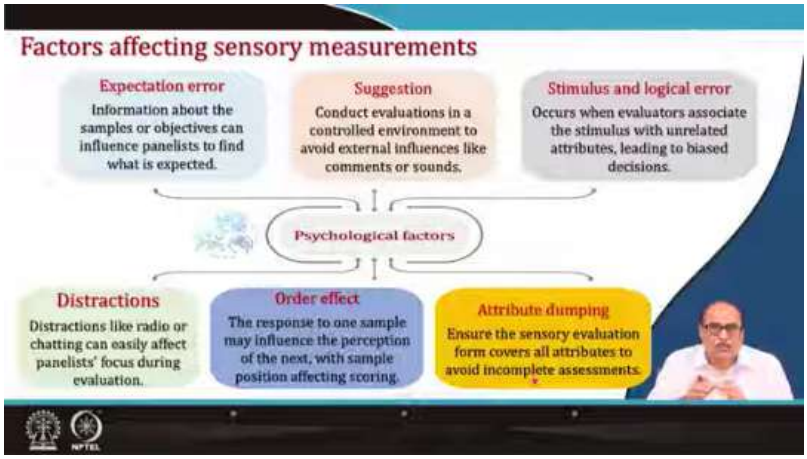

So, now let us see what are the various methods of determining sensory threshold. It may be the ascending method of limits or the descending method of limits. Like in the ascending method, a series of samples with increasing concentrations of a stimulus is presented until the participant detects the stimulus, and this method is often used to determine the absolute threshold. For example, start with water and gradually add sugar until the sweetness is detected. Then, the descending method, is the opposite of the ascending method, where the stimulus is initially presented at a detectable level and then it is reduced until it cannot be, or it is no longer able to be detected. Like, starting with a sweet solution and gradually diluting it until the sweetness is no longer detectable. So, these are the two methods by which one can find out the sensory threshold.



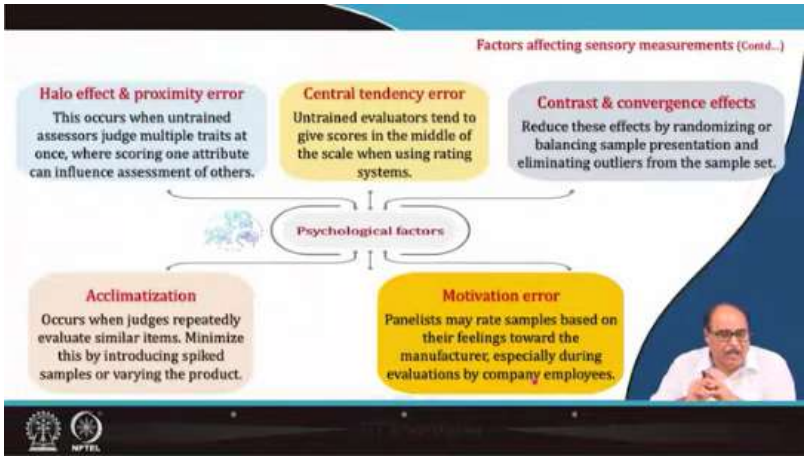

Then, there is also another method, like the staircase method. You can see here in the figure staircase method where presentation sequence and stimulus intensity are shown. So, this method alternates between increasing and decreasing the stimulus. Here, increasing then decreasing the stimulus concentration in each step. To find the exact detection threshold, like increasing sugar concentration until detected, then decreasing slightly, repeating until the threshold is pinpointed. Then, the forced-choice method of detection threshold. Here, the participants are forced to choose between samples, one of which contains the stimulus at various concentrations, helping to pinpoint the detection threshold. Like for example, presenting a set of three samples, here, three samples are presented with one containing a detectable level of sugar and asking the participant to identify which one is sweeter. Which one is there: two pure samples and one mixture sample, and then the participants or panellists are asked to identify.


Then, an example of threshold detection in the food and beverage industry can take sugar in soft drinks; determining the detection threshold for sweetness helps manufacturers strike a balance, ensuring their drinks are sweet enough to satisfy consumers without being overly

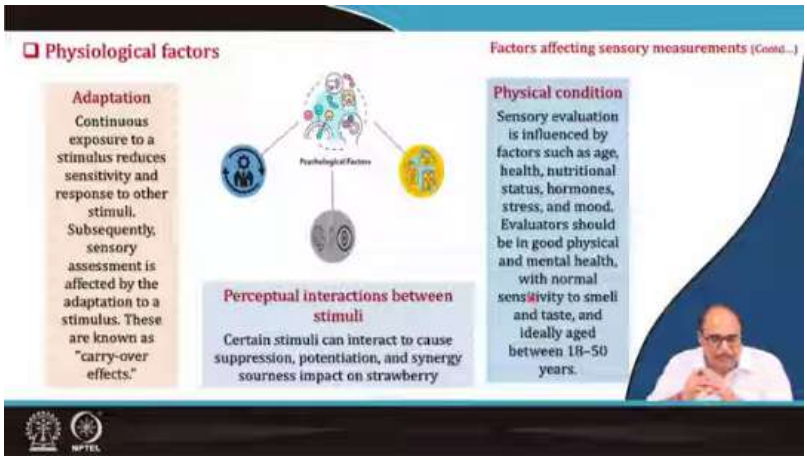
sweet and then addressing both taste and health concerns. Similarly, the bitterness in coffee. Coffee producers test the detection threshold for bitterness to create a product with a pleasant, balanced bitterness. That appeals to consumers without being overly harsh. Similarly, ice cream, the flavour and aroma of its ice cream. Ice cream makers use the threshold detection limit to determine the optimum amount of aroma compounds, which ensures that they are detectable without being overpowering. Creating a pleasant and lasting flavor experience. Similarly, there are so many examples you will find where this detection limit helps in regulating. The product in the formulation and getting good quality products.




