QUALITY CONTROL OF RAW MATERIALS

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Summary

Food influences the health of a population to a great degree, therefore, the control of food quality is an important government activity, and is legislatively regulated. Raw food materials quality is a complex term that includes nutritional, sensory, hygienic-toxicological, and technological points of view. Food has to fulfill all quality requirements, but above all, it has to be safe. High quality products can be produced only from high quality raw materials. One can say that raw materials influence the quality of the end products in the highest degree. Of course, the quality of products is further influenced by the technological procedures used. Quality depends not only on the technological procedure itself, but also on the hygienic level of machinery used, and on the total hygienic situation of the manufacturing surroundings.

As was already mentioned, the quality of endproducts is influenced primarily by the raw materials used. For this reason, close cooperation between agriculture and processing

plants is needed. The farmers, in many cases, make agreements with the food industry, not only on the quantity of raw materials produced, but above all on their quality. The quality of raw material is evaluated, and farmers are paid according to that quality (for example for wheat, milk, eggs, and so on). In all cases the raw material must fulfill all hygienic requirements. Great attention is paid to the presence of different kinds of contamination, such as heavy and toxic metals, toxic metabolites of micoorganisms, residues of pesticides, the presence of GM material, and others.

In perishable raw materials, the microbiological quality of the raw material plays an important role and has to be controlled. The water content of many raw food materials has the biggest influence on its storability. The water content and weight during acceptance are closely followed. For quality control of individual raw materials, different quality parameters are chosen, according to the quality requirements of products for which the raw material will be used. For example, wheat quality, after water content, will be tested on the amount and bakery quality of gluten. For quality evaluation of fruits, in addition to their appearance, the content of ascorbic acid, sugar, and acidity is controlled. In meat especially the fat content is followed. Different evaluation methods based on different principles may be used; as far as quality determination of raw material, usually rapid control methods are preferred (for example, water content of cereals by the NIR method). Their selection depends on many factors. The special methods used for contaminant determination must be sensitive and specific to be able to detect accurately even a low concentration of these compounds, and are usually done by specialized central state or private laboratories.

This chapter deals with food quality and assurance of raw materials. Basic composition of raw food material and methods suitable for control of individual classes of food components, including food additives and contaminants, are summarized.

1. Introduction

Food of high quality can be produced from raw materials of high quality, therefore, careful attention must be paid to the cooperation between the producer of raw materials and the processors. The main raw materials for the food industry are the products of agriculture. The quality of raw materials used influences the total quality of produced food. Quality control is, therefore, a cornerstone in the production of high quality food. Food quality is a rather complex term. It includes perspectives of quality from nutritional, hygienic, sensory, and even technological viewpoints. All mentioned forms of quality attributes influence the quality of the endproduct. As will be described later, some of these attributes can influence food quality in a decisive manner.

To assure for the consumer a food supply of guaranteed quality, an effective food control service and reliable control methods are needed. The raw materials for food production are heterogenic ones. According to their origins, raw materials can be divided into two basic classes, plant and animal.

The quality control of individual raw materials depends on many factors: the length of storage, their disposition to spoilage, the possibility of the presence of contaminants and their ability to influence nutrition, and the total sensory quality of the products, and so on.

2. Water

As is known, water is the single most important factor for the maintenance of living organisms. An understanding of its occurrence in foods is fundamental to the technological principles of food production and preservation. The moisture content of natural, processed, or manufactured foods may determine the food's legal standard of identity, texture, palatability, consumer acceptability, and shelf life.

Water is also an important raw material in the food industry. It may be an integral component of the final product, as in beer or soft drinks. Water is used in many technological processes, including the cleaning of equipment.

The occurrence of water in foods depends on the physical and chemical composition of the natural food tissue or processed food product. Water can be widely distributed within a food as a solvent system for sugars, salts, organic acids, phenols and hydrophilic macromolecular carbohydrates, gums, or proteins, to form a colloidal system.

Forces of hydrogen bonding and capillary action also characterize the occurrence of water in foods. The dipolar nature of water molecules enables them to participate in hydrogen bonding. Hydrogen bonding interactions of water molecules may strictly involve water-water interactions, but water molecules may also associate with functional groups of organic molecules that contain nitrogen, oxygen, fluorine, or chlorine. It has been observed that the perishability of different foods having the same water content is not the same. This difference between foods of the same water content is connected with the differences in water interactions. To take this factor into account, the term "water activity" was developed. Water activity (A_w) is defined in the following manner:

$$A_w = \frac{P}{P_0}$$

where
A_w is the water activity, P = is the partial vapor pressure above the food sample, and
Po = is the vapor pressure of pure water at the same temperature.
The water activity of some foods is given in Table 1.

