Addis Ababa University
School of Chemical & Bio-Engineering
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LECTURE NOTE ***(by Adamu Zegeye)***

1. FOOD QUALITY

Quality has become an important issue in agri-business and food industry. In the last two decades many scientists, technologists and managers, contributed largely to the thinking about quality.

The described quality concepts range from simple illustrations to complex models reflecting factors that might influence quality expectation and perception by consumers or customers. General concepts for quality as well as specific concepts for quality perception of food products have been summarized.

1.1 DEFINITIONS AND BASIC CONCEPTS

Van den Berg and Delsing (1999) described quality as a necessary condition and relationship between suppliers or companies delivering products dedicated to the satisfaction and expectations of the customers or consumers.

According to Evans and Lindsay (1996), the concept of quality is described by different criteria, based on judgments, product-, user-, and manufacturing based
criteria.

From a judgmental point, quality is considered as synonym of excellence or superiority. From this viewpoint quality is loosely related to a comparison of product characteristics, it is (sometimes) more a quality image created by marketing.

From a product-based view, quality is defined as a function of a specific, measurable variable, reflected in quantitative differences and often associated with price: higher price for better product.

The user-based definition of quality reflects the consumer's wishes. The value-based criteria, is related to the price of the product. From this point of view, quality is represented by a competitor sold at a lower price or a product that offers greater usefulness or satisfaction at a comparable price.

The manufacturing-based quality is described as the desirable outcome of engineering and manufacturing practice, or conformation to specifications. These specifications include targets with tolerances, as specified by the designers of products and services.

Quality dimensions

Several authors attempted to define factors, attributes or dimensions, which are assumed to be relevant for the quality perception of a product.

Table 1 includes the quality characteristics of goods related to food.

GOODS	FOOD
*Performance • Features: additional properties • Conformity: physical and performance characteristics corresponding to pre-established standards • Durability: duration before physical deterioration or reparation • Reliability • Aesthetics: how a product looks, feels, or sounds • Serviceability: speed, courtesy, and competence of repair	*Physical product features: (sensory properties) such as taste, odors, texture • Additional features: e.g. convenience of ready-to-eat meal • Product safety: no risks for the consumer • Shelf life: storage time for agriculture and food products • Reliability: constant behavior of a product (appearance color, size, image) • Complaint service: quick response to rejected food products • Availability of the product at food service

*Perceived quality: subjective assessment of quality delivered by image, advertising, or brand names	market Perceived quality: advertisement or brands with influence on quality perception. • Price of the product

Intrinsic and extrinsic attributes

A product has physical features that are turned into quality attributes by the perception of a consumer. With respect to food products, quality perception appeared to be affected by different types of attributes. Relevant attributes for consumers involve safety, nutritional value (health aspect), sensory properties (like taste, flavor, texture, and appearance), shelf life, convenience (e.g. ready-to-eat meal) and product reliability (correct weight, right composition etc.).

Extrinsic attributes refer to production system characteristics and other aspects, like environmental impact or marketing influence. They do not necessary have a direct influence on physical properties but may affect acceptance of products by consumers. For example, the use of pesticides, of antibiotics to improve animal growth, or the application of biotechnologies to modify product properties, can have a significant effect on food acceptance.

Intrinsic attributes characterize the physical product, whereas marketing efforts mainly determine extrinsic attributes. According to this classification, typical intrinsic attributes include appearance, color, shape and texture. Typical extrinsic attributes are price, brand name, packaging, labeling, product information. According to this classification extrinsic attributes are mainly related to marketing variables, whereas in our model typical food aspects like production characteristics and environmental impact are included.

Quality perception is formed at two different moments: when the product is purchased, consumers have a quality expectation, whereas upon consumption, the actual quality is experienced. Quality expectation is an important factor in consumer choice behavior, while quality experience is important for repetitive purchase.

Extrinsic attributes are related to the product but are not part of it, like price, brand or store name. These cues have a predicted value for the consumer and thus influence the quality expectation. Generally, the intrinsic cues are more considered than extrinsic cues.

Production system characteristics do not necessarily affect the physical attributes, e.g. use of pesticides will not directly influence product features but might affect quality expectations but a change in production system characteristics may influence the physical features.

In a case study in the biological meat production chain, it was shown that if meat was biologically produced, it influenced positively the quality expectation. Appearance was negatively judged and overruled the positive effect of the production system characteristics.

1.2 INTRINSIC QUALITY ATTRIBUTES

The intrinsic attributes are safety and health aspects of a product, shelf life and sensory properties, convenience and product reliability.

A. Sensory properties and shelf life

Sensory perception of food is determined by the overall sensation of taste, odor, color, appearance, texture. The physical features and chemical composition of a product determine the sensory properties. In general high moisture agri-food products are perishable. After harvesting a fresh product or after processing, the food deterioration process starts, which affects negatively the sensory properties. Processing and/or packaging are aimed at delaying, inhibiting or reducing the deterioration processes in order to extend the shelf life period.

The shelf life of a product can be defined as the time between harvesting or processing and packaging of the product and the point at which it becomes unacceptable for consumption. Shelf life can be restricted by microbiological, and/or (bio) chemical and/or physiological and/or physical processes. For example, freshly harvested peas are spoiled within 12 hours, whereas canned peas can be kept for 2 years at room temperature. The unacceptability is usually reflected by altered sensory properties, for example formation of rotten odor or sour taste by bacteria spoilage.

The actual shelf life of a product depends on the rate of the deterioration processes, e.g. although a product is safe, not spoiled by bacteria it will become unacceptable because of its grey color.

Microbiological processes in foods can result in food spoilage with the development of undesirable sensory characteristics, including loss of texture, development of off-flavors and off-colors. In some situations the food contains pathogens and becomes unsafe prior detecting any changes in sensory characteristics.

Typical chemical reactions that can limit product shelf life are non-enzymatic browning (Maillard) and oxidative reactions, which causes changes in appearance and lowers the nutritional value and oxidative reactions, especially auto-oxidation of lipids which alter the flavor, bleaching of plant pigments(carotenoids).

