

**Post Harvest Operations and Processing of
Fruits, Vegetables, Spices and Plantation Crop Products**
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Lecture 50
Quality Characteristics

Concepts Covered

- Fermented fruit and vegetable beverages
- Quality characteristics
 - ✓ Physical & rheological
 - ✓ Nutritional & sensory
 - ✓ Microbiological properties & spoilage microorganisms
- Quality evaluation



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This lecture discusses the quality characteristics of plant based fermented foods and beverages. It includes different fermented fruit and vegetable beverages and its quality characteristics such as physical and rheological qualities, nutritional and sensory properties, microbiological properties and spoilage microorganisms. It also discusses about evaluation of these properties and quality characteristics.

Fermented Fruits and Vegetables

Fermented fruit and vegetable beverage

- The fruits and vegetables are usually fermented to improve the palatability and shelf life.
- **Many forms of juice either raw, centrifuged and filtered are used for fermentation.**
- However, it is important to kill the harmful spoilage microorganism thus heat treatments like pasteurization, sterilization are usually done before fermentation.
- **Various types of fermentation depending upon the need is done by making different conditions favorable for enzyme activities.**
- The fermented beverage is stored at low temperature for higher shelf life.




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Different Beverages and Microorganisms Used in Fermentation

Different beverages and microorganisms used in fermentation

Beverage	Origin	Substrate	Microorganisms isolated
Hardaliye	Turkey	Red grapes	<i>Lactobacillus paracasei</i> , <i>L. casei</i> , <i>L. brevis</i> , <i>L. pontis</i> , <i>L. acctotolerans</i> , <i>L. sanfrancisco</i> , <i>L. vaccinostereus</i>
Kombucha	China	Tea	<i>Glucomacctobacter spp. (G. xylinus)</i> , <i>Acctobacter spp.</i> , <i>Lactobacillus spp.</i> , <i>Zygosaccharomyces spp.</i> , <i>Hanseniaspora spp.</i> , <i>Torulaspota spp.</i> , <i>Pichia spp.</i> , <i>Dekkera spp.</i> , <i>Saccharomyees spp.</i>
Gefilus	Finland	Fruit juice	<i>Lactobacillus rhamnosus GG</i> , <i>Propionibacterium freudenreichii ssp. shermanii JS</i>



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The table provided shows different fermented beverages from different countries and the microorganism used for the fermentation or that has been isolated from the fermented beverages. Hardaliye is a beverage originated from Turkey that has red grapes as its substrate. Microorganism that are isolated from the beverage are *Lactobacillus paracasei*, *L. casei*, *L. brevis*, *L. pontis*, *L. acctotolerans*, *L. sanfrancisco*, *L. vaccinostereus*. Kombucha is another fermented beverage from China. It is fermented tea and microorganisms used are *Glucomacctobacter spp. (G. xylinus)*, *Acctobacter spp.*, *Lactobacillus spp.*, *Zygosaccharomyces spp.*, *Hanseniaspora spp.*, *Torulaspota spp.*, *Pichia spp.*, *Dekkera spp.*, *Saccharomyees spp.* Gefilus is a fermented juice from Finland and organisms used are *Lactobacillus rhamnosus GG*, *Propionibacterium freudenreichii ssp. shermanii JS*.

Different beverages and microorganisms used in fermentation (contd...)

Beverage	Origin	Substrate	Probiotic microorganisms
Proviva	Sweden	Orange, strawberry, or blackcurrant juice	<i>Lactobacillus plantarum 299v</i>
GoodBelly	U.S.A.	Mango, blueberry acai, pomegranate, blackberry, tropical green, cranberry, watermelon, tropical orange, and coconut water juices	<i>Lactobacillus plantarum 299V</i>
Biola	Norway, Finland	Orange-mango and apple-pear flavors and several vegetable juices	<i>Lactobacillus rhamnosus GG</i>



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In Sweden, Proviva is prepared from orange, strawberry or black currant juices. Microorganisms involved is *Lactobacillus plantarum 299v*. Goodbelly is a fermented beverage from USA prepared from Mango, blueberry acai, pomegranate, blackberry, tropical green, cranberry, watermelon, tropical orange, and coconut water juices, fermented by *Lactobacillus plantarum 299v*. Norway and Finland has Biola prepared from orange, mango, apple-pear flavour and several vegetable juices. *Lactobacillus rhamnosus GG* is the organism involved.

Different beverages and microorganisms used in fermentation (contd...)

Beverage	Origin	Substrate	Probiotic microorganisms
Kevika	U.S.A.	Sparkling lemon ginger probiotic drink	<i>Bacillus coagulans</i> , <i>L. rhamnosus</i> , <i>L. plantarum</i> , <i>L. paracasei</i>
Rela	Sweden	Fruit juice	<i>Lactobacillus reuteri MM₅₃</i>
Healthy life probiotic	Australia	Apple and mango juice	<i>Lactobacillus paracasei</i> and <i>Lb. plantarum</i>
Malee probiotic juices	Thailand	White grape and orange juice	<i>Lactobacillus paracasei</i>

- *Lactobacillus plantarum* is the common microorganism used for fermentation of fruit and vegetable beverage.
- Substrate can be different depending upon the type of beverage.



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Kevika is from USA, which is a sparkling lemon or ginger probiotic drink. Microorganisms used are *Bacillus coagulans*, *L. rhamnosus*, *L. plantarum*, *L. paracasei*. In Sweden Rela it is prepared from fruit juices and *Lactobacillus reuteri MM₅₃*. Healthy life probiotic is a drink from Australia made from apple and mango juices and *Lactobacillus paracasei* and *Lb. plantarum*. In Thailand, Malee probiotic juice is prepared from white grape and orange juice. *Lactobacillus*

paracasei is the microorganism used. It could be summarized from the table that lactobacillus plantarum is the most commonly used microorganism for the fermentation of food and beverages, which is a probiotic bacterium. Substrate can be different depending upon the type of beverage prepared.