So, there are various factors, which affect the sensory measurements like psychological factors, physiological factors, and other factors. So, in psychological factors, there may be expectation errors. Information about the samples or objectives can influence panellists to find what is expected. Then sometimes, suggestions are needed to conduct evaluations. In a controlled environment to avoid external influences like comments or sounds, etcetera. Later on, we will discuss what the sensory evaluation facilities should be. Then here, the evaluation should always be controlled in a controlled environment. Then there may be stimulus and logical errors, which occur when evaluators associate the stimulus with unrelated attributes, leading to biased decisions. Sometimes distractions like radio or chatting can easily affect panellist focus during evaluation, and the response to one sample may influence the perception of the next sample, with sample positioning affecting the scoring. And then, attribute dumping means ensuring the sensory evaluation form covers all attributes to avoid incomplete assessment. So, whatever sensory evaluation form is given, it should be complete in all respects.



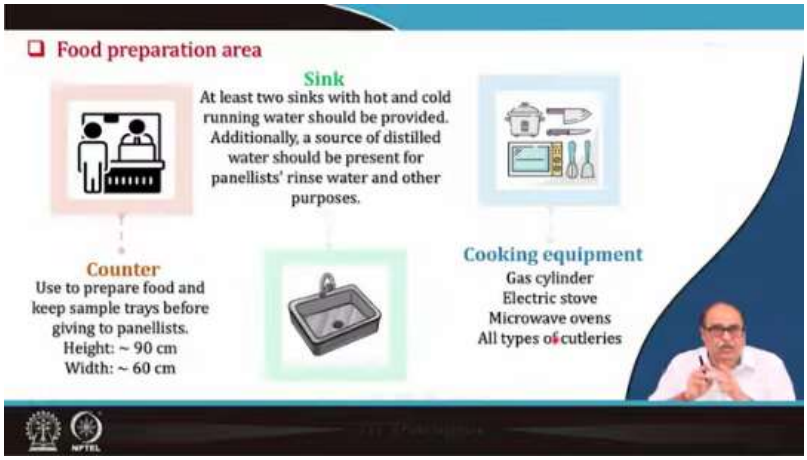

Also, there may be a halo effect and proximity error, which occurs when untrained assessors judge multiple traits at once and scoring one attribute can influence the assessment of the other. There also may be a central tendency error, where untrained evaluators tend to give scores in the middle of the scale when using rating systems. Then, contrast and convergence effects may be there, and these effects should be reduced by randomizing or balancing the sample presentation and eliminating lighter outliers from the sample test. Then, acclimatization and motivation errors occur when judges repeatedly evaluate similar items. So, minimize this by introducing spiked samples or wearing the product. Then, motivation errors can be minimized if panelists rate samples based on their feelings toward the manufacturer, especially during evaluation by company employees, etcetera. So, every possible effort should be made to minimize such types of errors.



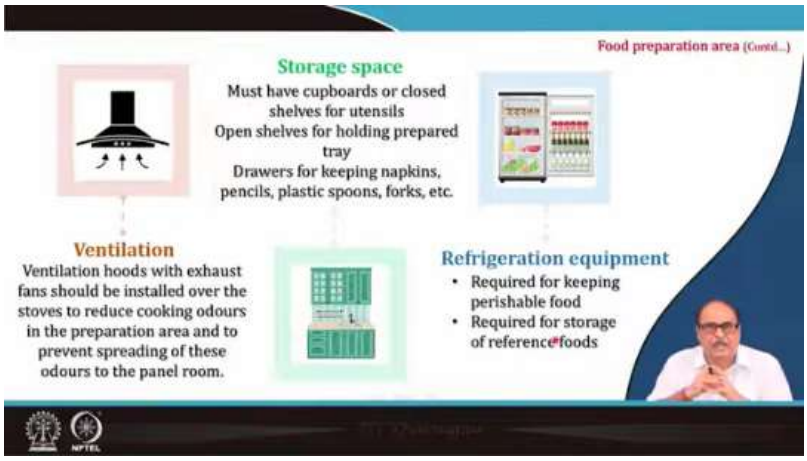

Then, the physiological factors which affect sensory measurements, etcetera, there is one adaptation like continuous exposure to a stimulus reduces sensitivity and response to other stimuli. So, subsequently, sensory assessment is affected by adaptation to a stimulus. So, these are known as carry-over effects. Then, the physical condition of the evaluator or the

panelist influences sensory evaluation, such as age, health, nutritional status, hormones, stress, and mood of the person evaluating it. Then, the evaluator should be in good physical and mental health, with normal sensitivity to smell and taste, and ideally, they should be aged between 18 to 50 years. Then, there may also be perceptual interactions between stimuli, where certain stimuli can interact to cause suppression, potentiation and synergy sourness impacts on strawberries or other products. So, there may be that you have to see that that is some time we have some perception like this product should be like that. So, that also influences our evaluation by the panelists.


