VEGETABLES AND PLANTS FOR EDIBLE STARCH, OIL, SUGAR AND BEVERAGE PRODUCTION

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Contents

Summary

Productive, sustainable, nutritious food systems can cope with the requirements of the growing global population to fulfill their right to be free from hunger. However, global population requires not only secure but also nutritious and safe food on sustainable resources.

There are more than 40 different nutrients essential to maintain good health in humans. These are categorized as carbohydrates, proteins, fats, micronutrients (vitamins and minerals), and water. Inappropriate energy consumption as well as inadequate intake of vitamins and minerals leads to faulty metabolism, disabilities and diseases.

Carbohydrates supply the 40- 80 per cent of total energy needed. The major carbohydrate supplying crops are cereals, sugar crops, root crops, pulses, vegetables and fruits. Cereals are the principal source of food supplies, accounting for about half of daily energy intakes Sugar crops such as sugar cane and sugar beet are rich in sugars, while many other secondary crops are regionally used sweeteners.

Plant sources contribute about 70 per cent of the world protein requirement; plant proteins have more important role in the diet of the population in the developing countries, especially in traditionally vegetarian regions. Cereals contribute more than two-thirds of plant proteins consumed, grain legumes about 18 per cent and other plant sources, such as root and tuber crops, vegetables and fruits about 13 per cent

In many developing countries cereals are the staple food crops and are cultivated continuously in the tropics and subtropics. However, pulses are key sources of protein and also an important part of the cropping system. Some of them have been staple foods of man and livestock since prehistoric times.

Fats and oils provide more than twice the amount of food energy as carbohydrates and proteins. Limiting fat in the diet is one of the most important recommendations for optimizing health. Dietary guidelines advise a fat consumption of about 30 per cent of the energy requirement, and, saturated fat should be limited to less than10 per cent, in a balanced diet.

With few exception vegetables and fruits contain very low levels of fats, generally below 0.5 per cent. In the contrary, nuts, kernels and seeds contain significant amount of oil. Vegetable oils are more or less unsaturated with the exception of the highly saturated palm and coconut oils

Vitamins, minerals, and several phytochemicals are called micronutrients.

Vitamins, which are organic micronutrients, cannot be synthesised by the body, while cyanocobalamin (vitamin B12), and metachinon (vitamin K2), are synthesized by bacteria in the gut. Vitamins are essential for healthy nutrition. Vegetables are particularly rich in vitamins and minerals, containing about sixty mineral elements. Consumption of a wide variety of vegetables, fruits and whole cereal grains, as well as pulses in a balanced ratio, helps maintain health and prevent many chronic diseases. Food diversity is the traditional means of ensuring a balanced, healthy diet containing all the necessary micronutrients.

Nutritional quality could be highly improved by food fortification, eliminating antinutrients or by using traditional food processing to increase the bioavailability of nutrients for the human body.

Food borne diseases are among the most widespread public health problems both in developing and developed countries. Hundreds of millions suffer from diseases caused or promoted by a nutritionally inadequate diet or by consumption of unsafe food and water.

The most dangerous sources of food safety hazards are microbial infections, environmental contaminants and agrochemical residues, which arise along the food chain, from the crop growth, harvest, transport and storage, to processing, marketing, preparation and serving. Thus, to protect public health in a local level, it is essential to assess the major risk factors resulting from the local diet and methods of food preparation, and, those of the local environment on foods.

Where the food chain is not secure or food safety is a problem along the food chain, a productive and sustainable, year-round home garden system can help to feed the family. Home gardens, with their multiple functions, can make a substantial contribution towards meeting household food needs. In a productive and sustainable gardening system the most effective exploitation of the given climatic conditions involves sufficient water supply, maintenance and improvement of soil fertility, appropriate cultural practices, and, low-cost weed, pest and disease management.

By the application of careful planting sequences and proper timing, as well as by using cover crops, food can be supplied for the family throughout the year. Involving indigenous plants in the plant sequence is useful for diversification of the diet and to meet specific needs.

Enhancing food security in the growing cities several forms of urban and peri-urban agriculture have evolved within and surrounding the cities. Urban and peri-urban agricultural production contributes to secure year-round market supply of fresh vegetables, fruits and other cash-crops in some developing countries where the transport of perishable products are risky from the rural areas toward the cities

In most cases the scarcity of water in the dry season, low soil fertility, soil degradation and pollution by wastes and atmospheric deposition of local emitters, pests an diseases are the main constraints. The lack of science on the farmers' side, the careless use of wastewater (unprocessed or semi-processed waste) in irrigation, and, uncontrolled application of raw manure and agro-chemicals make urban farming risky concerning public health and environment.