Quality Characteristics

Quality characteristics

Physical properties

- The physical properties of fermented beverage are of great importance for their positive perception by consumers.
- **The plant based fermented beverage must provide the required texture liked by consumer.**
- The consumer do their first judgment based on the physical properties of the fermented beverage.
- **Color and appearance are the most important for quick judgment. However, taste, texture, aroma, etc. also contributed equal role in acceptance of final products.**

Physical properties

Texture TSS Color pH Titratable acidity Aroma

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Physical Properties

Quality characteristics includes the physical, chemical, and microbiological properties of the beverage. The physical properties of fermented beverage are of great importance for their positive perception by consumers. The plant based fermented beverage must provide the required texture liked by consumer. The consumer do their first judgment based on the physical properties of the fermented beverage. Color and appearance are the most important for quick judgment. However, taste, texture, aroma, etc. also contributed equal role in acceptance of final products. The physical properties of the beverages that are considered in quality analysis are texture, total soluble solids (TSS), color, pH, titratable acidity and aroma.

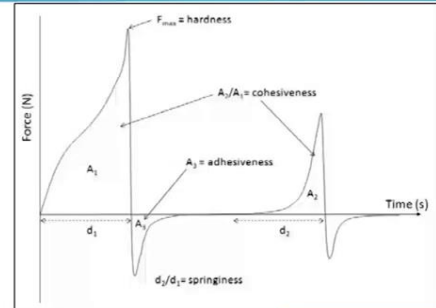
Texture

The texture is measured as hardness, adhesiveness, cohesiveness, springiness and gumminess. The texture profile curve provided shows that hardness is the highest force, followed by cohesiveness and adhesiveness as the negative peak.

Physical properties (contd...)

□ Texture

- Texture of beverage are measured by hardness, adhesiveness, cohesiveness, springiness & gumminess.
- **Hardness** is the peak force of the compression cycle, which is defined as the necessary force to achieve a required level of deformation. It is the final power required to reach a stable deformation.
- **Adhesiveness** is the force required to detach a sample from the probe. It is calculated as the field surface of a negative peak.
- **Cohesiveness** is calculated as quotient field surfaces indicated by the curves of the second and the first press.
- **Springiness** is a ratio of the time measured from the start of the second and the first cycles of pressing to reach maximum deformation during each cycle.
- **Gumminess** is determined as a multiple of hardness and cohesiveness.



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Physical properties (contd...)

□ Total soluble solids

- Total soluble solids (TSS) are measured by refractometer either hand and abbe's refractometer.
- **The measured TSS or sugar content includes the carbohydrates, organic acids, proteins, fats and minerals of the fruit.**
- It represents from 10-20% of the fruit's fresh weight which increased as fruit matured making the product less acidic, sweeter fruit.

□ Color measurement

- The color of the fruit juice and concentrate was determined using a colorimeter.
- **This is very important property as it defines the first appearance of fermented fruits and vegetable beverages.**



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Total Soluble Solids

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Color Measurement

The color of the fruit juice and concentrate was determined using a colorimeter. This is very important property as it defines the first appearance of fermented fruits and vegetable beverages. For measurement photometric methods or Hunter lab colorimeter is used.

Physical properties (contd...)

- ☐ **pH**
 - It is a quantitative measure of the acidity or basicity.
 - **Fruit juices have different pH level which can be measured by pH meter.**
 - The balance of pH level is important to have optimum taste and shelf life of the fermented product.
- ☐ **Titratable acidity**
 - Titratable acidity (TTA) is a measure of the amount of acid or acids present in a food sample.
 - **It is an important parameter defining the quality of fermented fruit juices.**
 - If TTA of juice is higher then it become difficult for saliva to neutralize it and become potentially damaging particularly to the teeth.
 - **Thus, an optimum TTA must be maintained to have better quality of fermented fruit beverage.**

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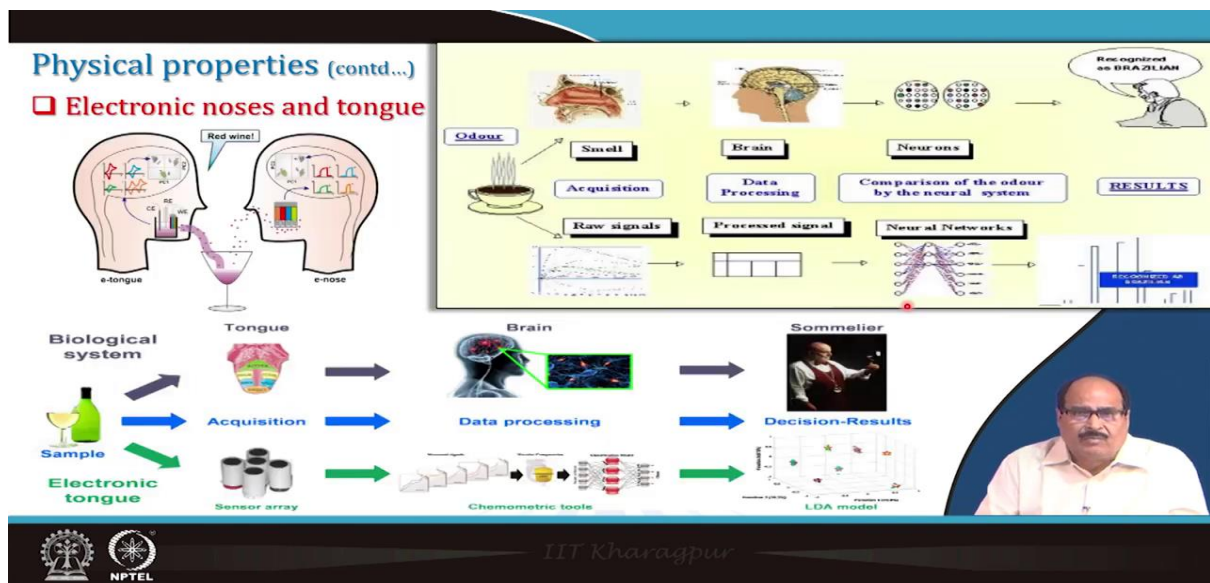
NPTEL

pH

pH is a quantitative measure of the acidity or basicity. Fruit juices have different pH levels which can be measured by pH meter. The balance of pH level is important to have optimum taste and shelf life of the fermented products.