Then, now let us talk about the sensory facilities. What should be sensory facilities like? A sensory testing facility can be of two types. One is a permanent testing facility, and the other may be a temporary testing facility. And the facilities are the basic requirements for sensory. The basic requirement for sensory facilities should be that they should have a properly designated food preparation area. Then there should be a separate panel booth, as you can see here in this figure, for the discussion. There would be a quiet panel booth area, there should not be much noise, and it should not be crowded. So that the panellists can properly concentrate on the sample while evaluating. Also, the desk or office area for the panel leader should be there, and there should be supplies for the preparation and serving of the samples. All these arrangements should be there inside the sensory facility.

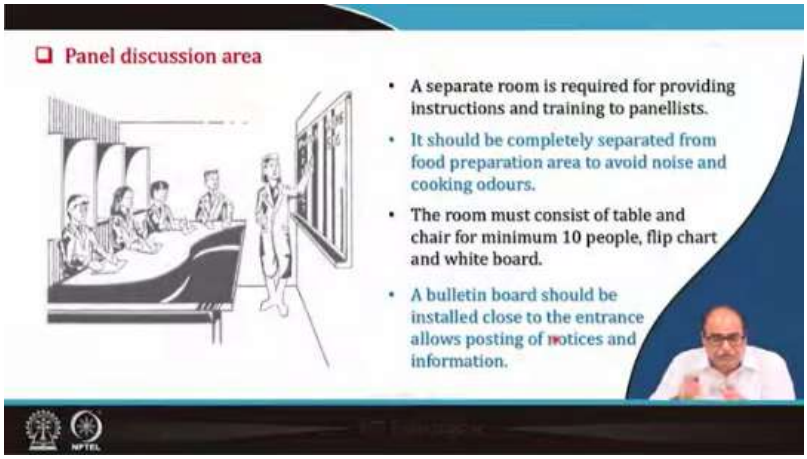



So, in the food preparation area, there should be all the required facilities like sinks, that is, at least two sinks with hot and cold running water, should be provided and additionally, a source of distilled water should be present for the panellist to rinse their mouth or for other purposes, etcetera, and all those things. Also, cooking equipment like a gas cylinder, electric stoves, microwave ovens, or all types of cutlery, etcetera, which is required for cooking as well as the subsequent serving of the sample to the panellist, should be there. Then, the counter where the food should be served for analysis is prepared food and kept as a sample before giving it to the panellist. There should be a proper counter, and a proper designated place, and its height is normally 90 centimetres, width 60 centimetres or, depending upon the facilities, this can be maintained.

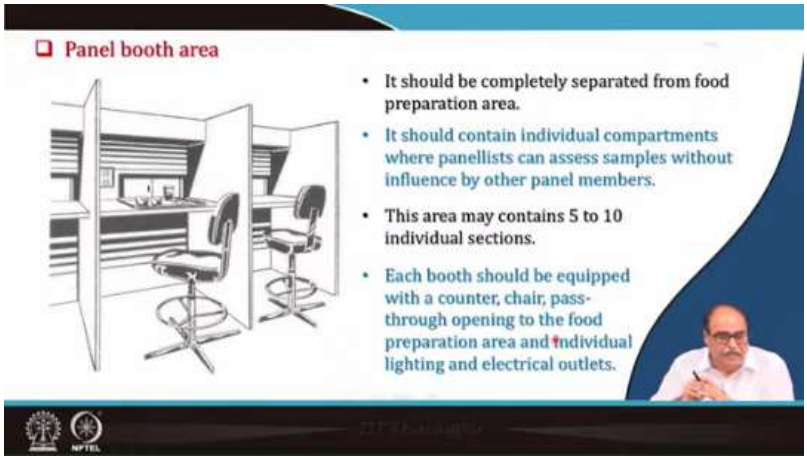



Then, also, the facility should have adequate storage space, that is, the storage space must have cupboards or closed shelves for utensils, etcetera, open shelves for holding prepared trays, and drawers for keeping napkins, pencils, plastic spoons, straws, etcetera. So, all these facilities should be built in. Then, proper ventilation, that is again very important, that is, ventilation hoods with exhaust fans should be installed over the stoves to reduce

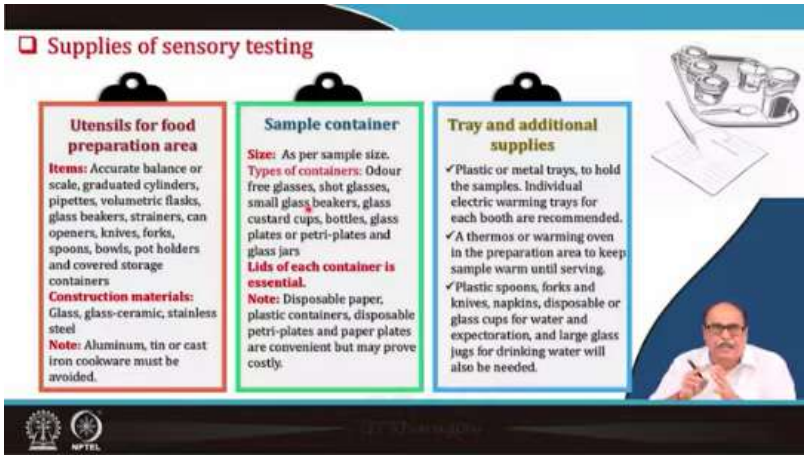
cooking odors in the preparation area and to prevent the spreading of these odors from the panel room and such areas. So, the panel room should be maintained fresh; it should not have any food odor or any other things. Then also, refrigeration equipment is required for keeping the perishable foods required for the storage of reference foods, etcetera. So, there should also be some refrigeration facility in this instrument, in the storage facility or in the panel sensory evaluation facility.