Generally chemical changes occur during processing and storage of agri-food products. The non-enzymatic browning reaction also leads to desirable quality characteristics such as browning of bread crust and brown color of fried meat.

Biochemical reactions involve enzymes released by disruption of the integrity of plant or animal tissue. For example, cutting of fresh vegetables initiates several enzymatic reactions, such as browning by phenolases and formation of off-flavors by lipoxigenase. In similar circumstances biochemical reactions are controlled and used to produce better digestible food, e.g. fermentation of cabbage. A typical example is meat ageing by increased temperatures while surface growth of bacteria is controlled by ultra violet light. Physical changes are often due to mishandling of agrifood products during harvesting, processing and distribution. During storage and distribution, fluctuating temperature and humidity conditions can result in desiccation of humid products, swelling of dried products or phase changes. The breaking of emulsions and phase separation are also typical physical processes resulting in negative product features. Physiological reactions commonly occur during post-harvest storage of fruits and vegetables and strongly depend on storage conditions. The products still have a respiration rate and ethylene is still produced having a considerable effect on typical post harvest defects.

The shelf life of a product is often limited by one major reaction, but sometimes a typical quality defect may be due to different mechanisms. For example, rancid off-flavor can be due to lipase activity producing short fatty acids chains or by oxidation of fatty acids. It is therefore necessary, to control this quality defect, to identify the responsible mechanism generally, the fastest reaction is responsible for the shelf life limitation. For example, undesirable changes in texture of bread usually occur prior to growth of molds. In this case physical degradation is faster than microbiological changes, degradation being the shelf life limiting factor. Inhibition, reduction or prevention of the main shelf life limiting factor often results in an extended shelf life for that specific factor. During the extended storage slower degradation processes may became prominent. For example freezing of foods extends the microbial-free shelf life but after 1 - 1 ½ year color and texture changes occur by chemical and physical reactions. To control the technological product quality it is important to understand the different processes that limit product shelf life and affect sensory properties.

B. Product safety and health

Product safety and health aspects are important intrinsic quality attributes. Health aspects refer to food composition and diet, nutritional imbalance having negative consequences on human health. Nowadays, the food industry anticipates these nutritional needs by the development of functional foods. These products are assumed to contribute positively to human health, e.g. low-fat and low-cholesterol products, but also vitamin or mineral enriched foods.

Food safety refers to the requirement that products must be free of hazards with an acceptable risk. A hazard can be defined as a potential source of danger, while risk can be described as a measure of the probability and severity of harm to human health.

Different sources can affect food safety: growth of pathogen micro-organisms, presence toxic compounds, physical agents and occurrence of calamities. Negative health effect can have a different time span and can be acute (such as allergic reactions or food poisoning) whereas others induce long-term, chronic effects via cancer, heart and vascular diseases. These chronic effects can be due also to unhealthy balances of diet or long term exposure to chemical agents.

C. Product reliability and convenience

Product reliability refers to the compliance of actual product composition with its description. For example, the weight of the product must be correct within specified tolerances. If it is claimed as enriched with vitamin C it must be in agreement with actual concentration in the product after processing, packaging and storage. Deliberate modification of the product composition will cause damage to the product reliability, i.e. product falsification. An example is when alternative (cheaper) raw materials are used and not mentioned on the label.

Product reliability is generally an implicit expectation, consumers expect that a product is in compliance with the information mentioned on the packaging.

Convenience relates to ease of use or consumption of the product for the consumer. Product convenience can be accomplished by preparation, composition and packaging aspects. Convenience foods range from sliced and washed vegetables to complete ready-to-eat meals that only have to be warmed in the microwave or oven. Much attention is paid in the food industry to development of ready-to-eat meals that can be easily and quickly prepared while having good sensory and nutritional properties. Also packaging concepts are more and more designed to
fulfill the consumer's need for convenience.

1.3 EXTRINSIC QUALITY ATTRIBUTES

Production system characteristics, environmental implications of food products and their production and marketing aspects can be considered as extrinsic quality attributes . Extrinsic quality attributes do not necessarily have a direct influence on physical product properties, but can influence consumer's quality perception. For example, marketing activities can influence consumer expectations but have no relationship with any physical property.

A. Production systems characteristics

Production characteristics refer to the way a food product is manufactured. It includes factors such as the of pesticides while growing fruit and vegetables, animal welfare during cattle breeding, use of genetic engineering to modify product properties or use of specific food preservation techniques. The influence of production systems characteristics on product acceptance is very complex. For example, there has been much concern about public acceptance of new genetically modified food products and genetic engineering in general.

B. Environmental aspects

Environmental implications of agri-food products refer mainly to use of packaging and food waste management. Intrinsic quality properties such as taste or nutritional value are related to personal interests, whereas environmental properties of food may be related to wider community oriented interest. Consumers express interest in buying foods from environ-mentally sound production, either because of concern for their own health or because of concern for the external environment. With respect to the environmental consequences of packaging waste, European directives have been enacted to reduce this environmental impact. Since 1997 the food packaging industry is legally liable to improve material recycling and thus reducing packaging waste. With respect to waste management, inefficient processing is mainly a cost problem for processors and not yet a major quality concern of consumers.

C. Marketing

The effect of marketing on product quality is complex. The marketing efforts (communication via branding, pricing and labeling) determine extrinsic quality attributes, affecting quality expectation. Marketing can also affect credence attributes (which can be checked by consumers themselves) influencing quality experience.

II. SENSORY QUALITY AND CHEMICAL COMPOSITION

Name:	Product:		
Panelist No.:	Date:		
Instructions: Taste the given samples, then place an x mark on the point in the scale which best describes your feeling.			
SCORE*	SAMPLE CODE		
(9) Like extremely			
(8) Like very much			
(7) Like moderately			
(6) Like slightly			
(5) Neither like nor dislike			
(4) Dislike slightly			
(3) Dislike moderately			
(2) Dislike very much			
(1) Dislike extremely			

Triangle Test

Name ______________ Date ________

Type of Sample ______________________

Instructions

Taste samples from left to right. Two are identical; determine which is the odd sample.

If no difference is apparent, you must guess.