Water supply is the limiting factor of plant production in many regions.
Sound and effective management of water resources has a key role in sustainable plant production. Rational exploitation and utilization involve designing, operating and maintaining water resources, high efficacy of irrigation techniques with minimum loss, and, agronomic water-saving practices including the regulation of soil water storage in the field and high water use efficiency of the crops.

1. Concept of food security

International low states that everyone has the fundamental right to be free from hunger.

Rome Declaration on World Food Security, 1996, reaffirms “the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food” (source: FAO)

Nothing but productive, sustainable, nutritious food systems can cope with the requirements of the growing global population to fulfil their right mentioned above. This means much more than agriculture system: additionally to crop production it involves postharvest management, industrial processing and distribution of the products as well as food preparation in the households.

1.3. Food supply

The tremendous efforts of the “Green Revolution” started in the early 1960s and aimed food sufficiency, saved millions of lives by developing new agricultural technologies, such as the development and use of improved crop varieties, mineral fertilizers, chemical plant protection, and plant hormones, and, high mechanization.

During the 1980s the importance of sustainability became gradually clear. Tailoring economical and environmental categories on the level of requirements, “effectiveness” was substituted by the term “productivity” concerning crop production. However, global population requires not only secure but also nutritious and safe food on sustainable resources.

Over 800 million people do not receive enough energy and protein to meet their daily requirements, and, 792 million people of them live in developing countries. That means that one in every five is permanently starving in the developing countries. Roughly the half of the death of children under five years old is caused by protein-energy malnutrition (PEM). Promising that FAO projections estimate a reduction of the extension of energy- and protein deficiency to a population of 580 million by 2015 from the 792 million in 2000.

However, these numbers are likely under-estimated, since they are based on calories per capita calculations assuming equitable distribution of food among and within the households. We know that the situation is worse. Not only the unavailability of foodstuff, but inappropriate distribution, poverty and inadequate utilization in the households are the main causes of malnutrition, interacting with poor social and health conditions. Within the households, generally women, children and elderly or disabled people are in detrimental position.

1.4.Malnutrition

There are more than 40 different nutrients essential to maintain good health in humans. These are categorized as carbohydrates, proteins, fats, micronutrients (vitamins and minerals), and water.

In a healthy diet the sources of energy mainly are starchy plants, as cereals and root and tuber crops. Protein requirement is covered partly by animal and partly by plant proteins, where legumes have an important role in protein nutrition.

According to WHO estimation, about the half of the global population is suffering from some kind of malnutrition in developing as well as in developed countries. Malnutrition means an abnormal physiological condition caused by deficiencies, excesses or imbalances in energy, protein and/or other nutrients.

1.2.1. Under-nourishment

About 1.2 billion people are undernourished; their food intake is continuously insufficient to meet dietary energy requirements. The food intake of more, than 1.2 billion over-nourished people is continuously in excess of dietary energy requirements. And, even more people are permanently on some kind of unbalanced diet that lacks essential nutrients for a healthy and active life.

Inadequate food consumption leads to health, social and cultural consequences. These are involved in the recurring renewal of the cycle of malnutrition in a population. In a poor family, a malnourished woman with low weight gain in her pregnancy generally has a baby with low birth weight. With an inadequate feeding, mortality rate is higher, infections and impaired mental development is more frequent among these babies. As children, they may be stunted, with reduced mental capacity, and when the girls are grown up, with inadequate food, health and care, the cycle starts again with their pregnancy. These families cannot get out of poverty as permanent malnutrition makes the people week, increases the risk of chronic diseases and highly reduces their working ability. Under-nutrition is often the outcome of either an insufficient food intake or poor utilization of food by the body, or both. In many cases of permanent energy deficiency the limited intake of protein is utilized by the metabolism as a source of energy, with the consequences of serious protein-energy deficiency syndromes (PEM). PEM is the most lethal form of malnutrition. It magnifies the effects of every disease. According to WHO statistics PEM affected every fourth child in the world in the millennium. More than 70 per cent of them live in Asia, 26 per cent in Africa and 4 per cent in Latin America and the Caribbean.