Titratable acidity

Titratable acidity is a measure of the amount of acid or acid present in a food sample. It is an important parameter defining the quality of the fermented fruit juices. If titratable acidity of juice is higher, then it becomes difficult for saliva to neutralize it and becomes potentially damaging particularly to the teeth. Thus an optimum TTA must be maintained to have a better quality of fermented fruit beverage.



Electronic Noses and Tongue

Electronic noses and tongue could be used to determine the taste and smell of the fermented beverages. The slide shows the sensory perception of the red wine via human tongue and nose, and electronic tongue and nose. Wine tasting requires high skill and sensory perception.

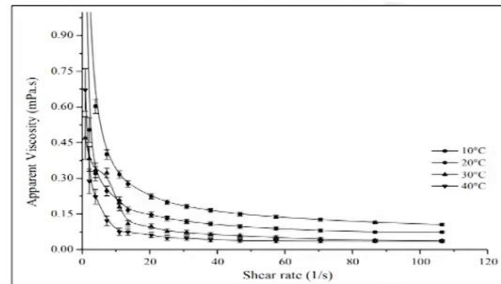
The mouth has tongue which has taste buds, where acquisition of taste occurs. Similarly, e-tongue has sensory arrays that works as taste buds. They collect the information as like in our actual system. Then information acquired by tongue is immediately sent to our brain for processing. The brain analyses the information sent by the tongue and record it as the taste of that product. The e-tongue send the information to the chemometric tools, process it by comparing the pre-recorded data sets and models developed to give the decision.

Similarly, the olfactory cells in the human nose acquires the information on the smell and send it to the brain by the nerves. The neurons in the brain compares the odor and provides the decision. The e-nose acquires the smell using sensors and the information is processed using neural networking and decision is provided.

In summary, similar to the human nose and tongue these electronic devices use sensors and processing model for brain to provide results. The food matters are volatilized and the volatiles are sensed by sensors like metal oxide sensors. The data collected is sent to the instrument to analyze using neural network or PCA. In discriminative sensory analysis the system is first provided with fresh samples or standard samples and the data generated is compared with the given samples.

Rheological properties

- The rheological measurement of the fermented beverage is important for knowing about its consistency.
- In general, the controlled viscometer having coaxial geometry or cone and plate geometry is used for carrying out steady shear experiment.
- In this experiment, the shear rate is varied from 0 to 100 Hz and the temperature is remained fixed.
- The viscosity vs. shear rate graph reveal flow property of juice which is either the pseudoplastic or dilatant.
- The consistency coefficient of juice sample is measured by evaluation of Power Law model.



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Rheological Properties

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Rheological properties (Contd.)

Power law model

$$\eta = K\gamma^{n-1}$$

Where,

η is viscosity of juice (Pas)

K is the consistency coefficient (Pasⁿ)

γ is shear rate (Hz)

n is flow behavior index

$$K = A_K \exp\left(\frac{E_K}{RT}\right)$$

$$\eta = A_\eta \exp\left(\frac{E_\eta}{RT}\right)$$

Where,

A_K, A_η are the pre-exponential constants

E_K, E_η are the activation energy (KJ/mol)

R is the universal gas constant (KJ/K.mol)

T is absolute temperature (K)

- The consistency coefficient and flow behaviour index are used for explaining the rheological properties of fermented beverage.
- Temperature and total soluble solids of beverage affect consistency coefficient and viscosity.
- The consistency coefficient and viscosity of beverage follows Arrhenius concept.



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The power law model is given by the equation,

$$\eta = K\gamma^n$$

Where, η is viscosity of juice (Pas); K is the consistency coefficient (Pasⁿ); γ is shear rate (Hz); n is flow behavior index.

$$K = A_K \exp \frac{E_K}{RT}$$

$$\eta = A_\eta \exp \frac{E_\eta}{RT}$$

Where, A_K , A_η are the pre-exponential constants; E_K , E_η are the activation energy (KJ/mol); R is the universal gas constant (KJ/K.mol); T is absolute temperature (K).

The consistency coefficient and flow behaviour index are used for explaining the rheological properties of fermented beverage. Temperature and total soluble solids of beverage affect consistency coefficient and viscosity. The consistency coefficient and viscosity of beverage follows Arrhenius concept.

Nutritional properties

- Fermented foods and beverages are more nutritious than their unfermented counterparts due to the presence of microorganism during fermentation.
- **Microorganisms are both catabolic and anabolic; break down complex compounds, and synthesize complex vitamins and other growth factors.**
- The LAB & yeast fermentation were observed to enhance nutritional content and food digestibility.
- **Enzymatic hydrolysis in fermented foods cause**
 - ✓ reduction in levels of anti-nutrients viz. tannins and phytic acid (degradation with the help of phytases), and
 - ✓ results in enhanced bioavailability of simple sugars or polysaccharides (amylases), proteins (proteases), free fatty acids (lipases), and iron.



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Nutritional Properties

During the fermentation process, various new primary and secondary metabolites are produced and compounds like vitamins, minerals are synthesized. Thus, fermented beverages are considered more nutritive than their unfermented counterparts. Fermented foods and beverages are more nutritious than their unfermented counterparts due to the presence of microorganism during fermentation.

Microorganisms are both catabolic and anabolic; break down complex compounds, and synthesize complex vitamins and other growth factors. The LAB & yeast fermentation were observed to enhance nutritional content and food digestibility. Enzymatic hydrolysis in the fermented food cause reduction in the levels of anti-nutrients like tannins and phytic acids et cetera, degradation with the help of phytases, and results in enhanced availability of simple sugar or polysaccharides (amylases), proteins (protease), free fatty acids (lipases), and iron.

Nutritional properties (contd...)

- The *Rhizopus oligosporus* or similar molds in the 'Tempe', an Indonesian origin-rich dish, cause increase in niacin about seven times and synthesized vitamin B₁₂ through fermenting bacterium growing with the essential mold.
- The *Klebsiella pneumoniae* bacterium, i.e., (nonpathogenic strain), is responsible for producing vitamin B₁₂ when inoculated into Indian idli fermentation.
- Similar nutritional improvement in fermented beverage can be observed.



