UNIT- IV- FOOD QUALITY MANAGEMENT

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 agri-food products have been summarized.

Van den Berg and Delsing (1999) describe 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.

Intrinsic and extrinsic attributes :

The quality concept is focused on technological attributes and factors that can contribute to product quality performance (Figure 1). They are represented as a Quality triangle. A product has physical features that are turned into quality attributes by the perception of a consumer. With respect to agrifood 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, flavour, texture, and appearance), shelf life, convenience (e.g. ready-to-eat meal) and product reliability (correct weight, right composition etc.). These attributes can be defined as intrinsic attributes and are directly related to the physical product properties. (Luning & al, 2002).

Table 1 Quality characteristics of goods in relation 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 • Perceived quality: subjective assessment of quality delivered by image, advertising, or brand names	• Physical product features: (sensory properties) such as taste, odours, texture • Additional features: e.g. convenience of ready-to-eat meal • Product safety: no risks for the consumer • Shelf life: storage time for agri and food products • Reliability: constant behaviour of a product (appearance colour, size, image) • Complaint service: quick response to rejected food products • Availability of the product at food service market • Perceived quality: advertisement or brands with influence on quality perception. • Price of the product

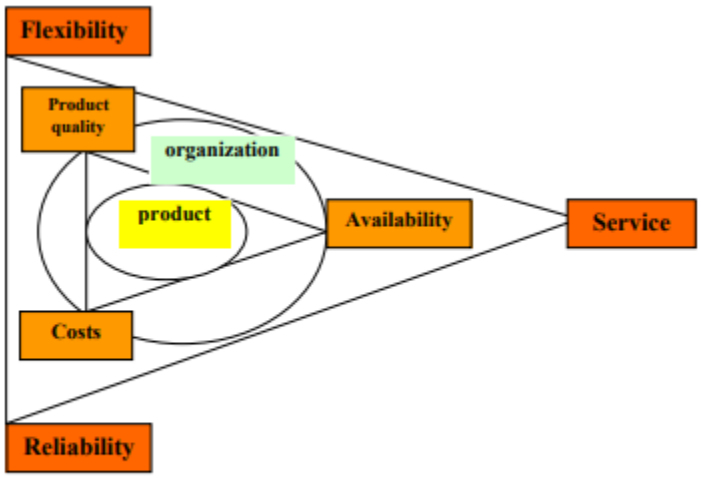

Figure 1
The Quality Triangle Concept
(Luning & al, 2002)

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. These intrinsic and extrinsic attributes and the factors (parameters) in the food production chain that can influence these attributes are reflected in Figure 2.

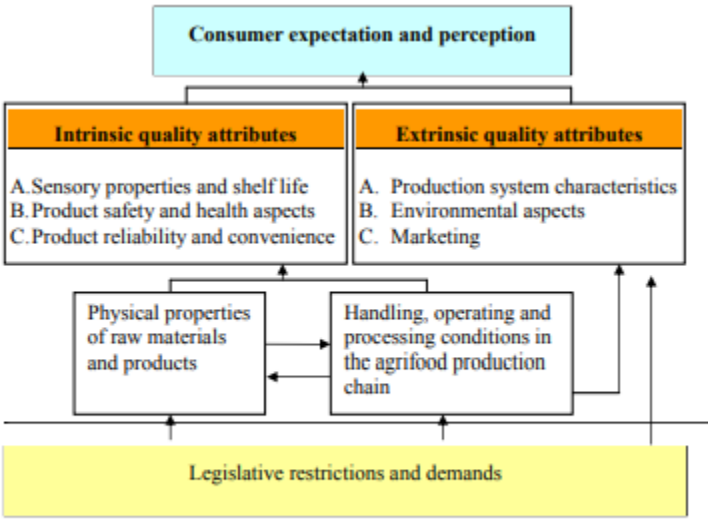

Figure 2
General intrinsic and extrinsic attributes affecting consumer expectation and perception (Luning & al, 2002)

Intrinsic attributes characterize the physical product, whereas marketing efforts mainly determine extrinsic attributes. According to this classification, typical intrinsic attributes include appearance, colour, shape and texture. Typical extrinsic attributes are price, brand name, packaging, labelling, 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.

According to Van Trijp and Steenkamp their concept 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.

QUALITY ATTRIBUTES OF FOOD

To control and assure the quality, a good understanding of factors and parameters which affect these attributes in agrifood production chain is needed.

INTRINSIC QUALITY ATTRIBUTES

There are different classifications with respect to intrinsic and extrinsic quality attributes, one being presented in Figure 2. 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

Figure 2 shows how the sensory perception of food is determined by the overall sensation of taste, odour, colour, appearance, texture.