Then it should have a designated panel discussion area. A separate room is provided for giving instructions and training to panelists. As you can see here, it should be completely separated from food preparation areas to avoid noise and cooking odors, etcetera. The room must consist of tables and chairs for a minimum of 10 people, and writing boards, etcetera or its capacity may be required to be even more than 10, depending upon the facility's needs. So, a bulletin board should be installed close to the entrance to allow posting of notices and information, etcetera.

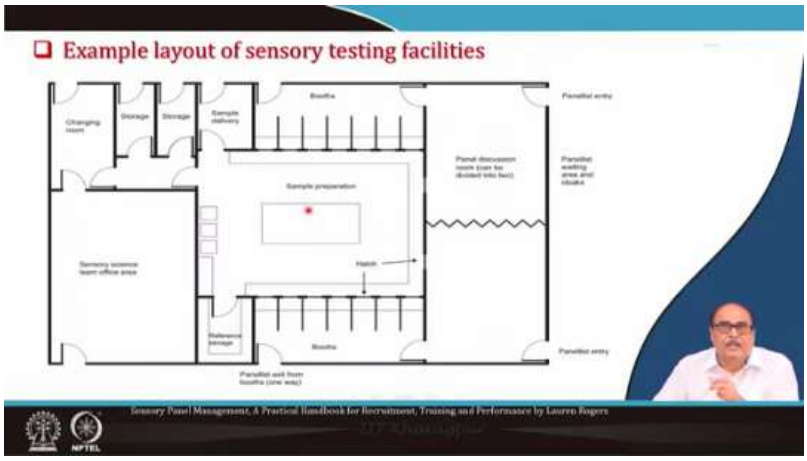


Then, the panel booth area, as you can see here, should be completely separated from the food preparation area; it should contain individual compartments, like individual compartments should there is where the panellist can access the sample without being influenced by the other panel members. This area may contain 5 to 10 individual sections, and each booth should be equipped with a counter, chair, pass-through or opening to the food preparation area, individual lighting and electrical outlets, etcetera. It means that everything necessary is needed, and a clean, comfortable environment that is, the panellist should be provided with all ease so that they can assess and evaluate the sample in a good mood.

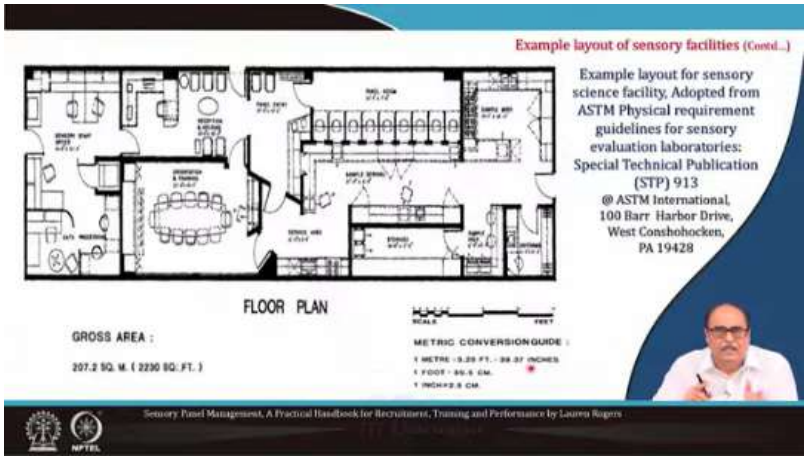



Then, supplies for the sensory testing, that is, how these foods are supplied to the panellist, means utensils for the food preparation area, like items, accurate balance or scale, graduated cylinders, pipettes, volumetric flasks, glass beakers, strainers, or whatever is required like can openers, knives, forks, bowls, pot holders, and covered storage containers, etcetera. All these materials should be there, utensils in the preparation area, and these utensils may be either of glass, glass ceramic, or even stainless steel, but aluminum tins or cast iron cookware must be avoided. Then, the sample container's size should be as per the sample requirement. These containers, like odor-free glasses, short glasses, odor-free glasses, small glass beakers, glass custard cups, bottles, glass plates, or petri plates, glass jars, etcetera, and lids for each container should be provided. Here also, disposable papers, plastic containers, disposable petri plates, paper plates, etcetera. These appear to be convenient, but they may prove costly. But the other utensils are also very important; there should be proper cleaning and sanitation requirements, that is, these utensils, equipment, etcetera, particularly these beakers, glassware, stainless steel, should be properly cleaned before they are used for serving the sample. Then, trays and additional supplies like plastic or metal trays to hold the samples or individual electric warming trays, for each booth are