The *Rhizopus oligosporus* or similar molds in the 'Tempe', an Indonesian origin-rich dish, cause increase in niacin about seven times and synthesized vitamin B₁₂ through fermenting bacterium growing with the essential mold. Thus, the fermented food has B₁₂ which is not normally present in plant food sources. Similarly, *Klebsiella pneumoniae* bacterium, i.e., (nonpathogenic strain), is responsible for producing vitamin B₁₂ when inoculated into Indian idli fermentation. Similar nutritional improvement in fermented beverages can be observed. Fermentation process synthesis vitamins resulting in bio-enrichment, produces peptides, enzymes, polyglutamic acid, increases antioxidant activity, saponin and isoflavone values, and causes degradation of antinutritive compounds.

Sensory Properties

Sensory properties is crucial as most of the fermented beverages are accepted based on their sensory characteristics by the consumers. The parameters analyzed through sensory studies include taste, aroma, flavour, colour, appearance, aftertaste, texture et cetera.

Sensory properties

- The parameters analysed through sensory studies include taste, aroma, flavour, colour/appearance, aftertaste, texture, etc.
- **Various statistics based methods are used for analysing the sensory data and draw conclusion from it.**
- The acceptability of fermented fruits and beverages is largely depend upon its sensory properties.

- ✓ Thus, it is important to have a brief knowledge about various sensory methods used for testing of fermented fruits and beverage.



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The acceptability of the fermented food and beverage is largely dependent upon its sensory properties. Thus, it is important to have a brief knowledge about the sensory method used for testing of fermented foods and beverages. In sensory analysis, the panel of judges or even consumers are given the beverage and asked to record their perception about the beverage into a datasheet provider and then the data are analyzed to make decisions. The different tests for sensory analysis are discriminative tests, 9-point hedonic scale testing, ranking method and fuzzy method.

Discriminative Tests

Sensory properties (contd...)

❑ Discriminative tests

- Difference test is one of the most useful sensory tests.
- **This test is designed to discriminate difference between two or more samples.**



• Paired comparison test

- ✓ This test is used to make comparison between only two samples based on sensory attributes like texture, taste, acidity, color, etc.
- ✓ **This test is relatively easy to organize and implement.**
- ✓ It is typically used in comparing new and old processing techniques, change of ingredients in a product, preference testing at the consumer level, etc.



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Discriminative or difference tests is one of the most useful sensory tests. This test is designed to discriminate difference between two or more samples. The types of discriminative tests are paired comparison test, duo-trio test, triangle test and multiple sample test.

Paired Comparison Test

Paired comparison test is used to make comparison between only two samples based on sensory attributes like texture, taste, acidity, colour, et cetera. This test is relatively easy to organize and implement. It is typically used in comparing new and old processing techniques, change of ingredients in the product, preference testing at the consumer level et cetera. If already a standard reference beverage exists in the market, this test is used to compare any newly developed beverage with it.


Duo-trio Test


Sensory properties (contd...)

- **Duo-trio test**
 - ✓ It is a modified paired comparison test. One sample is identified as reference (R), first given to panelists for evaluation. Subsequently two coded samples, one of which is identical to R, are presented.
 - ✓ The panelist is asked to indicate, which of the two samples is the same as 'R'.
 - The test is suitable for products that have relatively intense odour, taste and/or kinesthetic effects such that sensitivity of evaluator is significantly reduced.

Duo-Trio Test

Assessor Name:	Assessor No.:	Date:
You have been provided with an identified reference sample and two coded samples.		
Taste the reference sample and then the two coded samples from left to right.		
Circle the sample you identify to be the same as the reference.		
Explain why the other sample is NOT a match and indicate the intensity of difference (very slight, slight, moderate, obvious, or very obvious).		
If you cannot determine which the matched sample is, please make a guess.		
You must rinse your mouth between each sample.		
Reference	853	394
Comments:		





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It is a modified paired comparison test. One sample is identified as a reference (R), first given to panelists for evaluation. Subsequently two coded samples, one of which is identical to R are presented. The panelists are asked to indicate which of the two samples is same as the reference R. The test is suitable for products that have relatively intense odor, taste and/or kinesthetic effects such that sensitivity of evaluator is significantly reduced. The duo trio assessment sheet is provided in the slide. It has column for assessor name, number and date and the instructions to perform the test. The sample codes along with column for the comments are also provided.

Triangle Test

Sensory properties (contd...)

- **Triangle test**

- ✓ Triangle test is most well known and more frequently used out of the three difference tests.
- ✓ As its name implies, it is a three-product test in which all the samples are coded and the panelist's task is to determine which two are most similar or which one is most different from the other two.
- ✓ This test is more difficult test because the panelist must recall the sensory characteristics of two products before evaluating the third and then make a decision.

Name: Sally Date: 1/7/08

TRIANGLE TEST (Single Tasting)

Please assess the AROMA and PALATE of the three wines and circle the code of the sample that is different from the other two.

CIRCLE THE SAMPLE WHICH IS DIFFERENT FROM THE OTHER TWO
If no difference is perceived, you must guess.

Codes

Set 1: 212 652 347

Set 2: _____

Thank you!