Food	Water activity
Meat, eggs, vegetables, fruits	0.97–0.98
Cheese, bread	0.97
Fruit jams	0.82–0.94
Sausages	0.82–0.85
Dried fruits	0.6–0.0

Honey	0.5
Pasta	0.50
Sugar	0.10

Table 1. Water activity of some foods

The water activity of foods is important for their microbiological stability. For their growth, common bacteria need water activity of at least 0.94, yeasts need 0.90, and molds need 0.75. Some species of yeast are osmophilic; they can grow in an environment with water activity of 0.60.

Water activity influences the rate of enzyme reactions, lipid oxidation, nonenzymatic browning, sucrose hydrolysis, chlorophyll degradation, anthocyanin degradation, and many other reactions. The role water plays in the chemical deterioration of foods is complicated by the fact that it is usually performed by more than a single function. For example:

- Water may be a reactant in the system, as in such hydrophilic reactions as sucrose hydrolysis or lipolisis.
- Water is usually the primary solvent in the system, and as such, influences the diffusion of the reactants and the reaction products. In this sense water, or the lack of it, has an important bearing on the reaction rate in dehydrated or frozen foods.
- Water may influence the catalytic properties of metals by shielding them, or by forming inactive metal hydroxides. The removal of water may expose new surfaces and allow interactions between lipids and proteins, or proteins and proteins, and these interactions do not occur in the presence of water.
- Water may be the product of the reaction, as in nonenzymatic browning, and thus be almost autocatalytic at low water activities.

Water used in food production has to fulfill requirements from the microbiological, biological, physical, chemical, and radiological points of view. Some of these requirements on water quality are given in Table 2.

Indices	**Requirements**
Appearance	colorless, bright
pH	6–8
Oxidability ($mg.dm^{-3}$)m	mostly 3
Coliform bacteria and enterococci	None [a)]
Mesophiles	20 or 100 [b)]
Psychrophiles	200 or 500 [b)]
Total soluble matter ($mg.dm^{-3}$)	mostly 1000, optimal 500
Humine substances ($mg.dm^{-3}$)	mostly 2.5 [c)]
Ammonia, ammonia ions ($mg.dm^{-3}$)	mostly 2.5
As ($mg.dm^{-3}$)	mostly 0.05
Ba ($mg.dm^{-3}$)	mostly 1.0
Al ($mg.dm^{-3}$)	mostly 0.2
Mg ($mg.dm^{-3}$)	mostly 125

Cr ($mg.dm^{-3}$)	mostly 0.05
Cd($mg.dm^{-3}$)	mostly 0.005
Mn ($mg.dm^{-3}$)	0.1 or 0.3 [c)]
Cu ($mg.dm^{-3}$)	mostly 0.1
Pb ($mg.dm^{-3}$)	mostly 0.05
Hg ($mg.dm^{-3}$)	mostly 0.001
Se ($mg.dm^{-3}$)	mostly 0.01
Ag ($mg.dm^{-3}$)	mostly 0.05
V ($mg.dm^{-3}$)	mostly 0.01
Ca ($mg.dm^{-3}$)	at least 20
Zn ($mg.dm^{-3}$)	mostly 5
Fe ($mg.dm^{-3}$)	0.3 or 0.5 [c)]
Nitrates ($mg.dm^{-3}$)	mostly 50
Nitrites ($mg.dm^{-3}$)	mostly 0.1
Chlorides ($mg.dm^{-3}$)	mostly 100
Fluorides ($mg.dm^{-3}$)	mostly 1.5
Cyanides ($mg.dm^{-3}$)	mostly 0.001
Sulfates ($mg.dm^{-3}$)	mostly 250
Active chorine ($mg.dm^{-3}$)	at least 0.05, mostly 0.3
Sulphan	mostly 0.01
Phenols ($mg.dm^{-3}$)	mostly 0.05 [d)]
Polyaromatic hydrocarbons ($mg.dm^{-3}$)	mostly 0.04
Oil substances ($mg.dm^{-3}$)	mostly 0.05

[a)] At aggregate source in 100 ml, at individual source in 10 ml
[b)] At aggregate source (first number), at individual source (second number in 1 ml)
[c)] At aggregate source
[d)] Expressed as phenol

Table 2. Quality requirements for drinking water

Drinking water should be free of pathogenic bacteria and any biological contamination. The requirements for bottled water, especially for water for infants, are even more stringent.