Sets of three samples	Which is the odd sample?	Comments
___ ___ ___	________	__________
___ ___ ___	________	__________
___ ___ ___	________	__________

2.1 SENSORY QUALITY

Methods of Sensory Evaluation

Sensory evaluation methods may be divided into two broad classes: affective and analytical methods (Institute of Food Technologists, 1981). Affective methods use consumer panels or trained panelists to answer questions such as the following:

• Which produ ct do you prefer?

• Which product do you like?

• How well do you like this product?

• How often would you buy/use this product?

Affective methods require a much larger panel size than do analytical methods in order to have greater confidence about the interpretation of the results. The most common analytical methods of sensory evaluation used in the wine industry are discrimination (or difference) and descriptive methods. Discrimination tests can be used to determine if products are different, if a given wine characteristic is different among samples, or if one product has more of a selected characteristic than another. Experienced panelists can complete discrimination tests.

Descriptive methods are used to provide more-comprehensive profiles of a product by asking panelists to identify the different characteristics within the product and quantify characteristics. Trained panelists must be used for descriptive methods (see Trained Panelists and Panelist Training).

2.2 SENSORY TESTS

Discrimination (Difference) Tests

Difference testing is used to determine if different winemaking processing techniques or operations have a sensory impact. As such, difference testing methods generally provide the winemaker with the practical information needed. They are the most feasible for use in a winery environment, and are simple and robust.
There are many other sensory methods available, including consumer preference and acceptance tests, and descriptive analysis. However, performing some of these more-elaborate tests may not be feasible in small- to medium-sized wineries. They are available through sensory service companies.

Difference testing is a way to determine if a sensory difference actually exists between samples. The degree or nature of the difference cannot be quantified, however. Descriptive tests are generally needed to truly define differences. There are four types of difference tests which can be used to answer some practical questions. The most common for use in the wine industry are the triangle difference test and the duo-trio difference test:
• triangle: "Is a particular lot made with rot -compromised fruit different from other lots?"

• duo -trio: "Is there a sensory difference among wines fermented with different yeasts?"

• pa ired comparison: "Does the high VA in this wine impact it sensorially?"
A brief description of the methodology of these procedures, including how to perform the tests, the number of tasters required, and the required result for concluding that a significant difference truly exists are available in sensory science literature (see Table 2). Once a difference has been established, another more elaborate test, such as a preference test, can also be performed.

Difference tests are sometimes applied in a crude fashion at the winery where only one or two tasters perform the evaluation. While better than no testing at all, to achieve a statistically-significant sensory result, a slightly more advanced procedure should be carried out using the minimum number of tasters (Table 2)

Generally, the larger the number of evaluators, the better. However, even a small panel of 5-7 will provide highly-valuable information that will greatly increase reliability and consistency of production decisions based on sensory assessment. Table 2 provides the number of correct responses for various tests to be statistically viable at the 95-percent confidence limit. This means that there is but a 5% chance that these results are simply due to random error.
Using a panel, as opposed to a single taster or two, reduces the risk of concluding there is no difference among wines, when one actually exists. Any number of panelists can be used, and the more tasters, the better. For an overview of wine sensory evaluation, and to determine the number of correct responses required for a significant result for any number of tasters, see Zoecklein et al. (1999 and 2005).

Table 2. Outline of sensory difference and preference tests

Test	Min. tasters	Use	Samples	Basic method	Results: are the wines significantly different?
Triangle	5	Multi-purpose	Three coded test samples. Two are the same wine (A) (but are coded differently). One is a different wine (B).	Tasters assess all three samples, then pick the sample which is different from the other two, or the odd one out. Serving orders3: AAB, ABA, BAA, BBA, BAB, ABB	**Correct response** - taster picks the odd one out. **Significance** - Required no. of correct/total responses2: Single tasting 4/5 5/6 5/7 6/8 Repeated tasting 7/10 8/12 9/14 9/16
Duo-trio	7	Comparison to a reference wine	One reference sample (Ref). Two coded test samples (A,B). A is the same wine as the reference (control wine). B is the wine to test.	Tasters assess the reference (Ref), then the two test samples (A,B). Tasters are asked to indicate which test sample is the same as the reference. Serving orders: Ref AB, Ref BA	**Correct response** - taster picks A as the same as the reference. **Significance** - Required no. of correct/total responses2: Single tasting 7/7 7/8 8/9 9/10 Repeated tasting 10/12 11/14 12/16 13/18
Paired comparison	7	When a difference is known	Two coded test samples (A,B). One is known to be chemically higher in an attribute (e.g., sweetness).	Tasters are asked to identify which sample is higher in an attribute (e.g., identify which sample is sweeter). Serving orders: AB, BA	**Correct response** - taster picks the sample that is higher (e.g., the presumed sweeter sample). **Significance** - Required no. of correct/total responses2: As for *Duo-trio*

Same/ different	7	When a difference is unknown	Two coded test samples (A,B).	Tasters assess both samples and indicate whether they think samples are the same or are different. Serving orders: AB, AA, BA, BB (Note: two serving orders are presented to each taster)	**Correct response** - taster correctly picks the two samples as being the same or different, depending on the serving order. **Significance** - Required no. of correct/total resonses2: As for *Duo-trio*
Paired preference	7	Which wine is preferred	Two coded test samples (A,B).	Tasters assess both samples and indicate which one they prefer. A choice must be made; the taster can't say they prefer neither. Serving orders: AB, BA	Count the number of people who prefer one wine over another (e.g., A over B). **Significance** - Required no. preferred A/total4: Single tasting 7/7 8/8 8/9 9/10 Repeated tasting 12/14 13/16 14/18 15/20

Selection of the appropriate difference test depends on many factors, including the following:

- objectives
- number of available tasters
- volume of wine available

Again, the most common discrimination methods include the triangle test, the paired comparison test, and the duo-trio test (ASTM, 1968; Meilgaard et al., 1991; Stone and Sidel, 1985). Although discrimination tests may be completed by a small number of panelists (10 to 12), statistical determination of differences is more enhanced with a greater number of responses. Analysis of these methods is made easy by the use of statistical tables from which results of the test may be quickly analyzed.