The assessment sheet shows three sets of wine samples. Each set consists of three wine glasses with a panelist's name and a checkmark. The samples are labeled with codes: 347, 212, and 652. In the first set, 347 is circled. In the second set, 347 is circled. In the third set, 347 is circled. In the fourth set, 347 is circled. In the fifth set, 347 is circled. In the sixth set, 347 is circled. In the seventh set, 347 is circled. In the eighth set, 347 is circled. In the ninth set, 347 is circled. In the tenth set, 347 is circled. In the eleventh set, 347 is circled. In the twelfth set, 347 is circled. In the thirteenth set, 347 is circled. In the fourteenth set, 347 is circled. In the fifteenth set, 347 is circled. In the sixteenth set, 347 is circled. In the seventeenth set, 347 is circled. In the eighteenth set, 347 is circled. In the nineteenth set, 347 is circled. In the twentieth set, 347 is circled. In the twenty-first set, 347 is circled. In the twenty-second set, 347 is circled. In the twenty-third set, 347 is circled. In the twenty-fourth set, 347 is circled. In the twenty-fifth set, 347 is circled. In the twenty-sixth set, 347 is circled. In the twenty-seventh set, 347 is circled. In the twenty-eighth set, 347 is circled. In the twenty-ninth set, 347 is circled. In the thirtieth set, 347 is circled. In the thirty-first set, 347 is circled. In the thirty-second set, 347 is circled. In the thirty-third set, 347 is circled. In the thirty-fourth set, 347 is circled. In the thirty-fifth set, 347 is circled. In the thirty-sixth set, 347 is circled. In the thirty-seventh set, 347 is circled. In the thirty-eighth set, 347 is circled. In the thirty-ninth set, 347 is circled. In the fortieth set, 347 is circled. In the forty-first set, 347 is circled. In the forty-second set, 347 is circled. In the forty-third set, 347 is circled. In the forty-fourth set, 347 is circled. In the forty-fifth set, 347 is circled. In the forty-sixth set, 347 is circled. In the forty-seventh set, 347 is circled. In the forty-eighth set, 347 is circled. In the forty-ninth set, 347 is circled. In the fiftieth set, 347 is circled. In the fifty-first set, 347 is circled. In the fifty-second set, 347 is circled. In the fifty-third set, 347 is circled. In the fifty-fourth set, 347 is circled. In the fifty-fifth set, 347 is circled. In the fifty-sixth set, 347 is circled. In the fifty-seventh set, 347 is circled. In the fifty-eighth set, 347 is circled. In the fifty-ninth set, 347 is circled. In the sixtieth set, 347 is circled. In the sixty-first set, 347 is circled. In the sixty-second set, 347 is circled. In the sixty-third set, 347 is circled. In the sixty-fourth set, 347 is circled. In the sixty-fifth set, 347 is circled. In the sixty-sixth set, 347 is circled. In the sixty-seventh set, 347 is circled. In the sixty-eighth set, 347 is circled. In the sixty-ninth set, 347 is circled. In the seventieth set, 347 is circled. In the seventy-first set, 347 is circled. In the seventy-second set, 347 is circled. In the seventy-third set, 347 is circled. In the seventy-fourth set, 347 is circled. In the seventy-fifth set, 347 is circled. In the seventy-sixth set, 347 is circled. In the seventy-seventh set, 347 is circled. In the seventy-eighth set, 347 is circled. In the seventy-ninth set, 347 is circled. In the eightieth set, 347 is circled. In the eighty-first set, 347 is circled. In the eighty-second set, 347 is circled. In the eighty-third set, 347 is circled. In the eighty-fourth set, 347 is circled. In the eighty-fifth set, 347 is circled. In the eighty-sixth set, 347 is circled. In the eighty-seventh set, 347 is circled. In the eighty-eighth set, 347 is circled. In the eighty-ninth set, 347 is circled. In the ninetieth set, 347 is circled. In the hundredth set, 347 is circled.

Triangle test is the most well-known and more frequently used out of the three different tests. As its name implies, it is a three-product test in which all the samples are coded and the panelist's task is to determine which two are most similar, or which one is most different from the other two. The test is more difficult test because the panelists must recall the sensory characteristics of two products before evaluating the third and then make a decision.

An example of the test is provided in the slide. There are three samples here coded as 212, 347, and 652. The panelists are provided with the samples and the assessment sheet. They have to record which sample is different from other two. If no difference is perceived, the panelists are forced to guess one samples. The data obtained is analyzed statistically to come to a conclusion. As shown in the slide, all panelist except one selected 347 as the most different. Thus, the probability of 347 being a different sample is higher.

Multiple Sample Test

Test involving more than 3 samples are classified as multiple sample tests. They may have equal (symmetrical) or unequal (asymmetrical) numbers of each sample. When they are applied as true difference tests, the judge is required to separate the sample into two groups of like samples. When they are applied as directional tests, the judge is asked to identify the groups of higher or lower intensity of a given criterion. The assessment sheet provides the information to group the samples. The panelists have to taste the samples and evaluate it to the reference sample of odor and flavor. They have to rate in each sample degree of difference and direction of quality.

Sensory properties (contd...)

Multiple sample test

- ✓ Test involving more than 3 samples are classified as multiple sample tests.
- ✓ They may have equal (symmetrical) or unequal (asymmetrical) numbers of each sample.
- ✓ When they are applied as true difference tests, the judge is required to separate the sample into two groups of like samples.
- ✓ When they are applied as directional tests, the judge is asked to identify the groups of higher or lower intensity of a given criterion.

Name..... Date.....

Product.....

- Taste it carefully for the quality characters to be evaluated to the reference sample for odour and flavour.
- Rate in each sample degree of difference and the direction of quality.

Degree of difference		Direction of quality	
Rating	Difference from standard		
0	None	E Equal	
1	slight	I Inferior	
2	moderate	S Superior	
3	large		

sample code no odour flavour

 Degree Direction comments Degree Direction comments

Signature



9 Point Hedonic Scale

Sensory properties (contd...)

9-point hedonic test

- ✓ Hedonic relates to the psychology of pleasurable and non pleasurable states of consciousness.
- ✓ In hedonic method, psychological states of like and dislike are measured on a rating scale.
- ✓ Normally rating scale has been categorized into five forms, viz. numerical, graphic, standard, cumulated points and forced choice forms.
- ✓ The nine points numerical scale as given in figure has been most extensively used for new product development & consumer studies.

9-Point Hedonic scale method for sensory analysis

Participant no. Tested on

You are requested to assess the given samples in terms of characteristics mentioned on the basis on the 9-point hedonic scale given below.