Many public water supplies are not up to the standard required for soft drinks manufacture or, if generally up to standard, may drop below it at times. Therefore, for the manufacturer to be able to produce a beverage of uniformly high quality, further treatment of some public supplies is necessary. It is well known that the quality and characteristic taste of beer (for example, Pilsner Urquell) is based on a source of suitable water.

3. Raw Materials of Plant Origin

Cereals, legumes, fruits, vegetables, and oil seeds are among the most important raw materials of plant origin. The main characteristics of some agricultural products to be controlled, and the methods used for their determination will be briefly treated (see *Food Quality Indices*).

3.1. Cereals

Consumption of cereals and cereal products plays an important role in supplying the population with energy and proteins. Since cereal proteins are generally of relatively poor nutritional quality, problems can arise when they constitute the major source of dietary proteins. This is true especially in developing countries, where more than 80% of the total available proteins are of plant origin and about 60% of this amount is derived from cereals. In developed countries, plant proteins account for only about 40% of the total proteins consumed. To the main important representatives of this group belong wheat, rice, corn, barley, and oats. Basic composition of cereals is given in Table 3.

Cereals	**Content in %**			
	Water	**Proteins**	**Lipids**	**Starch**
Wheat	13.2	11.7	2.2	59.2
Rye	13.7	11.6	1.7	52.4
Barley	11.7	10.6	2.1	52.2
Oats	13.0	12.6	5.7	40.1
Rice	13.1	7.4	2.4	70.4
Corn	12.5	9.2	3.8	62.6

Table 3. Basic composition of cereals

Cereals as raw material are primarily graded on the basis of their physical properties: size, shape, weight of 1000 kernels, test weight (kg per hectoliter), color, hardness, presence of other grains and other foreign kernels, percentage of damaged grain (mechanically, by heat, by insect, due to sprouting, and so on).

Cereals are products usually stored for a long period. Therefore, water activity is the most important item for their acceptance and storability. The content of water is controlled mainly by rapid methods using near infrared spectroscopy. This procedure also provides the determination of protein content, which is important for production of bakery goods. In addition to this procedure, the classical method based on the Kjeldahl procedure is often used. But it is not only the total protein content that influences the quality of bakery endproducts. Especially in wheat, the protein quality is most important. Major wheat protein fractions are the gliadin and glutenin, comprising 80% to 85% of total endosperm protein in an approximate ratio of 1:1. These two proteins possess the unique property of forming an elastic-cohesive mass, gluten. This property of wheat proteins has a crucial influence on the quality of bakery and pasta products. For these reasons, determination of wet gluten content, physical dough testing, measurement of amylolytic activity, and the baking test are used for quality evaluation. For physical dough testing different instruments such as the farinograph and the mixograph are used. The best procedure to prove the suitability of cereals for bakery production is the baking test (see *Cereals and Pulses*).

The main constituent of the maize kernel is starch (see Table 3.). The main protein fraction (about 50% of total protein) is the prolamine (zein) fraction. This is the largest proportion of prolamine found in any of the common cereal grains. Zein is practically devoid of two essential amino acids, lysine and tryptophan, and thus is not a high quality protein. Corn glutelin is composed of a mixture of proteins. These proteins are linked extensively by disulphide bonds to form a highly complex protein that causes problems during the wet milling of corn. The discovery of high-lysine corn varieties has provided a genetic basis for producing corn of higher nutritional quality. The endosperm protein of normal corn contains 40% to 50% zein and 20% to 30% glutenin, whereas the zein and glutelin contents of new strains of corn are about 20% and 40%, respectively. More important, the proteins of new strains have almost 70% lysine and 20% more tryptophan than normal corn.

Rice is a staple food for a great part of the world's population. Rice is rich in starch, about 80% of rice protein forms glutelin. Among cereal grains, rice is unique because it contains high levels of glutelins and a low prolamine content. The lysine content of rice is relatively high (3.5% to 4.0%), because of the low level of prolamine. As with other cereal proteins, lysine in rice is the first limiting amino acid. Technologically, hardness is an important quality index of rice. It influences rice during handling. Proper hardness can reduce loss during milling and processing.

When cereals are stored at a higher water activity, the danger of the presence of toxic metabolic products of different fungi's mycotoxins may occur. In this case, mycotoxin content must be determined, for which a different method can be used (TLC, HPLC, and others).