The physical features and chemical composition of a product determine the sensory properties. In general agrifood 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 odour 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 colour.

Microbiological processes in foods can result in food spoilage with the development of undesirable sensory characteristics, including loss of texture, development of off-flavours and off-colours. 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 flavour, bleaching of plant pigments (carotenoids). Generally chemical changes occur during processing and storage of agrifood products. The non-enzymatic browning reaction also leads to desirable quality characteristics such as browning of bread crust and brown colour 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-flavours 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-flavour 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 moulds. 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 colour 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.

Table 3: An overview of major shelf life limiting reactions in agrifood products

Shelf life limiting (changes)	Causes or type of reaction	Undesirable effects
Microbiological changes	Growth of spoilage micro-organisms; spoilage bacteria, moulds and yeast's: • Acetobacter (fresh meat, poultry) • Aeromonas (fresh meat) • Envinia (fruit and vegetables) • Pseudomonas (fresh meat, poultry) • Cladosporium (fresh/frozen meat) • Lactic acid bacteria (various food)	Common effects: • loss of texture – development of off-flavours, off-taste – and off-colours – formation of slime – rotting
Chemical reactions	1. Non enzymatic browning (Maillard reaction) 2. Oxidation reactions	1. • Browning, e.g. dried milk powder • Formation of toxic compounds 2. • Formation of rancid off-flavours by lipid oxidation • Bleaching of carotenoids by autoxidation
Biochemical reactions	Enzymatic reactions; catalyzed by: a) Phenolases b) Milk proteinase c) Lipases d) Lipoxygenase e) Chlorophyllase f) Phospholipase	a) Browning of cut surfaces of light coloured fruits and vegetables b) Gelation of milk subjected to ultra-high short-time (UHST) temperature processing c) Short-chain fatty acids in milk lead to undesirable hydrolytic rancidity; and undesirable flavours; d) Degradation products of the polyunsaturated fatty acids with undesirable effects on flavour, colour, texture and nutritional value e) Degradation of green chlorophyll pigments during post harvest storage f) Released fatty acids are substrates for lipoxygenase leading to off-flavours in plant foods or undesirable textural changes in frozen fish
Physical changes	1. Mishandling of agrifood products • Bruising or crushing • Temperature fluctuations • Humidity conditions 2. Other typical physical reactions • Retrogradation of starch	1. • Decomposition during post harvest storage of fruits and vegetables • Phase changes due to thawing and re-freezing of foods • Undesirable desiccation or moisture pick-up 2. • Undesirable texture changes of starch containing bakery products
Physiological reactions	Processes in respiring agrifoods • Respiration process • Post harvest defects by ethylene • Chilling injury	• Accelerated ripening by ethylene or by incorrect storage conditions • Typical effects like bittering of sprouts, browning of leaf nerves • Some fruits and vegetables get brown spots upon storage at too low temperatures

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. An overview of major hazardous agents is presented in Table 2

Table 2
Overview of factors that can affect safety, including examples

Pathogenic micro-organism **Pathogenic bacteria**	**Toxegenic moulds**
▪ **FOOD INFECTION** • *Salmonella ssp.* • *Shigella ssp.* • *Escherichia coli* • *Listeria monocitogenes* • *Campylobacter jejuni* ▪ **FOOD TOXINS** • *Clostridium botulinum can produce highly toxic neurotoxins* • *Straphylococcus aureus may produce different enterotoxins*	**FOOD MYCOTOXINS** • *Aspergillus flavus* and *A. parasiticus* can produce aflatoxins • *Penicilium citrinum* may produce citrinin • *Penicilium patulum* and other penicillia may produce patulin • *Fusarium ssp* can produce zearalenone and trichothecens, such as DON (deozynivalenoal)

Chemical Toxic Compounds		
Natural toxins	**Toxins formed during processing, storage and handling**	**Contaminants**
• Protease inhibitors in beans, peas, potatoes and cereals • Glucosinolates in cabbage and related species • Cyanogenes in peas, beans, cassava, bitter almonds • Pyrrolizidine alkaloids in potatoes, tomatoes • Hydrazine in mushrooms • Hemagglutaninins in beans and peas	STORAGE AND HANDLING • Seafood poisoning PROCESSING E.G. • Heterocyclic amines • Maillard reaction products • Formation of nitrate at cooking	ENVIRONMENTAL CONTAMINANTS • PCB's • Nitrate RESIDUES E.G. • Pesticides, like DDT • Veterinary drugs, i.e. antibiotics and hormones • Disinfectants and detergents • Packaging compounds, such as teraphtalic acid, BADGE

Physical Agents
Glass, wood, metal pieces, stones, pests and insects, etc

Pathogenic micro-organisms

Pathogenic micro-organisms include both bacteria and moulds. A distinction must be made between food infection and food poisoning (Table 2).