These tests are relatively simple for the panelists if the panelists are knowledgeable about the product and characteristics of interest. In each method, the panelist is forced to make a decision or choice among the products. The amount of information drawn from these tests is limited to a detection of difference. It is not possible to know the degree of differences that exist among products, or if the change in the characteristic affects acceptability of, or preference for, the product.

Triangle Test. Triangle tests are useful as a multi-purpose test. The taster is required to select the sample which is different. Triangle tests are often preferred, as they require fewer tasters, and there is a greater likelihood that a result will be genuine and not due to a chance effect.
The triangle test uses three samples to determine if an overall difference exists between two products. The three samples include two that are identical, and one that is different. The samples must be coded with individual three-digit numbers.

(derived from a random numbers table) and presented at one time to the panelists. The panelist is requested to identify the code on the scorecard representative of the odd sample. This method requires the panelist to make a choice among the samples; the panelist has a 33% chance of simply guessing correctly. This test method has good applications in determining if a process change affects the overall product character. Fatigue is a factor, as panelists usually must re-taste several times. Adaptation may also occur as a result of re-tasting. It is recommended that no more than two sets (six samples) be evaluated at one testing session.
Interpretation is based on the minimum number of correct responses required for significance at a predetermined significance level, given the total number of responses received. The minimum number of correct responses may be found in statistical tables provided in several publications (ASTM, 1968; Meilgaard et al., 1991; Stone and Sidel, 1985).
For example, two wines processed under identical conditions are fermented in the bottle for 6 months at two different temperatures, 7°C (45°F) and 13°C (55°F), in order to determine if the warmer fermentation temperature results in a different product. Twenty-four panelists evaluate the two wines, using a triangle test.
A difference is wanted at a 5% level of significance ($p \leq 0.05$). Fifteen of the 24 panelists correctly identify the odd sample. Is there an overall difference between the product fermented at 7°C, compared with the product fermented at 13°C?

At the 5% level of significance with 24 panelists, a minimum of 13 correct responses were needed to determine that there was a significant difference between the samples. There is a 95% or greater probability that the product fermented at 13°C is noticeably different from the product fermented at 7°C.
Duo-Trio Test. Duo-trio tests are sometimes used instead of triangle tests to compare unknown differences between wines. Tasters are presented with a reference wine, and then two test wines; one wine is the same as the reference, and the other is the wine to be tested. Evaluators are asked to identify the sample that is the same as the reference wine.

This test might be preferred, as the evaluator has a reference wine to compare. Generally, people find it easier to evaluate with a reference standard. It can also be better for assessing red wines by palate, as there is less palate fatigue. One disadvantage of this test, versus a triangle difference, is that more tasters are required (see Table 1).
The reference sample may always be set as the same product (constant reference) or may be randomly chosen so that each product is represented (balanced reference). This test method is less efficient than the triangle test, with a 50% chance of guessing correctly, and requires a large amount of sample, but is frequently used when a flavor is complex or intense. Interpretation is easily determined from a statistical table (ASTM, 1968; Meilgaard et al., 1991; Stone and Sidel, 1985).

Paired Comparison Test. Paired comparison tests can be used when there is a known difference in chemical composition of the wines (a simple difference test), which requires a sensory assessment. For example, a higher VA is present. But does the wine have a spoilage character? Is the wine more volatile?
They can also be used to see if there is a directional difference for a single characteristic (“Which product is more acidic? Product 738 or Product 429?”) between the samples. This test can be useful when assessing alternative wine blends. The test requires the same amount of wine and tasters as the duo-trio test. Products are compared such that each sample is placed in the first tasting position an equal number of times. This test causes less fatigue and is frequently used for strongly flavored or complex products.

Whereas the triangle test provides only a 33% chance of guessing correctly, there is a 50% chance with the paired comparison test. Therefore, more panelists (at least 20) are recommended to complete this test. Interpretation is easily determined via a statistical table (ASTM, 1968; Meilgaard et al., 1991; Stone and Sidel, 1985).

Same/Different Tests. A same/different test is similar to the paired comparison test, however, it is used when the difference between two wines is unknown. Evaluators are asked to identify whether they think the two samples presented are the same or different. These tests are easy to set up, but more panel members are required, and evaluators must perform the test at least twice, receiving a different randomized serving order each time.

Descriptive Tests

Frequently, it is important to know how a wine changes with a new vineyard site, how intense a characteristic is, etc. Discrimination testing, which is easy to use, easy to interpret, and easy for panelists to complete, is initially used to determine that a difference does exist. Such methods cannot provide information about the description of those differences, though.
Descriptive evaluation methods are more difficult to complete and interpret, but provide much more information. They provide a quantitative measure of wine characteristics that allows for comparison of intensity between products, and a means of interpretation of these results. Examples of descriptive test methods include quantitative descriptive analysis (QDA®), flavor profile analysis, time-intensity descriptive analysis, and free-choice profiling (Hootman, 1992; Meilgaard et al., 1991; Stone and Sidel, 1985). QDA® is frequently used because it requires less training time than several of the other methods.

Quantitative Descriptive Analysis (QDA®). QDA® was developed by the Tragon Corporation and the University of California, Davis. Proper QDA® techniques require following strict methodology.
Descriptive analysis of wines using QDA® requires products with relatively similar characteristics. If possible, 10 to 12 panelists are selected to participate based on ability to discriminate, communication skills, and task comprehension. Using fewer trained panelists is possible for descriptive analysis, but individual responses have a greater effect on the mean scores.

During the training, the group is provided with different wines that represent the range of characteristics that may be tested during the actual test sessions (see Panelist Training). Wine characteristics are identified, definitions or

descriptions of the characteristics are determined, and references exemplifying the characteristics are established. The reference standards are used to further train the panelists to identify the desired characteristics and learn to rate intensity levels.
A scorecard is developed by consensus of the panel that includes all characteristics of interest in the order in which they are to be evaluated. Each characteristic is rated on a 6-inch (15.2-cm) line scale with descriptors of “weak” and “strong” as endpoint anchors. The anchor terms are located 1/2 inch (1.27 cm) from each end of the line; an alternate method places vertical anchors 2.5 cm from each end (Hootman, 1992). Either method is satisfactory. It is important that panelists know they may use the entire line to mark their perception of intensity, even those regions toward the ends of the line.
Panelists continue training until the sensory specialist determines that everyone is demonstrating comprehension of the task, and all panel members can identify and rate each characteristic. Preliminary testing should occur to determine the reliability and validity of the individual panelists before initiating the actual testing (see Performance Evaluation).
After the training is completed, the panelists function independently in the evaluation setting. No more than six or seven attributes should be evaluated at each setting to avoid fatigue. If intense aroma characteristics are evaluated, fewer than six wine samples should be evaluated in one testing.