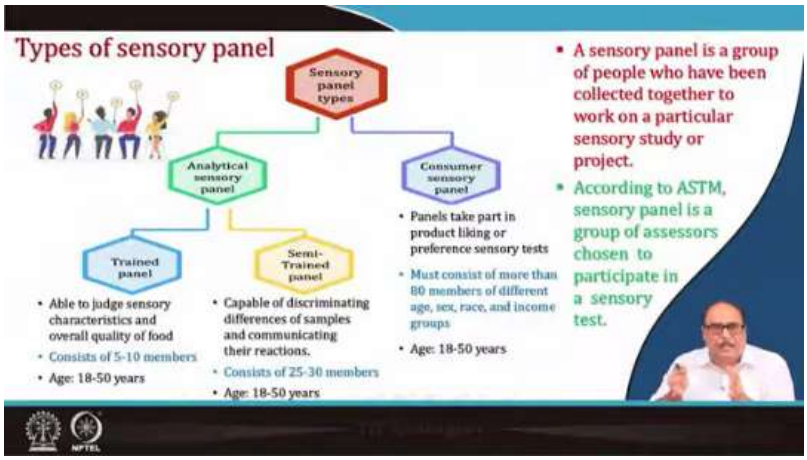
recommended, and a thermos or warming oven in the preparation area, to keep the sample warm until serving, and then plastic spoons, forks, knives, napkins, disposable glass cups, etcetera. That is, they should be provided; even large glass jars for drinking water will also be needed. So, these are some of the supplies for sensory testing.



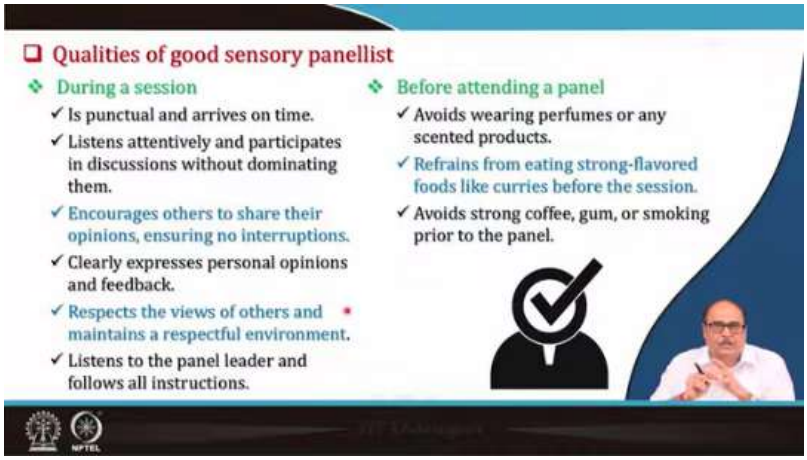

Then, you can see; this is an example layout of the sensory testing facilities, that is, here, there is this; this is the panelist entry on this side or that side. And, at the entry-level itself, there may be one or two rooms that can be divided into two rooms, that is, the panel discussion area, necessary equipment, furniture, display board, etcetera. which we discussed earlier that can be provided here. Then you go inside these are the booths where the samples are analyzed both ways, and in the middle, there is a sample preparation area, and these are the storage area, changing room, and then the sensory science team office area and all those things. So, this can be considered and also this every have that is from outside also there is a proper entry etc. provided. So, to avoid contamination and be free.



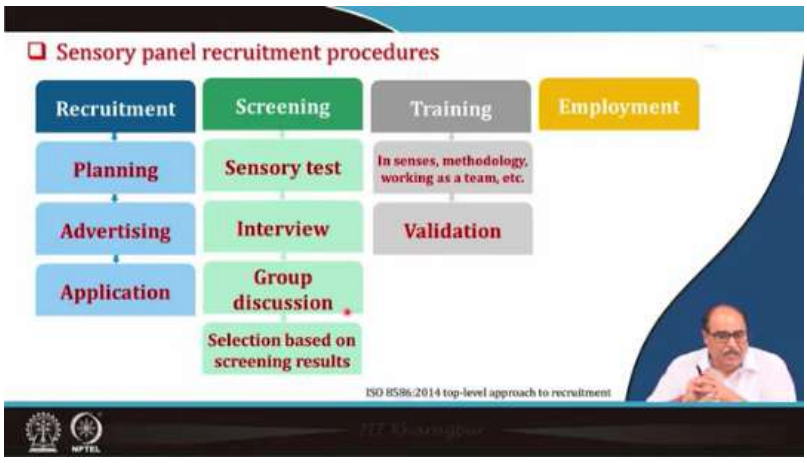
This is another layout example layout for a sensory science facility adapted from the ASTM physical requirement guidelines for sensory evaluation laboratories and a special technical publication, ASTP 913. So, this is also similar to the sample preparation, and these are the sample booth areas and storage facilities. This is the training room or at least the orientation room, etc. Then the data processing room also has a sensory staff office and the utilities, etc. So, this and then maybe one-dimensional movement so that people can go and then come here. So, this is these are the two types of sensory laboratory facilities. Are there layouts you can give them?




Then now, let us talk about the type of sensory panels, and how to select a sensory panel. What should be the quality requirements of a panellist that is a sensory panel? Obviously, it is a group of people. They have been collected together to work on a particular sensory study or project. So, according to ASTM, a sensory panel is a group of assessors chosen to participate in a sensory test. So, there will be two types of sensory panels: analytical sensory panels and consumer sensory panels. Analytical sensory panels may be trained panels or semi-trained panels. Trained panels are able to judge sensory characteristics and the overall quality of the food. It should consist of normally 5 to 10 members, aged 18 to 50 years. The semi-trained panel is capable of discriminating differences in samples and communicating their reactions. There should be 25 to 30 members, aged 18 to 50 years. The consumer sensory panel is where the panellists take part in product liking or preference sensory tests. It must consist of more than 80 members of different ages, sexes, races, and income groups. Normally, the age of these panelists may vary from 18 to 50 years here as well.