It is well known that cereal proteins contain low amounts of the essential amino acid lysine. In some cases, this essential amino acid is used for fortification during flour production. For the determination of lysine, the classical spectrophotometric method is suitable, which is based on the reaction of 2,4-dinitrofluorobenzene, or the procedure based on the determination of the total content of all amino acids using different automatic amino acids' analyzers is suitable.

Nutritionally, cereal products play an important role as the carriers of dietary fiber. Dietary fiber has influenced health positively because of its ability to reduce many of civilization's illnesses, such as cardiovascular disease and cancer. Dietary fiber contains cellulose, hemicellulose, lignin, pectin, and other polysaccharides that cannot be split into energetically exploitable products by the human body. Concentration of dietary fiber in cereal products can be enhanced by selection of a suitable variety, or during the technological procedures, especially during the milling of cereals. For the determination of dietary fiber, different methods, based on chemical or biochemical (enzymatic) principles, are applied.

In addition to the use of cereals for human nutrition, they are used as fodder for domestic animals and as raw materials for the special production of, for example, malt for brewery purposes. Of course, the demand for quality of such raw material differs according to the use for which these products are meant. After water content, the most important criterion for fodder is the total content and quality of proteins.

The quality requirements of barley for the production of malt are different. Malt has to fulfill the requirements of breweries: the high extractability and low concentration of compounds (soluble proteins and different kinds of polyphenols, especially leucoanthocyanidins) that lead to the formation of clouds in produced beer during storage. For these purposes, the brewing industry developed special analytical procedures based on chromatographic and spectrophotometric principles.

The raw materials belonging to the whole group of cereals have to be controlled with regard to contaminants. In addition to the already mentioned mycotoxins, the other contaminants can originate in soil, used fertilizer, or different kinds of pesticides used for the crop's protection. As far as the contamination of soil is concerned, the highest danger is the transfer of toxic heavy metals into the crops, especially lead (from petrol, due to air pollution) and cadmium (from some phosphorus-containing fertilizers). For determination of toxic heavy metals, methods based on the AAS principal are used most often. Pesticides that help to reduce loss during cereal production are a second possible source of contamination. To determine the content of pesticide (mostly herbicide, fungicide, and insecticide) residue is a special and difficult task because, in many cases, it is not known before the analysis what kind, or even what class, of pesticides was used for crop protection. This kind of analysis can be done in laboratories equipped with special and expensive laboratory techniques (GC-MS, HPLC-MS, and others).

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Biographical Sketch

Jiří Davídek, Ph.D., Dr. Sc., is a Professor of Food Science in the Faculty of Food and Biochemical Technology, and is a member of the Department of Food Chemistry and Analysis, Institute of Chemical Technology, Prague, Czech Republic.

Professor Davídek received his M.Sc. degree from the Institute of Chemical Technology, Faculty of Food and Biochemical Technology in 1954. He obtained his Ph.D. in 1969 from the same Institute under the direction of Prof. Dr. G. Janíček. After doing postdoctoral work with Dr. J. Fragner at the Research Institute of Food Industry in Prague and with Dr. A.W. Khan at the National Research Council, Division of Biosciences in Ottawa, Canada, he was appointed Associate Professor of Food Chemistry and Analysis at the Faculty of Food and Biochemical Technology, Institute of Chemical Technology, Prague, in 1960, and became a full Professor there in 1970.

Dr. Davídek is a member of the Czech Chemical Society and Chairman of the Division of Food and Agricultural Chemistry. He is a national representative in the Food Chemistry Division, Federation of European Chemical Societies (FECS), and is member of the Czech Biochemical Society, the American Institute of Food Technologists, and numerous other scientific societies. He is also a member of the editorial board of the Czech *Journal of Food Sciences*, German *European Research and Technology*, and Chinese *Biomedical and Environmental Sciences*. He has served as the Head of the Department of Food Chemistry and Analysis, Dean of the Faculty of Food and Biochemical Technology in Prague, and Vice-Chairman of the Czechoslovak Academy of Agriculture. In 1972 he received the State Prize for Research, and in 1982 he was awarded both the Gold Medal from the Czechoslovak Academy of Agriculture and the Silver Medal of Professor Jaroslav Heyrovsky from the Czechoslovak Academy of Science.

Professor Davídek has published more than 330 papers and is the author of 16 books published variously in Czech, English, German, and Polish. He has also delivered more than 350 lectures at scientific conferences and symposiums. He often works as a chairman at the International meetings organized by the Food Chemistry Division of FECS (Euro Food, Chemical Reactions in Foods, and so on). His research interest focuses on food quality, food analysis, Maillard reactions, the formation of sensory active compounds, food additives, and natural toxic compounds.