Products are evaluated for intensity of the characteristics on the scorecard. Panelists rate the intensity of each attribute by marking a vertical mark across the appropriate horizontal rating line. These marks are converted to numerical data by measuring the distance from the origin (“weak”) of the line to the vertical mark.

Sometimes only one or two characteristics are of interest, so an entire profile is not necessary. This reduces the effort required by the panelist and the time needed for data handling and interpretation by the sensory specialist. A line scale as is used for QDA® is appropriate for this, or a category scale with seven to nine verbal descriptors may be used. The category scale is easier to use by panelists with less training than a QDA® panelist.
Data analysis is completed using a mixed model analysis of variance for treatment by subject, with replication (Hootman, 1992). To determine individual panelists’ abilities to perceive differences among products, a one-way analysis of variance is completed for each panelist. This analysis can also be used to determine if an attribute is helpful in differentiating among wines.

Subsequent analysis, using a two-way analysis of variance design, is needed to determine product differences and interactions by the panel (Hootman, 1992). An independent statistical analysis is completed for each characteristic that is measured.

A graphic presentation, called a spiderweb plot, of all characteristics may be made to illustrate the differences and similarities of the descriptive profiles of the wine samples evaluated. This is accomplished by plotting the mean score for a given characteristic on an axis that represents the 15.2-cm line scale used on the scorecard (Hootman, 1992). Each axis extends from a center point like spokes on a wheel, and represents a single characteristic. The center point is equivalent to the low-intensity origin of the line scale, and the highest intensity is equivalent to the end of the axis.

Affective Test Methods

Commonly-used affective methods include a paired preference test, a preference ranking test, and the hedonic test method (ASTM, 1968; Meilgaard et al., 1991; Stone and Sidel, 1985). The test method must be simple and easy to understand, so the consumers making up the panel will know how to respond.

Paired Preference Test. Once a significant difference has been established between two wines, a preference test can be performed. This is useful in determining which wine blend or which yeast fermentation is preferred, for example.

It is important to note that a preference test should be performed separately and after a difference test. It may be tempting to combine the two, but this should be avoided, as results can be misleading. In determining preference, it is also important for the tasters to consider (and possibly discuss) the desired wine style required before tasting the wine. The preference decision should not be a personal preference, but a preference for the wine which best suits the desired wine style.

These tests try to answer the question of which product is preferred, or how much the product is liked.

- The panelists included in these tests should be users of the product.
- There is no need for panel training.
- Optimally, there should be more than 30 panelists.

• There are several types of preference and acceptance tests. A common one is the 9-point hedonic scale.

The paired preference test is set up in the same manner as the paired comparison method for discrimination testing. Two samples are compared to determine which product is preferred. A large number of similar responses must be obtained to determine that one product is preferred more than the other. The minimum number of similar responses needed to determine if the preference is significant is based on the total number of responses obtained, and may be determined from a statistical table.

Ranking Test. If more than two samples are evaluated, a preference ranking test may be completed. Usually three to five samples are the most that can be efficiently ranked by a consumer. This test asks the consumer to order the samples based on preference, with a ranking of “1” meaning most preferred.

Hedonic Test. The hedonic scale may be used to determine degree of acceptability of one or more products. This scale is a category-type scale with an odd number (five to nine) categories ranging from “dislike extremely” to “like extremely.” A neutral midpoint (neither like nor dislike) is included. Consumers rate the product on the scale based on their response.

Principal Component Analysis (PCA)

An advanced statistical method, principal component analysis is frequently used in the wine industry to illustrate relationships between a reduced set of variables. Patterns in descriptive sensory data may be determined by analyzing the data by this multivariate statistical method. The number of variables is reduced using factor analysis, such that the first principal component statistically identified explains most of the variability in the data (Meilgaard et al., 1991). The second component, which is not correlated with the first, explains the majority of the remaining variance.

Additional principal components may be identified, up to the number of observed variables, until no significant variability can be explained from extraction of another principal component. Usually there are only two or three principal components of value, because most of the variability will be explained in the first components that are extracted (Meilgaard et al., 1991).

A graphic portrayal of principal component analysis attributes may be used to illustrate relationships among principal attributes of different wines. Primary and secondary principal components are presented as axes at right angles with each other (Meilgaard et al., 1991).

Data Sheets for Hedonic and Triangle Tests

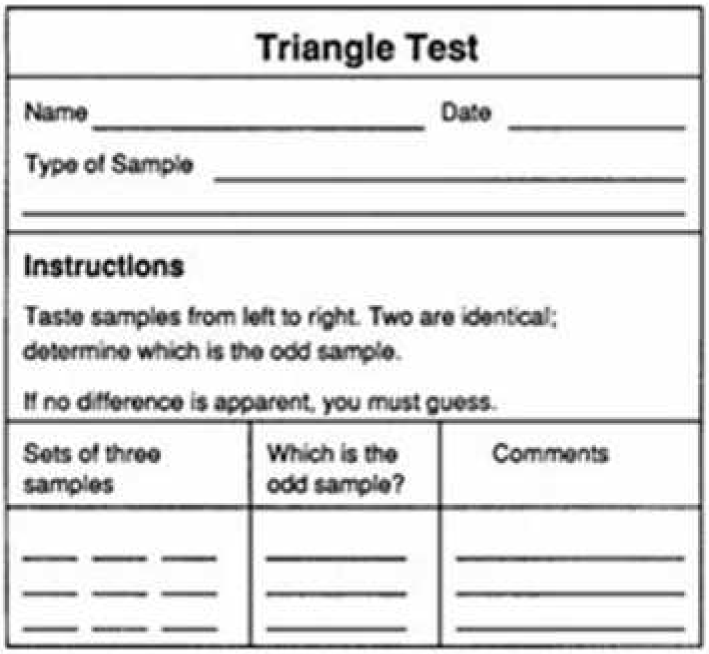
9-point Hedonic Test

Name:		Product:	
Panelist No.:		Date:	

Instructions:
Taste the given samples, then place an x mark on the point in the scale which best describes your feeling.