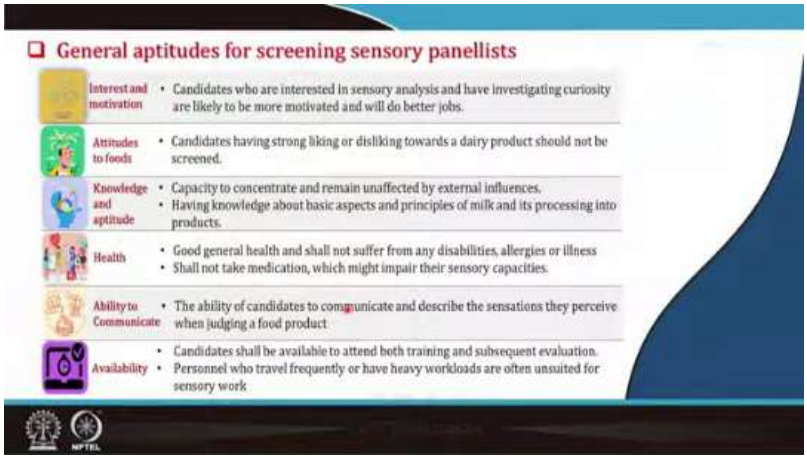



So, the qualities which a good sensory panelist should have, particularly during the testing session, they should be punctual and arrive on time. They should listen attentively and participate in discussions without dominating. They encourage others to share their opinions, ensuring no interactions, etcetera. The panellist, during a session, should clearly express personal opinions and feedback. It should be noted that he should respect the views of others and maintain a respectful environment. Also, he should listen to the panel leader and follow all instructions. So, this is during the session or before attending the session or before going for the analysis, he or she should avoid wearing perfumes or any scented products. They should refrain from eating strong-flavour foods like curries before the session. Otherwise, so that the mouth is clean, there is no lingering effect or taste, etcetera, in the mouth. Also, they should avoid strong coffee, gum, or smoking prior to the panel. So, they should be properly prepared.



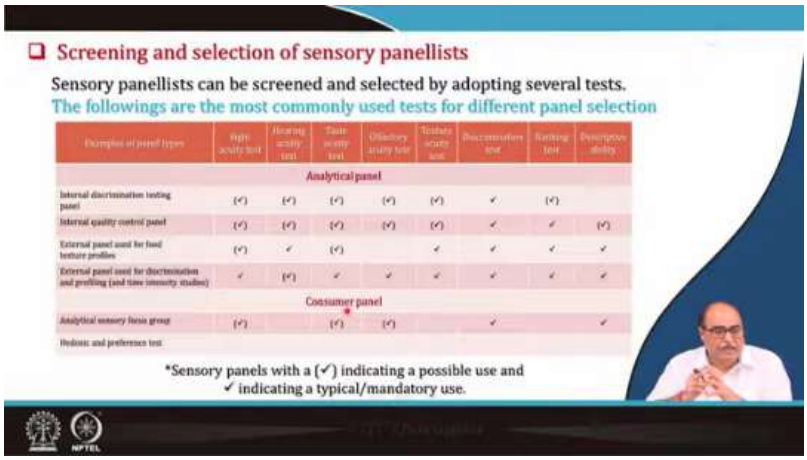

Then, the sensory panel recruitment procedure, how you do that, is recruitment. Then, like planning, advertising, getting applications, that is what type of test you want to do, what you want the criteria in the panellist to be. Because these are very, very important in the

case of the winery, and these sensory panellists are very, very important; they are highly paid staff in the tea testing facilities in the tea industry, in the wine and alcoholic beverages industry or any other beverages and food industry. So, they should be properly recruited. Sensory panellists should undergo proper screening tests that are sensory tests, and then interviews, group discussions, and selection based on screening results should be made. Finally, after that, they are screened. Then, they should receive proper training, which includes training tests in sensory methodologies, working as a team, etcetera. And then, finally, it should be validated. Once it is determined by the expert committee that yes, the panellist is now properly trained, he or she has the required correct qualifications, and all those things, then they should be properly employed.

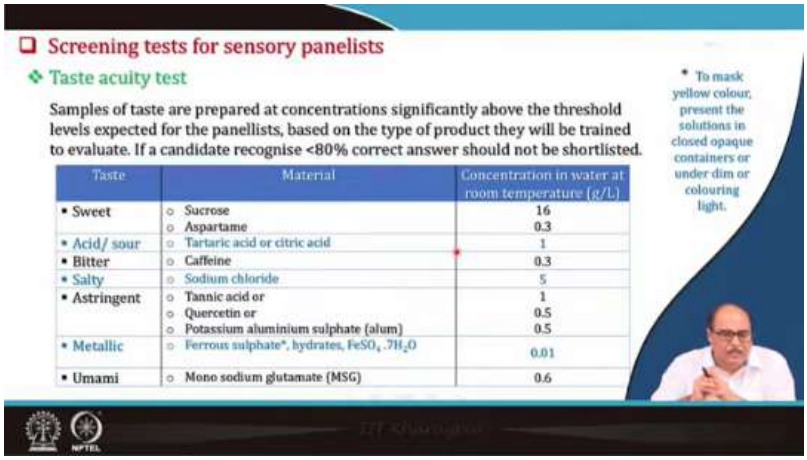



So, the general aptitude for screening a sensory panelist should be, that is, the interest and motivation that the expert committee must evaluate in the candidates that is, those who are interested, and they shortlist the candidates who are interested in sensory analysis and have investigative curiosity. They are likely to be more motivated and will do other jobs, etc. Then, attributes towards the food, that is, candidates having a strong liking or disliking towards a particular product, should not be screened; that is, they should have a general liking and particularly depending upon, suppose you want to select a panel for food that is, that is to say, cereal food, bakery food, etcetera. So, if the person has a strong dislike or liking for that particular food or you want to panel for the dairy food if the person has a strong disliking for the dairy food. Such type of person should not be shortlisted or screened. Also, there should be knowledge and aptitude; there should be a capacity to concentrate and remain unaffected by external influences. The panellists should have knowledge about the basic aspects and principles of milk or other food products, and all these things are to be evaluated and processed into products. So, they should have proper knowledge of the product. So, for which the panelist is being recruited. The health: the