Scale	Score
Liked Extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Extremely dislike	1

Sample	Color	Texture	Aroma	Breakability	Overall acceptability
Sample 1					
Sample 2					
Sample 3					
Sample 4					

Name..... Age group

Signature of the participant



Hedonic relates to the psychology of pleasurable and non-pleasant states of consciousness. In hedonic method, psychological states of like and dislike are measured on a rating scale. Normally rating scale has been categorized into five forms, viz. numerical, graphic, standard, cumulated points and forced choice forms. The nine points numerical scale as given in figure has been most extensively used for new product development & consumer studies. The samples are rated on a 9-point hedonic scale ranging from 1 to 9 with 1 being extreme dislike and 9 being liked extremely. The samples are rated for their color, texture, aroma, breakability, and overall acceptability.

Ranking Method

Sensory properties (contd...)

Ranking method

- ✓ In ranking method two or more samples are provided to the panelists who are asked to arrange them in an ascending or descending order of intensity of a specific attribute, e.g. sweetness.
- ✓ Ranking is often used for screening inferior from superior samples in product development. This method is also suited for comparison of market samples of different brands.
- ✓ Samples may be ranked in order of degree of acceptability or by a specific attribute.


Name..... Date.....

Product.....

Please rank the samples in numerical order according to your preference or intensity of aroma/taste characteristic of the product.

Intensity/preference	sample code
1	_____
2	_____
3	_____
4	_____

Signature _____




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In ranking method two or more samples are provided to the panelists who are asked to arrange them in an ascending or descending order of intensity of a specific attribute, e.g. sweetness. Ranking is often used for screening inferior from superior samples in product development. This method is also suited for comparison of market samples of different brands. Samples may be ranked in order of degree of acceptability or by a specific attribute. The assessment sheet for ranking the samples based on aroma/taste characteristic of the product is provided in the slide.

Fuzzy Method

Sensory properties (contd...)

Fuzzy method

- ✓ Here the rating of both sample and its attributes in terms of importance is done.
- ✓ For each sample, the scale of measurement is from not-satisfactory to excellent and for sensory attributes, the scale is varied from not at all important to extremely important.
- ✓ The sensory data is converted into triplets using the pre-defined fuzzy methods. These triplets are then converted into membership function values using standard fuzzy scales and finally similarity values are evaluated for ranking of the samples.
- ✓ Fuzzy method has advantage of taking the importance of sensory attributes for ranking of the samples.
- ✓ The method is also used to rank the sensory attributes based on their similarity values calculated using the importance scores.

Sensory quality attributes & range across samples	Sensory scale factors				
	Not satisfactory	Fair	Medium	Good	Excellent
Color					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Aroma					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Taste					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Memorability					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sensory quality attributes of range divide in general	Sensory scale factors				
	Not at all important	Slightly important	Important	Highly important	Extremely important
Color					
Aroma					
Taste					
Memorability					



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In fuzzy method the rating of both sample and its attributes in terms of importance is done.


For each sample, the scale of measurement is from not-satisfactory to excellent and for sensory attributes, the scale is varied from not at all important to extremely important. The sensory data is converted into triplets using the pre-defined fuzzy methods. These triplets are then converted into membership function values using standard fuzzy scales and finally similarity values are evaluated for ranking of the samples. Fuzzy method has advantage of taking the importance of sensory attributes for ranking of the samples. The assessment sheet for fuzzy method is provided.


Microbiological Properties

Microbiological properties

- In fermented beverages, various kind of microorganisms like yeasts, molds, algae, viruses, bacteria, pathogens, spoilage, beneficial, inert, etc. may be present.
- Early destruction of spoilage causing microorganism (MO) are generally done before fermentation. However, further safe GMP practices must be followed to have spoilage MO free fermented beverage at the end.
- However, the thermal processing should be done in such a way so that the spoilage organism get killed but beneficial organism must remain preserved.

Fermented Foods/Beverages	Substrates Used	Microorganisms Involved in Fermentation
Dairy products Curd, Yogurt, Cheese, Yakult, Kefir	Milk and milk casein	<i>Lactobacillus bulgaricus</i> , <i>Lactococcus lactis</i> , <i>L. acidophilus</i> , <i>L. cremoris</i> , <i>L. casei</i> , <i>L. paracasei</i> , <i>L. thermophilus</i> , <i>L. kefir</i> , <i>L. caucasicus</i> , <i>Penicillium camemberti</i> , <i>P. roqueforti</i> , <i>Acetobacter lovaniensis</i> , <i>Kluyveromyces lactis</i> , <i>Saccharomyces cerevisiae</i>
Vegetable products Kimchi, Tempeh, Natto, Miso, Sauerkraut	Soybean, cabbage, ginger, cucumber, broccoli, radish	<i>Leuconostoc mesenteroides</i> , <i>Aspergillus</i> sp., <i>Rhizopus oligosporus</i> , <i>R. oryzae</i> , <i>I. sakei</i> , <i>I. plantarum</i> , <i>Thermotoga</i> sp., <i>I. hokkaidonensis</i> , <i>L. rhumosus</i> , <i>Rhodospirillum rubrum</i> , <i>Leuconostoc carnosum</i> , <i>Bifidobacterium dentium</i> , <i>Enterococcus faecalis</i> , <i>Weissella confusa</i> , <i>Candida sakei</i>
Cereals Babura, Ambali, Chitra, Dosa, Kuru-Zaki, Marcha	Wheat, maize, sorghum, millet, rice	<i>L. pantheris</i> , <i>L. plantarum</i> , <i>Penicillium</i> sp., <i>S. cerevisiae</i> , <i>I. mesenteroides</i> , <i>F. faecalis</i> , <i>Trichosporon pullulans</i> , <i>Pedococcus aciflactici</i> , <i>F. cerevisiae</i> , <i>Debaryomyces hansenii</i> , <i>Deb. tamarii</i>
Beverages Wine, Beer, Kombucha, Sake	Grapes, rice, cereals	<i>Aspergillus oryzae</i> , <i>Zygosaccharomyces bailii</i> , <i>S. cerevisiae</i> , <i>Acetobacter pasteurianus</i> , <i>Gluconacetobacter</i> , <i>Acetobacter xylinus</i> , <i>Komagatacoccus xylinus</i>
Meat Products Sucuk, Salami, Arjia, Jama, Nham	Meat	<i>I. sakei</i> , <i>I. curvatus</i> , <i>I. plantarum</i> , <i>Leuconostoc carnosum</i> , <i>Leuconostoc gelatum</i> , <i>B. hiberniformis</i> , <i>L. faecalis</i> , <i>L. hirci</i> , <i>L. durans</i> , <i>Bacillus subtilis</i> , <i>L. divergens</i> , <i>L. carnis</i> , <i>L. cecorum</i> , <i>B. lentus</i>