SCORE*	SAMPLE CODE		
(9) Like extremely			
(8) Like very much			
(7) Like moderately			
(6) Like slightly			
(5) Neither like nor dislike			
(4) Dislike slightly			
(3) Dislike moderately			
(2) Dislike very much			
(1) Dislike extremely			

Triangle Test



Triangle Test

Name ____________ Date ________

Type of Sample ____________

Instructions

Taste samples from left to right. Two are identical; determine which is the odd sample.

If no difference is apparent, you must guess.

Sets of three samples	Which is the odd sample?	Comments
___ ___ ___	______	______
___ ___ ___	______	______
___ ___ ___	______	______

2.3 CHEMICAL COMPOSITION

Food science is an interdisciplinary subject involving chemistry, biology, microbiology, and engineering. ***Food chemistry is the science that deals with the chemical composition and properties of food and the chemical changes it undergoes.*** The subject of food chemistry as an independent branch of science was formed in the19-th century in parallel with growing interest on food quality and suppressing of food adulteration and falsification. New methods of food analysis allowed us to discover and characterize not only the major nutrients (such as proteins, carbohydrates and lipids) but also essential minor components such as vitamins and essential minerals and finally thousands of minor and micro components being natural constituents of food (such as aroma compounds, natural coloring matters, natural antioxidants).

Chemical properties of proteins and enzymes, lipids, carbohydrates, vitamins, flavors and colorants, minerals and other micro components, food additives and contaminants, occurring in different foods, nutritional requirements, changes during processing and storage will are treated.

As a result of investigations of food quality control stations and many other institutions, at present a lot of books, data banks and other facilities are available for obtaining information about chemical composition of foods. Cereals are staple foods in majority of countries and play a central role in nutrient supply. The chemical composition of cereals grains is characterized by a high content of starch, a substance with a relatively significant protein content, and a relatively low lipid content. Similarly the chemical composition of many plant and animal products are currently available in food science literature. Based on their values different engineering properties of foods can be estimated.

III. PHYSICAL PROPERTIES OF FOODS

3.1Size, Shape, Volume, and Related Physical Attributes

3.1.1 Size- Size is an important physical attribute of foods used in screening solids to separate foreign materials, grading of fruits and vegetables, and evaluating the quality of food materials.

3.1.2 Shape is also important in heat and mass transfer calculations, screening solids to separate foreign materials, grading of fruits and vegetables, and evaluating the quality of food materials.

3.1.3 Particle size distribution

The range of particle size in foods depends on the cell structure and the degree of processing. The hardness of grain is a significant factor in the particle size distribution of flour. The particle size distribution of flour is known to play an important role in its functional properties and the quality of end products.

3.1.4 Volume is an important quality attribute in the food industry. It appeals to the eye, and is related to other quality parameters. For instance, it is inversely correlated with texture.

3.1.5 Density: Quality of food materials can be assessed by measuring their densities. Density data of foods are required in separation processes, such as centrifugation and sedimentation and in pneumatic and hydraulic transport of powders and particulates. In addition, measuring the density of liquid is required to determine the power required for pumping.

3.1.6 Porosity is an important physical property characterizing the texture and the quality of dry and intermediate moisture foods. Porosity data is required in modeling and design of various heat and mass transfer processes such as drying, frying, baking, heating, cooling, and extrusion.

3.1.7 Shrinkage is the decrease in volume of the food during processing such as drying. When moisture is removed from food during drying, there is a pressure imbalance between inside and outside of the food. This generates contracting stresses leading to material shrinkage or collapse.

3.2 Rheological Properties of Foods

Rheological properties are defined as mechanical properties that result in deformation and the flow of material in the presence of a stress.

Fluid flow
Viscosity is defined as the resistance of a fluid to flow

Texture is one of the most important quality characteristics of foods. Foods have different textural properties. These differences are caused by inherent differences due to the variety difference, differences due to maturity, and differences caused by processing methods.

3.3 Thermal Properties of foods *(visit your previous courses on Heat and Mass Transfer)*

3.3.1 Thermal conductivity
3.3.2 Specific heat
3.3.3 Thermal diffusivity

3.4 Water Activity

Most of the biochemical and microbiological reactions are controlled by the water activity of the system, which is therefore a useful parameter to predict food stability and shelf life. The rate of moisture transfer in the drying process and through the packaging film or edible food coating during storage can be estimated and as a result drying conditions, packaging, or coating material can be selected using water activity and sorption properties.

Water activity and sorption properties of foods have been considered as important physical properties in food formulations and processes. Most of the biochemical and microbiological reactions are controlled by the water activity of the system, which is therefore a useful parameter to predict food stability and shelf life. The rate of moisture transfer in the drying process and through the packaging film or edible food coating during storage can be estimated and as a result drying conditions, packaging, or coating material can be selected using water activity and sorption properties of foods. In addition, these properties must be considered in product development.

IV. FOOD SAFETY MANAGEMENT

4.1 FOOD SAFETY

Food safety refers to the requirement that products must be free of hazards with an acceptable risk. A hazard can be defined as a potential source of danger, while risk can be described as a measure of the probability and severity of harm to human health. (refer to the first chapter).

Food safety management systems generally include three components:

a) Quality management systems applied to food safety
b) Hazard Analysis and Critical Control Point (HACCP) systems
c) Prerequisite programs and Good Practices including Good Hygiene Practces (GHPs), Good Manufacturing Practices (GMPs), Good Agriculture Practices (GAPs), etc.

4.2 FOOD HAZARD

Hazards are biological, physical or chemical agents not intentionally added that may cause food to be unsafe for human consumption. The goal of food safety management system is to control certain factors that lead out-of-control hazards.