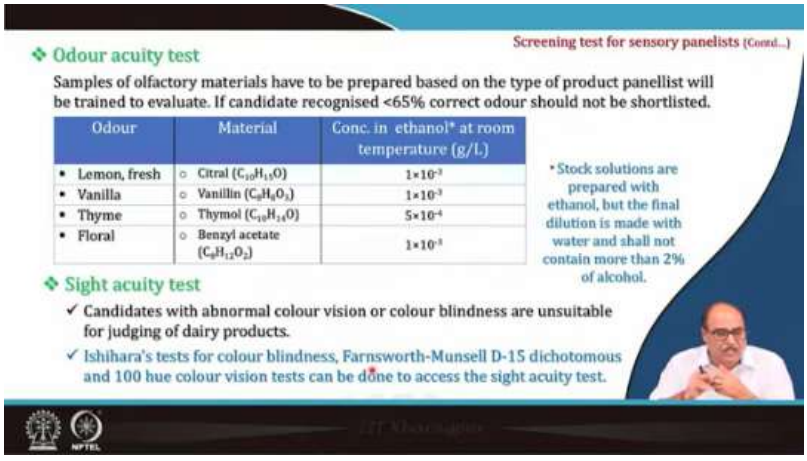
panellist should have good general health and shall not suffer from any disabilities, allergies, illnesses, etcetera. They shall not take any medication that might impair their sensory capability. Then, the ability to communicate: they should have the ability of the candidate to communicate and describe the sensations that they perceive when judging a food product. And finally, very importantly, the availability of the person candidates shall be available to attend both training and subsequent evaluation sessions. Panelists who travel frequently or have heavy workloads are often unsuited for the sensory work, etcetera because the availability of the person when the food is ready and for evaluation is a must.




Then, for screening and selection of the sensory panel, that is, they can be screened and selected by adopting several tests like these are some of the tests: sight acuity test, hearing acuity test, taste acuity test, olfactory acuity test. Texture discrimination test, ranking test, descriptive test; all these types of tests are there. And then examples of panel types like the panel may be an internal descriptive testing panel or an internal quality control panel, or there will be an analytical sensory focus group, hedonic preference group. So, accordingly, you can see that, these are some ticks within the parentheses is given, and only ticks are there. So, this is for the analytical panels as well as for the consumer panel. So, one should see that the sensory panels with a tick in the parentheses, which is indicated as a possible use and indicating a typical mandatory use, that is the just tick. Like, for example, an external panel used for food texture profile if you are, then they must have a proper hearing acuity test. They should clear texture acuity test, discrimination test, ranking test, and descriptive test; all these tests. But if they are having an acuity test also, a slight acuity test may help with the evaluation but these are mandatory. So, similarly, these criteria can be used for screening the panellist.

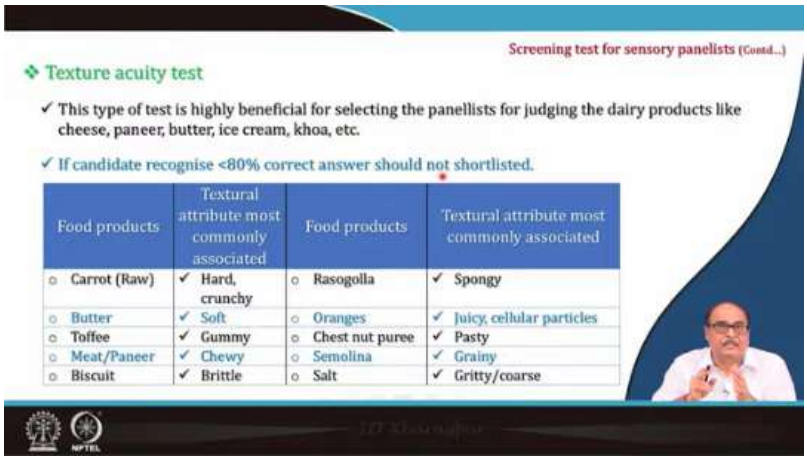



Then, a screening test for sensory panellists is like a test acuity test. Here, the samples of the test are prepared at concentrations significantly above the threshold levels expected for the panelist. Based on the type of the product, they will be trained all right to evaluate. And if a candidate recognizes less than 80 percent correct answers, they should not be shortlisted. For here, the test is sweet, sour, astringent, metallic, umami, etcetera, and the material may be for this, like sucrose or aspartame. You want to test, then sweet test, then sucrose solution or an aspartame solution, bitter the caffeine can be given. Salty sodium chloride, etcetera. And the concentration in water at room temperature, what should be the, for example, that is a salty 5 per cent solution of 5 gram per litre solution of sodium chloride can be given to the person to test it is a test acuity. So, similarly, that is like the umami test. If you want, then 0.6 grams per litre of this monosodium glutamate solution should be given to the person to test for their taste acuity and so on.