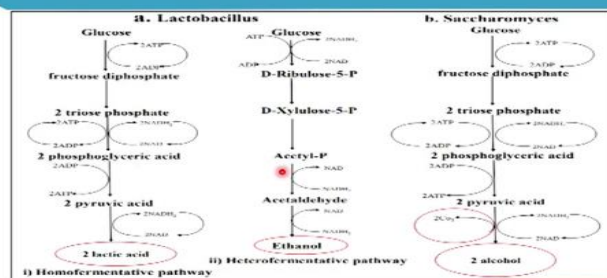
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In fermented beverages, various kind of microorganisms like yeasts, molds, algae, viruses, bacteria, pathogens, spoilage, beneficial, inert, etc. may be present. Early destruction of spoilage causing microorganism (MO) are generally done before fermentation. However, further safe GMP practices must be followed to have spoilage MO free fermented beverage at the end. However, the thermal processing should be done in such a way so that the spoilage organism gets killed but beneficial organism must remain preserved. The table provides information about the fermented food and beverages, substrate used and the microorganism involved in the fermentation. Dairy based fermented products are curd, yoghurt, cheese, yakult, kefir, and et cetra. The substrate used are milk and milk casein. Microorganisms involved are *L. bulgaricus*, *L. lactis*, *L. acidophilus*, *L. cremoris*, *L. casei*, *L. paracasei*, *L. thermophilus*, *L. Kefir*, *L. caucasicus*, *Penicillium camemberti*, *P. roqueforti*, *Acetobacter lovaniensis*, *Kluyveromyces lactis*, and *Saccharomyces cerevisiae*. In case of vegetable-based products like kimchi, tempeh, natto, miso and sauerkraut, the substrate are soybean, cabbage, ginger, cucumber, broccoli, and radish, the fermenting microorganisms are *Leuconostoc*

mesenteroids, *Aspergillus sp.*, *Rhizopus oligosporus*, *R. oryzae*, *L sakei*, *L. plantarum*, *Thermotoga sp.*, *L. hokkaidonensis*, *L. rhamnosus*, *Rhodotorula rubra*, *Leuconostoc carnosum*, *Bifidobacterium dentium*, *Enterococcus faecalis*, *Weissella confuse*, and *Candida sake*. For the cereals based fermented foods like bhatura, ambali, chilra, dosa, kunu-zaki, and marchu, the substrates are wheat, maize, sorghum, millet and rice. The microorganisms involved are *L. pantheris*, *L. plantarum*, *Penicillium sp.*, *S. cerevisiae*, *L. mesenteroids*, *E. faecalis*, *Trichosporon pullulans*, *Pediococcus acidilactici*, *P. cerevisiae*, *Delbruekii hansenii*, and *Deb. Tamari*. For the beverages like wine, beer, kombucha and sake, the substrate are grapes, rice and cereals. *Aspergillus oryzae*, *Zygosaccharomyces bailii*, *S. cerevisiae*, *Acetobacter pateurianus*, *Gluconacetobacter*, *Acetobacter Xylinus*, and *Komagataeibacter xylinus* are the fermenting organisms. Meat products like sucuk, salami, arija, jama and nham has meat as substrate, while *L. sakei*, *L. curvatus*, *L. plantarum*, *Leuconostoc carnosum*, *Leuconostoc gelidium*, *B. licheniformis*, *E. faecalis*, *E. hirae*, *E. durans*, *Bacillus subtilis*, *L. divergens*, *L. carnis*, *E. cecorum*, and *B. lentus* as fermenting microorganism.

Microbiological properties (contd...)

- For all the fermented foods and beverages, lactic acid bacteria (LAB) is the dominant microbiota, which has been considered the most critical part contributing to beneficial effects in fermented foods/beverages.
- The fermenting microorganisms mainly involve LAB like *Enterococcus*, *Streptococcus*, *Leuconostoc*, *Lactobacillus* and *Pediococcus*; and yeasts and molds viz. *Debaryomyces*, *Kluyveromyces*, *Saccharomyces*, *Geotrichium*, *Mucor*, *Penicillium* and *Rhizopus species*.



For all the fermented foods and beverages, lactic acid bacteria (LAB) is the dominant microbiota, which has been considered the most critical part contributing to beneficial effects in fermented foods/beverages. The fermenting microorganisms mainly involve LAB like *Enterococcus*, *Streptococcus*, *Leuconostoc*, *Lactobacillus* and *Pediococcus*; and yeasts and molds viz. *Debaryomyces*, *Kluyveromyces*, *Saccharomyces*, *Geotrichium*, *Mucor*, *Penicillium* and *Rhizopus species*. In homofermentative pathway, *Lactobacillus* converts glucose to fructose diphosphate and to 2 triose phosphate, to 2 phosphoglyceric acid, to 2 pyruvic acid and finally to 2 lactic acids. In the process it uses phosphate from ATP to produce ADP and

takes hydrogen from NADH_2 to give out NAD. In heterofermentative pathway glucose is converted to D-Ribulose – 5 – P and it involves one ATP and 2 NAD. It is converted to D-Xylulose-5-P and to Acetyl-P. It takes up H_2 from NADH_2 to produce Acetaldehyde and produces ethanol with NADH_2 . *Sacharomyces* converts glucose to ethanol with fructose diphosphate, triose phosphate, phosphoglyceric acid, and pyruvic acid as the intermediate metabolites.

Microbiological properties (contd...)