Food can become contaminated by toxic chemicals or toxins in our establishment or in the environment. Food may become naturally contaminated from the soil in which it is grown or from harvest, storage or transportation practices. These inherent hazards along with the hazards that may be introduced in our establishment such as metal fragments from grinding can lead to injury, illness, or death.

Hazards include:

a) Biological agents

Bacteria and their toxins
Parasites
Viruses
The sources include soil, water, etc.

b) Physical objects

Bandages
Jewlery
Stones
Glass
Bone and metal fragments
Packaging materials

The control measures include visual inspection, filters and sieves, metal detectors, magnets, separation by density etc.

c) Chemical contamination

Plant and animal toxins
Non-food grade lubricants
Food additives
Insecticides

Strict control of pestcides and residue limits help to control chemical contamination

4.3 HACCP

In short HACCP is Hazard Analysis Critical Control Point. The principles of HACCP embody the concept of active managerial control by encouraging participation in a system that ensures foodborne illness risk factors are controlled. There are seven principles of HACCP are.

HACCP begins by Performing Hazard Analysis: It is about understanding the operation and determining what food safety hazards are likely to occur. The manager needs to understand how the people, equipment, methods, and foods all affect each other. The processes and procedures used to prepare the food are also considered. This usually involves defining the operational steps (receiving, storage, preparation, cooking, etc.) that occur as food enters and moves through the operation. Additionally, this step involves determining the control measures that can be used to eliminate, prevent, or reduce food safety hazards. Control measures include such activities as implementation of employee health policies to restrict or exclude ill employees and proper hand washing.

Details of each step are given in food science literature. But see the example given hereunder:

<u>**List of the 7 principles**</u>

1. **Conduct a Hazard Analysis**
2. **Identify Critical Control Points**
3. **Establish Critical Limits**
4. **Establish Monitoring**
5. **Establish Corrective Actions**
6. **Establish Verification**
7. **Establish Documentation and Records**

1. Hazard Analysis

A "*hazard*" is anything which may cause harm to your customers.

There are three types of hazards:-

a) biological b) chemical C) physical

a. Biological Hazards

Biological hazards include food poisoning bacteria such as *Salmonella, E. coli* and *Bacillus cereus*, which are hazardous because they can:-

- **survive** inadequate cooking
- **multiply** to harmful levels in food given the right conditions
- **spread** from raw foods to ready to eat foods (cross contamination)

b. Chemical Hazards

Chemical hazards may be present on certain foods in the form of pesticides or cleaning residues. Chemical hazards may also arise from incorrect storage and misuse of cleaning chemicals or rodent bait. Not using food grade equipment may also contaminate the food.

c. Physical Hazards

Physical hazards include contamination from foreign bodies like glass, wood, metal, hair, flies etc. To identify all the hazards associated within your business, you may wish to consider what

process steps are applicable to your business. You will then need to think about the three hazards at each stage/process step of your operation.

Process steps: this is a stage in the business operation to produce certain foods. You will need to think what stages are applicable to your business and either take a generic or specific approach to the foods you produce. For example; purchase/receipt/collect, delivery, storage, Preparation, cooking, cooling, storage, service.

2. Critical Control Points (CCP's)

CCP's are the stages of your process where the hazards must be controlled for the food to be safe to eat.

3. Critical Limit

Critical limits are specified safety limits at your CCP's, which separates acceptable (*safe food*) from unacceptable (*unsafe food*). Critical limits are usually numerical values based on scientific finding. For example: Critical limit for the storage of foods in a fridge. 0 < > 5^{O}C this is **good practice** but the food stored at this temperature is not critical **8^{O}C this is the critical limit 10^{O}C** this has exceeded the critical limit and is **potentially unsafe.**

4. Monitoring

Monitoring procedures would need to be established to ensure hazards are
controlled at CCP's. Such monitoring activity may involve temperature checks, visual inspection and time recording. Monitoring forms are available.

5. Corrective Action

Corrective action, are procedures to be taken when monitoring (at CCP's) has identified that the critical limit has been or is likely to be exceeded.Such action must either make the food safe or prevent its entry into the food chain.

For example: the fridge temperature is 10^{O}C. Your corrective action may state to; Re-monitor in one hour, relocate the food to another fridge operating at or below 8^{o}C, call the manager/owner, call the fridge engineer.

6. Verification

This involves taking an overview of your HACCP based system to ensure it is working effectively. It is checking that the checks already done are true and effective at controlling your hazards e.g. Managers weekly checks and food sampling would be verification procedures.

7. Documentation

A HACCP based system must have appropriate ***documentation*** to demonstrate it is working effectively. These will usually incorporate HACCP charts, work instructions, written procedures/policies, training records, monitoring records, sampling records, invoices, receipts etc.

Review

To ensure the **HACCP** is working effectively, it is important to *review* the food safety system at regular intervals. This may be when there is a change of menu, a complaint, a new product, a new premise or a visit from the Environmental Health Service.

IT IS GOOD PRACTICE TO REVIEW THE SYSTEM AT LEAST ONCE A YEAR.

V. FOOD QUALITY AND SAFETY CERTIFICATION

5.1. TERMINOLOGIES AND CONCEPTS ABOUT CERTIFICATION

Standardization: The objective of standardization is to set up a standard for a procedure or a product specification, to which every stakeholder adheres, in order to ease logistical procedures, facilitate trade and possibly improve quality if the requirements of the standard involve an improvement comapared to common practices.

Standards: Two types of standards exist-product standards (specifications and criteria for the characteristics of products) and process standards (criteria for the way the products are made). Food safety standards are essentially process standards whose aim is to improve the safety of the end products.

A standard can be the subject of a certification program (like ISO standards for instance) or not (like the ones of the codex Alimentarius).

Standard setting body: Standards can be set up by governmental institutions, by the private sector (buyers or suppliers), or even by certification bodies that want to set their own standards, perhaps based on an existing standard.

Certification: Certification is a procedure by which the third party gives written assurance that a product or process is in conformity with the corresponding standard. Thus the certificate demonstrates to the buyer that the supplier complies with certain standards, which might be more convincing than if the supplier itself provided the assurance.