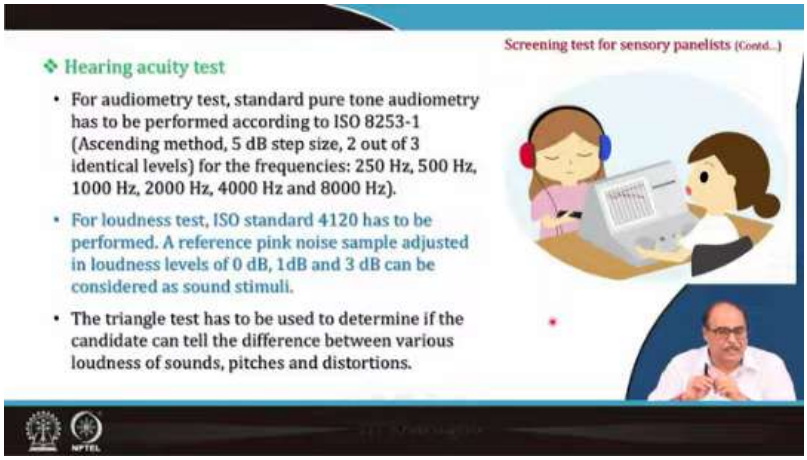



Similarly, the odor acuity test also involves preparing samples for the odor, such as fresh lemon odor, vanilla, thyme, or floral odor, etcetera. So, for example, if you want to test the vanilla odour, the person should be given a concentration in ethanol at room temperature,

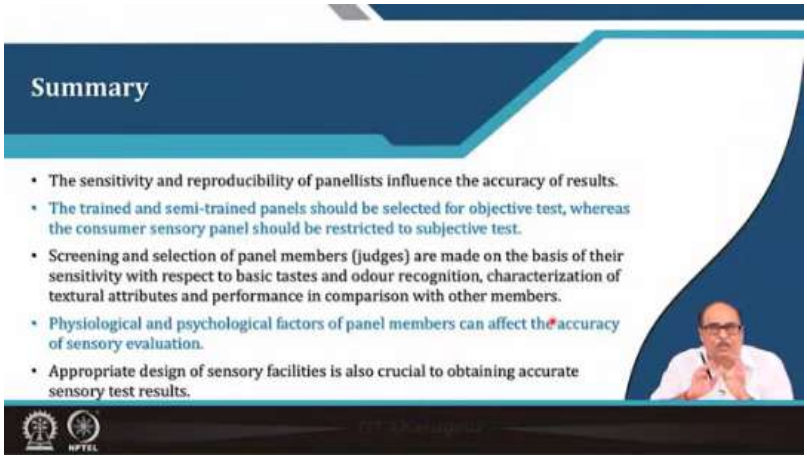
like 1 into 10, to the power of minus 3 gram per litre. Vanillin compound can be given for floral benzyl acetate compound. So, then the stock solutions are prepared with ethanol, but the final dilution is made with water and shall not contain, finally, more than 2 percent alcohol. So, these solutions are provided and then given to the panellists, and they so, again, if a candidate recognizes less than 65 per cent correct odour, they should not be shortlisted. Similarly, in the sight acuity test, candidates with abnormal color vision or color blindness are unsuitable for judging dairy products or any other food products. That is Ishihara's tests for colour blindness, Farnsworth-Munsell D15 dichotomous, and 100 hue colour vision tests can be done to assess the sight acuity test. Similarly, the texture acuity test, this type of test, is highly beneficial for selecting the panelist for judging dairy products. Like cheese, paneer, butter, aroma, etcetera, etcetera. That is a candidate like this should be again given food products like carrots, butter, and toffee.




So, the texture for toffee should be gummy texture, for oranges juicy, cellular products, etcetera; these are the textural attributes. So, these foods, the various foods, can be given to the analyst, and they should be like rasgulla; they should be able to tell whether it is spongy or not. So, if a candidate recognizes less than 80 percent correct answers, it should not be shortlisted means that they must be able to recognize more than 80 percent of the answers.




Then similarly, the hearing acuity test is also for audiometry test, standard tone audiometry has to be performed according to the ISO 82531, that is ascending method, 5 dB step size 2 out of 3 identical levels for frequencies 250 hertz, 500 hertz, 1000 hertz, 2000 hertz, 4000 hertz, and 8000 hertz. So, for the loudness test, ISO standard 4120 has to be performed. A reference pink noise sample adjusted to a loudness level of 0 dB, 1 dB, or 3 dB can be considered as sound stimuli. So, the triangle test has to be used to discriminate if the candidate can tell the difference between various loudness of the sample, pitches, and distortions etc.




So, finally, I would like to summarize this lecture by saying the sensitivity and reproducibility of panellists. Influences the accuracy of results, and therefore, the trained and semi-trained panel should be selected. For objective tests, the consumer sensory panel should be restricted to subjective tests. Screening and selection of panel members, like judges, etc. are made on the basis of their sensitivity with respect to the basic taste and other recognitions, Characterization of the textural attributes and performance in comparison with other members. Psychological and physiological factors of panel

members can affect the accuracy of sensory panels, and accordingly, the judges should be in good physical health, etcetera, and they should be selected. Appropriate design of sensory facilities is also crucial to obtaining accurate sensory result reports.


So, these are the references.


Thank you very much for your patient hearing.