MINERALS AND OTHER MICROCOMPONENTS

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Summary

From quantitative point of view, water is the main component of majority of foods. Particularly the fresh fruits and vegetables, meats, fish, milk and their products have high water content. This is connected with essential role of water in living organisms which are raw materials of food production. The water content of foods influences their texture and physical properties and there exists a correlation between storability and water content. The spoilage of foods is connected mainly with growth of microorganisms and the main factor of microbiological spoilage is the adequate water content of the food.

The minerals in foods comprise a large and diverse group of elements and complex ions. Foods contain generally more than 50 different elements which presence may be confirmed by up to date analytical techniques. Many of these are nutritionally required by humans. One part of elements is found in the body in significant concentrations (e.g. calcium, phosphorus, magnesium, sodium, potassium, chlorine, and sulfur). Many of

other elements are present in very small concentrations known as microelements or trace elements. According to our present knowledge one part of these elements fulfill physiological functions in the body. To this group belong e.g. the iron, copper, cobalt, manganese, zinc, iodine, selenium, chromium, molybdenum, fluorine, vanadium, silicon, and nickel. These elements are called essential trace elements. Whether other trace elements are contaminants or their biological role is until now unknown, this will be clarified by further investigations. Concerning their biological functions they may be divided in three groups

I. Calcium and phosphorus are the main components of bones and teeth. These elements give rigidity and strength, magnesium, fluorine, and silicon also contribute to the mechanical stability of the body
II. Small fractions of calcium, magnesium, and phosphorus, but greatest part of sodium, potassium, and chlorine are present as electrolytes in body fluids and soft tissues taking part in different physiological, biochemical processes. A detailed discussion of their exact role is beyond the scope of this article. The reader is referred to literature given at the end of this article.
III. Essential elements are integral part of certain enzymes, and of other biologically important compounds. Trace elements function also as activators of enzymes.

Minerals are common constituents of all foods of animal and plant origin. Drinking water is only a minor source of minerals. Mineral supplements and sodium chloride are additional sources. Concentration of minerals in foods and drinking water varies widely depending, on the case of plants, on species, soil composition, conditions of growing etc. Mineral content of animals is also depending on species, feeding and other conditions of farming.

Among other food constituents—not treated in earlier articles—only the antinutritional factors (phytic acid in cereals and legumes, trypsin- inhibitor in soya, glucosinolates in rape seed) and the natural toxicants of plants and marine organisms are shortly overviewed in the framework of this article.

1. Minerals in Foods

1.1. Introduction

Although water is in majority of foods the quantitatively main inorganic component (Table 1) and water requirement of human organism is generally quantitatively higher than that of other nutrients, water content of drinking water and beverages play the main role in supply of organism and moisture of other foods has only a secondary role.

Food	**Water content (%)**
Cereal grains	10-13
Bread	38-42
Oilseeds	5-10
Milk	82-87
Cheese	38-69

Dried milk	4-5
Butter	16-20
Meat(depending on fat content)	50-81
Fish	65-81
Blood	78-82
Egg	74-78
Fruits	75-95
Nuts	8-9
Vegetables	75-95

Table 1: Water content of some foods

In the framework of this article the physical and chemical properties of water will not be treated. Some aspects connected with food spoilage and preservation will be discussed in *Spoilage and Preservation of Food*. Readers interested in more details are referred to the literature presented at the end of this article.

In addition to organic compounds composed generally from small number of species of elements (carbon, oxygen, hydrogen, nitrogen and as minor components sulfur and phosphorus) foods contain, in widely variable concentration, a lot of other elements in free or bounded form. By combustion of foods, the organic will be destroyed and the remaining matter, called ***ash*** or ***mineral content*** by food analysts, will contain different inorganic compounds (mainly salts- and oxides of metals). In 19th century, when systematic study of chemical composition of foods started, only the total quantity of minerals (ash) was determined and some of elements, today called ***macroelements,*** such as calcium, phosphorus, magnesium, potassium, sodium, chlorine. Later, parallel with the progress in analytical methods in chemistry and biochemistry of nutrition, a more detailed analysis has been made. As a result from year to year more and more elements were detected in foods (more than fifty today) generally in very low concentrations. This group received the name: ***micro- or trace elements.*** The exact physiological role of macroelements is known and consequently their dietary requirements too. In the case of trace elements physiological importance of several elements (e.g. iron, copper, selenium, zinc, manganese etc.) is clarified. On the other hand, the exact role of others is unknown or not yet fully confirmed. Recommendations regarding dietary requirements of humans are generally based on animal experiments or studies of some epidemics caused by shortage of given trace elements.

Although every food, and in smaller concentration the drinking water too, contain mineral components, the prediction of mineral content of a food product is connected with uncertainty because the mineral content even of the same species of plant or animal may vary considerable depending on soil composition, conditions of plant growing or animal farming. It may be in addition noted that absorption of individual elements from digestive tract varies also widely. Fortunately, a severe deficiency of given element is rare, although a marginal deficiency e.g. in iron may occur.

1.2. Chemistry of Minerals

Mineral components may be present in food in different forms. Elements in free form don't occur in foods (some pharmaceutical products or food supplements may contain reduced iron) in tissue fluids the metals are present as cations. Among anions the chloride, some phosphates, hydrocarbonates and sulfates may be mentioned. Many metals are present in the food bounded to organic compounds. For example, haemoglobin and myoglobin contain iron, vitamin B_{12} ***cobalt***. Copper and zinc are components of several enzymes. Finally calcium, magnesium and phosphorus salts are the main structural components of bones and teeth.