5.2. CODEX ALIMNTARIUS

The Codex Alimentarius is a collection of food standards, codes of practice, guidelines and other related texts. Codex standards represent agreements between member countries and are not therefore intended to lead to certification programs. However, Codex standards have become global reference points for consumers, food industries, national food agencies and the international food trade.

The Codex Alimentarius Commission (CAC) is an intergovernmental body that coordinates food standards at the international level. Its main objectives are to protect the health of consumers and ensure fair practices in food trade. The CAC has proved to be most successful in achieving international harmonization in food quality and safety requirements.

It has formulated international standards for a wide range of food products and specific requirements covering pesticide residues, food additives, veterinary drug residues, hygiene, food contaminants, labeling etc. These Codex recommendations are used by governments to determine and refine policies and programs under their national food control system. More recently, Codex has embarked on a series of activities based on risk assessment to address microbiological hazards in foods, an area previously unattended. Codex work has created worldwide awareness of food safety, quality and consumer protection issues, and has achieved international consensus on how to deal with them scientifically, through a risk-based approach. As a result, there has been a continuous appraisal of the principles of food safety and quality at the international level. There is increasing pressure for the adoption of these principles at the national level.

5.3 OVERVIEW OF THE EXISTING CERTIFICATION PROGRAMS

An increasing number of certification programs exist for food safety, related to both good practices(GAPs, GHPs, GMPs) and management systems, most of which refer to Codex Alimentarius standards. These programs have been set up by various types of national and /or global groups including government institutions, national standardization organizations (mostly private associations mandated by government), private certification bodies and the private sector (buyers, retailers and producers).

5.4 TOTAL QUALITY MANAGEMENT (TQM)

Total Quality Management is mainly concerned with continuous improvement in all work. It is a long term planning. It is the consistent improvement in the quality. It is a never ending process. Total Quality Management consists of three words: Total, Quality and Management

Therefore, TQM is the art of managing the whole to achieve excellence. TQM covers all the set rules, regulations, guidelines and principles that contribute in improving the organization continuously. It is a continuous process of improvement for individuals, groups of people and the whole organization. It is the application of quantitative methods and human resources to improve all the processes within an organization to satisfy the needs of customers consistently. TQM integrates all the fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach. It covers the most quality principles and practices proposed by quality gurus.

Total Quality Management (**TQM**) is a management approach for an organization, centered on quality, based on the participation and commitment of all the internal and external customers and aiming at strategically long-term success through customer satisfaction, and benefits to all members of the organization and to society.

Total Quality Management (**TQM**) is a top-management strategy aimed at embedding awareness of quality in all organizational processes.
Total Quality Management is a total system approach and it is an integral part of the strategic decision making of the top management. It works horizontally across all the functions and departments. It involves all the employees of three levels, i.e., top level, middle level and bottom level. It extends backward and forward and covers supply chain management as well as logistics management also. So, we can say that it is a consistent effort by everyone in the organisation to meet the expectations of the customers leading 100 per cent satisfaction. TQM requires that the company maintain the quality standard in all aspects of its business. This requires ensuring that things are done right the first time and that defects and waste are eliminated from operations.

The quality concept is initiated by the top management. The whole credit of the initiation of total quality management goes to the top management. Only the top management can create an environment that develops team-oriented environment and creates quality oriented culture that can prevent problems and continually improve. The end result of TQM is complete satisfaction of customers by giving them quality products and services. It is possible only when TQM programme is customer centric.

Success in terms of standard quality is possible only when the organizations has a culture of team formation and the employees work in teams and give their maximum. Teams can be formed vertically and horizontally. When top management is involving the lower level employees it is vertically and when the different departmental employees are involved then it is horizontally (employees of marketing, sales, production and finance departments are working for critical and complex projects). Teams are inter-organisational when the employees of other organisations are involved (like employees of banks, suppliers, audit companies, consultants etc. To deliver quality products and services is not an easy job. All the processes have to be developed and standardised by consistent improvement.

VI. STANDARD SETTING BODIES

6.1 INTERNATIONAL FOOD STANDARD (IFS)

IFS is a food safety and quality management protocol on HACCP that is designed for producers of all types of food products. The IFS program allows for two levels of certification:

- the foundation level is considered as the minimum requirements for international food industry
- the higher level is considered as a superior standard in the food industry
  (for the details refer the Ebooks)

6.2 SQF Codes

The Safe Quality Food (SQF) standards were originally established by the Western Australian Department of Agriculture, in response to the demands of the farming and small food manufacturing sectors for a quality assurance system that enabled their businesses to meet regulatory food safety and commercial food quality criteria. The SQF program is intended to deal with completefoodsafetymanagementsystem.

6.3INTERNATIONAL ORGANIZATIONFORSTANDARDIZATION (ISO)

The ISO is a network of hundreds of national standards bodies, one per member country, coordinated by a Central Secretariat in Geneva. It is a non-governmental organization but occupies a special position between the public and private sectors. ISO has established standards on quality management systems, the ISO 9000 series, that become an international reference for quality management requirements in business-to-business dealings. (refer to the attached ebooks for details).

6.4. ISO's KNOWN STANDARDS(ISO 9001, ISO 14001, ISO22000)

ISO 9001 and ISO 14001 are among the ISO's most well known standards ever. They are implemented by more than a million organizations.

ISO 9001 helps organizations to implement quality management. ISO 14001 assists to implement environmental management. ISO 22000 is a food safety management system that can be applied to any organization in the food chain, farm to fork. (see the attached ebooks).

VII. RESPONSIBLE ORGANIZATIONS FOR FOOD SAFETY IN ETHIOPIA

Some of the Ministries and organizations responsible for food safety in Ethiopia include:

a) Ministries of Health, Agriculture, Trade and Industry
b) International collborators: FAO, USAID, ILRI, WHO, WTO etc.
c) Other collaborating institutions: Addis Ababa University, ALERT, Faculties of Vet Medicine, Ethiopian Institute of Agricultural Research (EiAR) etc. (refer to the attached ebook about Ethiopia)

REFERENCES: Nine ebooks on food quality and safety management are attached