• Spoilage causing microorganism in wine

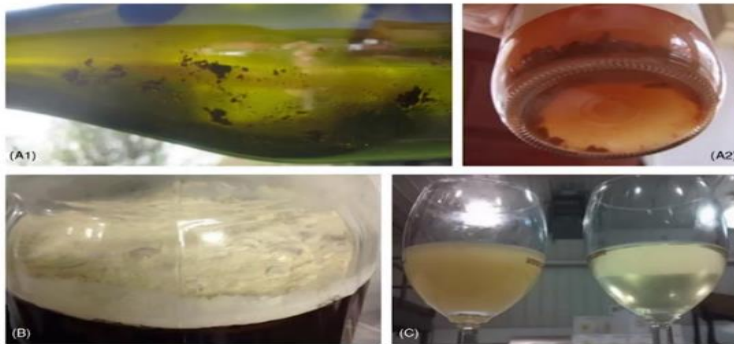
- ✓ Several microbial contaminants appear to survive on walls and other interior surfaces of wineries, including those of presses and fermentation tanks, and within wooden barrels.
- ✓ *Zygosaccharomyces*, *Dekkera*, *Saccharomyces*, and *Saccharomycodes* causes spoilage of bulk and bottled wines.
- ✓ *D./B. bruxellensis* and *Zygosaccharomyces bailii* are spoilage yeasts.
- ✓ *S. cerevisiae* appears to be more problematic than indicated, as some strains isolated from dry white wines seem to be more of a potential spoilage yeast than *Z. bailii*, due to its sorbic acid and sulfite tolerance at high ethanol levels.
- ✓ Both *Z. bailii* and *S. cerevisiae* can grow at low pH in the presence of acid concentrations near the legal limits.



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Spoilage causing microorganism in wine (contd...)



- The microorganism present in wine causes spoilage which could be seen from the change in physical properties like sedimentation, film formation, turbidity and viscosity change.

Microorganism sensory visual problems such as sediment (A1 and A2); film formation (B); and turbidity and viscosity (C).



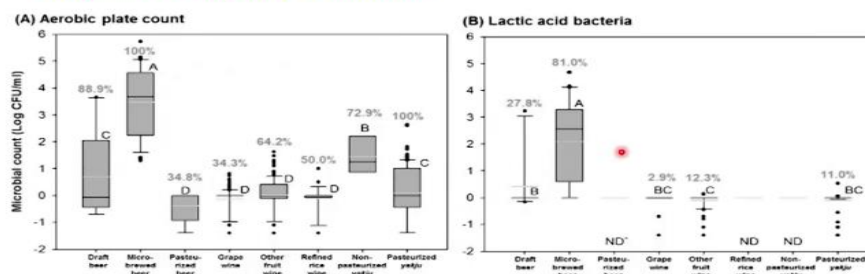
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The picture shows the microorganisms sensory visual problems such as sedimentation, film formation, turbidity and change in viscosity.

Case Study

Case study : Spoilage microorganism present in commercially available fermented alcoholic beverage

- The 469 commercially available fermented alcoholic beverages including beer (draft, micro-brewed, and pasteurized), fruit wine (grape and others), refined rice wine, and *yakju* (raw and pasteurized) were evaluated.



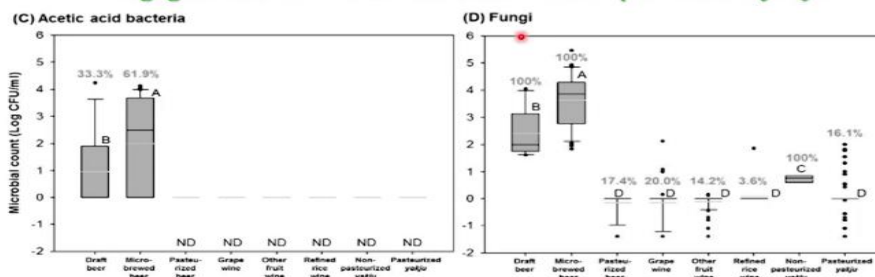
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Spoilage microorganism present in commercially available fermented alcoholic beverage were studied and presented as the case study. About 469 commercially available fermented alcoholic beverages including beer (draft, micro-brewed, and pasteurized), fruit wine (grape and others), refined rice wine, and *yakju* (raw and pasteurized) were evaluated. The graph shows that Microbrewed beer contained the highest number of microorganisms (average aerobic plate count, 3.5; lactic acid bacteria, 2.1; acetic acid bacteria, 2.0; and fungi, 3.6 log CFU/ml), followed by draft beer and yakju ($P < 0.05$), whereas the other FABs contained, 25 CFU/25 ml microorganisms. Unexpectedly, neither microbial diversity nor microbial count correlated

with the alcohol content (4.7 to 14.1%) or pH (3.4 to 4.2) of the product. Despite the harsh conditions, coliforms (detected in 23.8% of microbrewed beer samples) and *B. cereus* (detected in all FABs) were present in some products. *B. cereus* was detected most frequently in microbrewed beer (54.8% of samples) and nonpasteurized yakju (50.0%), followed by pasteurized yakju (28.8%), refined rice wine (25.0%), other fruit wines (12.3%), grape wine (8.6%), draft beer (5.6%), and pasteurized beer (2.2%)

Case study : Spoilage microorganism present in commercially available fermented alcoholic beverage (contd...)

- Acetic acid bacteria is not detected in pasteurized grape wine, refined rice wine, *yakju* and even in their non-pasteurized forms.
- The fungi growth was observed in beer and non-pasteurized *yakju*.



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Acetic acid bacteria are not detected in pasteurized grape wine, refined rice wine, *yakju* and even in their non-pasteurized forms. The fungi growth was observed in beer and non-pasteurized *yakju*.

Summary

Summary

- The fermented fruit and beverage has higher nutritional value than its unfermented counterparts.
- Various physical properties of fermented beverage like pH, texture, taste, color, aroma, titratable acidity and rheological can be measured using different instruments.
- Aroma and taste of wine can be measured using e-Nose and e-Tongue.
- The fermented beverage must have acceptable sensory property which can be analysed using four methods like discriminative tests, 9-point hedonic scale, ranking and fuzzy methods.
- The fermented fruits and vegetable beverage can be spoiled due to improper processing, carrying and storage conditions, thus, it is important to kill the spoilage microorganism with stability of beneficial microorganism.



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References for further reading are provided in the slide.