1.3. Mineral Content of Foods

1.3.1. General

Mineral content of foods may vary considerably depending on many factors. Concerning foods consumed in raw form (e.g. fruits, vegetables) they are in major part determined by genetically coded physiology of given plant or animal. However additional factors may influence the quantitative and qualitative composition of mineral content. In the case of plants it is well known that deficiency of some elements in soil may cause considerably lower concentration of element, being deficient in soil, in plant tissue and oppositely a higher concentration if soil rich in a given element may cause increased level of this element in plant tissues. As an example the selenium content of soil may be mentioned. In Finland very low selenium content was detected in soils causing very low selenium concentrations in cereals. As selenium is one of essential trace elements (being e.g. component of enzyme glutathione peroxidase) a deficiency in selenium supply of population was observed. To avoid this situation selenium enriched mineral fertilizers are used at these agricultural areas. Oppositely, in some parts of USA and China a very high selenium level in soil results in a very high selenium concentration in plants. The over dosage of selenium caused selenium intoxication of animals and humans consuming these plants.

Another factor may be the geographic location. As example it may be mentioned the iodine content of foods and the diet. In the area near the sea the transfer of iodine to soil occurs largely via atmospheric phenomena, and consumption of local feed and food of plant origin assures a good iodine supply of population. Among other factors the season, water supply, use of fertilizers, pesticides and fungicides may be mentioned.

If the food is a result of different processing in factories or in kitchen, in general, processing may cause losses of minerals being present in raw materials used and/or increase of mineral content due to mineral- containing additives e.g. (fortification of flour with iron). One source of losses may be the contact with water during cooking. The amount of losses depends mainly on solubility of mineral components and may be considerable. Among ingredients of many food products we may find the common salt, the sodium chloride (majority of meat products, cheese, baked goods etc.) and fortification (enrichment) with iron, zinc, calcium, magnesium is frequent in the practice. To avoid iodine deficiency, in many countries iodized salt (enriched with potassium iodide or iodate) is produced. Nitrates (nitrites) are used in curing process of meat.

Finally it may be mentioned that equipment used in processing may be a source of additional minerals mainly trace amounts of some heavy metals. This topic will be treated in the framework of *Additives and Contaminants.*

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Bibliography

Bardocz S., Gelencsér,E., Pusztai A. (1996) *Effect of Antinutrients on the Nutritional Valueof Legume Diets.* EC Publisher, Brussel [Report about results of a research project of European Union]

Brody T.: Nutritional Biochemistry (1994) Academic Press, San Diego, New York, Boston, London, Tokyo, Sydney, Toronto. [textbook written for students of nutrition and related biological sciences. In addition to biochemical role of nutrients, the book contain valuable data about chemical composition of foods and requirements of individual nutrients]

Fennema O.R.(1985) Food Chemistry, 2-nd ed., Marcel Dekker Inc., New York and Basel, 1985. [A widely used textbook for upper-level udergraduate and graduate students.]

Friedman M. (1986) *Nutritional and Toxicological Significance of Enzyme Inhibitors in Food.* Plenum Press, New York, London [Natural enzyme inhibitors, primarily inhibitors of proteases and amylases and their effect on digestibility of legume and cereal foods]

Lasztity Lj., Lasztity R. (1990) *Phytic Acid in Cereal Technology.* Y.Pomeranz, ed., Vol.10.AACC Publ.St Paul, pp.309-370.[Occurrence of phytic acid in cereals and cereal products and its effect on avalability and digestibility of iron and other essential metals]

Lasztity R.(1999) Cereal Chemistry, Akademiai Kiado, Budapest. [A monograph giving an high-level overview of chemistry of cereals and their products with useful, also for non specialists, tables of chemical composition including microconstituents]

Lasztity, R.-Hidvegi, M.- Bata,A.: Saponins in food. Food Rev.Int. 14(4), 371-390, 1998. [A review paper giving detailed information about occurrence, chemistry, toxicity and use of saponins].

National Academy of Sciences (1974) *Proposed Fortification Policy for Cereal Grain Products.* Washington. [History, rules and practice of enrichment of flour and other cereal products with iron and vitamins in USA]

Underwood E.J. (1977) *Trace elements in Human and Animal Nutrition.* Academic Press, New York. [An overall review of role of trace elements in nutrition]

Biographical Sketch

Radomir Lasztity D.Sc., Professor of the Department of Biochemistry and Food Technology at Budapest University of Technology and Economics, was born in 1929 in Deszk, Hungary. Dr Lasztity received his M.Sc. degree in Chemical Engineering in 1951 and his D.Sc. degree in Chemical Science in 1968. He is honorary president of International Association for Cereal Science and Technology (ICC) and deputy technical director. He was acting chairman of the Codex Committee on Methods of Analysis and

Sampling of the FAO/WHO Food Standard Program in the period 1975- 1988. Dr Lasztity is a member of the Food Chemistry Division of the Federation of European Chemical Societies. and a member of the editorial boards of several international scientific journals. Among other awards he has received the Bailey and Schweitzer Medal of the ICC, the State Prize of the Hungarian Republic, and the Golden Medal of Czech Academy of Sciences. Dr Lasztity's main research activities are chemistry and biochemistry of food proteins, food analysis and food quality control. He has published more than 800 articles in Hungarian and overseas journals. He is the author/editor of more than twenty books and textbooks [Chemistry of cereal proteins(1984, second ed. 1996), Amino Acid Composition and Biological Value of Cereal Proteins (1985), Cereal Chemistry (1999), Use of Yeast Biomass in Food Production (1991), Gluten Proteins (1987)].