Food infection is caused by the presence of living pathogens in food, which are transferred from food to the human body. Major bacteria that are responsible for food infections are Salmonella, Shigella ssp and some certain strains of Escherichia coli, Campylobacter jejuni.

Beef, turkey, chicken, eggs, pork and raw milk products are typical vehicle foods for Salmonellosis outbreaks.

Poor personal hygiene is a common factor in food-borne Shigellosis, with shellfish, chicken, salads, fruits and vegetables being prominent among vehicle foods.

Traveller's diarrhoea is often caused by specific strains of Escherichia coli.

Another source of food infection is caused by Listeria monocitogenes. Listeria species are widely distributed in soils, animal faeces, sewage, silage and water. Listeria infections also occur in foods, especially raw milk, soft cheeses and other dairy products. It is suggested that Listeria infections in some foods might be due to zoonotic transmissions, i.e. disease transmission from animalsto human.

Campylobacter jejuni is assumed to be the most common cause to acute bacterial diarrhoea in humans, it is an environmental organism but the bacteria are carried through the animal intestinal tract. A large percentage of all major meat animals contain C. jejuni in the faeces, especially poultry.

Food poisoning is caused by toxic compounds produced by pathogenic bacteria (enterotoxins) and moulds (mycotoxins) in food. The compounds can be released in raw materials or processed food products. Consumption of the poisoned food can result in symptoms that range from acute abdominal pain and diarrhoea to long term diseases such as cancer or histological changes in the liver.

Clostridium botulinum, Staphylococcus aureus and Campylobacter jejuni are well known bacteria responsible for production of enterotoxins in food.

Clostridium botulinum is an anaerobic spore forming bacteria widely spread in soil and water. Especially food packed under low oxygen concentrations containing low-acid foods may function as vehicle food for Clostridium.

Staphylococci have been detected in a large number of vehicle foods (like meat, chicken and bakery products).

Moulds can also cause poisoning, by mycotoxins, which can be produced by Aspergillus flavus and A. parasiticus. Major vehicle products are peas and cereals such as rice, corn and wheat stored under warm and humid conditions.

Toxic compounds

Toxic compounds can originate from different sources in the agrifood production chain toxins can occur as natural compounds in raw materials (natural toxins), but they can also be formed during storage and processing.

Other sources of toxic compounds are contaminants from the environment, residues from pesticides, veterinary drugs and disinfectants.

In addition, consumers often consider food and colour additives as unsafe toxic compounds as well (Table 2).

To estimate the risk of toxicants for food safety, the following points have to be considered:

• The origin of the compounds: natural, formed during processing. For example, fresh raw mushrooms contain hydrazine, a toxin, while formation is favoured by humid and warm storage. Toxic substances
formed during processing, such as the development of heterocyclic amines in broiled, smoked or deep-fried fish or meat.

• What are the properties of the toxic compounds?

The fat solubility. Fat-soluble toxic compounds can accumulate in the food cycle production. For example, small amounts of polychlorinated biphenyls (PCBs) accumulate in the adipose tissue of fatty fish species; by far the biggest source of PCBs in the human diet is fatty fish.

The degradability or inactivation. Some toxic compounds are very stable and therefore remain in the food production cycle for a long period. DDT, a very stable pesticide that has been used in the 40-50’s,
has accumulated in the food production cycle via milk fat, meat and breast milk. For many years human breast milk contained higher amounts of DDT compared to cow milk.

The intrinsic toxicity of the compound and the toxicity of its degradation products determine the risk. For example, the enterotoxin produced by Clostridium botulinum is highly toxic and the fatality rate is much higher than the enterotoxin produced by Clostridium perfringens. Oxalates and alkaloids have an indirect effect; they can bind bivalent metals and thus theirbioavailability.

Physical agents

The physical agent includes pieces of glass, stones but also pests and insects and radioactive isotopes.

C. PRODUCT RELIABILITY AND CONVENIENCE

Two other intrinsic quality attributes, shown in Figure 2, are represented by products 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 fulfil the consumer's need for convenience.

EXTRINSIC QUALITY ATTRIBUTES

Production system characteristics, environmental implications of food products and their production and marketing aspects can be considered as extrinsic quality attributes (Figure 2).
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 engineeringin general.

B. Environmental aspects

Environmental implications of agrifood 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 labelling) determine extrinsic quality attributes, affecting quality expectation. Marketing can also affect credence attributes (which can be checked by consumers themselves) influencing quality experience.