1.2.2. Over-nourishment

Another type of malnutrition occurring both in developing and developed countries, is over-nourishment, when people eat more food energy than use. Changes in the global food economy and rapid urbanization contributed to changing the traditional dietary habits to the consumption of high-fat containing energy-dense diet, which is low in carbohydrates and high in saturated fat. Energy supply of proteins and carbohydrates is equal: 4- 4 calories per gram, while fat provides 9 calories per gram. Such extra energy intake - especially when associated with reduced physical activity of urban lifestyle - leads overweight, obesity, faulty metabolic processes, and an array of serious health disorders, hart disease, hypertension and diabetes and with all their grave complications: weakness, low productivity, disabilities, shorter lifetime. Degree of overweight or obesity is expressed by using body mass index (BMI) that is a ratio of weight to fat. BMI is calculated for adults by dividing the weight (kilograms) by the square of height (meters).

$$\text{BMI} = \text{Weight in kg}/(\text{Height in meters})^2$$

If BMI is below 18.5, they are underweight, between 18.5 and 25, they are normal weight, between 25 and 30, overweight, and, a BMI over 30 means generally obesity. However, such calculations do not supply adequate estimations of body fat for children, pregnant or breastfeeding women, and, elderly people. Noteworthy the women are a little lighter than men with the same height are, since women have finer bones and less muscle mass.

1.2.3. Micronutrient deficiencies

Faulty metabolism, disabilities and diseases do not occur only as a consequence of inappropriate energy consumption, but of inadequate micronutrient intake as well, since the adequate consumption of both vitamins and minerals is essential for healthy body functions. Insufficient dietary intakes of the essential micronutrients and vitamins alter energy metabolism, reduce immune resistance and restrain brain functions. According to the review on micronutrient nutrition by Graham et al. (2000), over half of the world's population does not consume enough of each micronutrient in their food to support good health.

About 3700 million people, mostly women, babies and children are affected by iron deficiency in the world. More than 2000 million people suffer from anaemia that of three of four associated with iron deficiency; more than 900 million people are affected with iodine deficiency disorders including goiter and cretenism, and about 250 million children suffer from vitamin A deficiency that causes serious health disorders and disabilities (Graham et al., 2000).

In the other side, in the developed and partly in developing world, the dangerous tendency of micronutrient, vitamin and fibre malnutrition can be also recognised. By an increased consumption of excess energy with fat and refined sugar containing processed foods and drinks and, reduced intake of vegetables and fruits, millions of people become susceptible to diseases such as obesity, hypertension, cardiovascular disease, diabetes, osteoporosis and various types of cancer.

Many interactive factors, such as genetic and environmental factors, other meal components, food processing and meal preparation methods, eating habits, physiological state, etc. determine the bioavailability of nutrients in humans. Certain minerals and vitamins have promoter effect for the absorption, ingestion and utilization of other vitamins and minerals, whereas some compounds, called antinutrients can interfere with the absorption and utilization of nutrients by several mechanisms (see more in the article 5.2.3.1.Vegetables, root crops).

Although world hunger has been substantially reduced by the rapidly increasing agricultural production - the "green revolution" - in the last five decades, and, agriculture has a critical role in food security in regional and also in global scale, political and social interventions are also essential in eliminating hunger and malnutrition.

These mean co-ordinated national and international actions in policy, economy, social and health care and education for the household food security.

2. Our most important nutrients

Essential human nutrients are partly of an inorganic, partly of an organic nature, including protein, energy, carbohydrates, fats and lipids, vitamins and a great number of minerals and micronutrients. They affects positively or negatively on the maintenance of human health and are neutral or in positive or negative interactions with each other. According to the WHO's list there are over twenty essential nutrients which comprise the basis of all human nutrition. These are: protein, energy, vitamin A and carotene, vitamin D, vitamin E, vitamin K, thiamine, riboflavin, niacin, vitamin B6, pantothenic acid, biotin, vitamin B12, folate, vitamin C, antioxidants, calcium, iron, zinc, selenium, magnesium and iodine.

2.1. Carbohydrates

Carbohydrates supply the 40- 80 per cent of total energy intake. In an optimum diet, at least 55 per cent of total energy is provided by carbohydrates, except of children younger than two years old. Generally, a nutrient-dense, high carbohydrate diet is preferable for the human body.

A detailed classification and description of carbohydrates can be found in this volume in articles 5.2.3.6. and 5.2.3.3. entitled "Sugar bearing plants" and "Starch bearing crops as food sources".

Carbohydrates are classified according to their degree of polimerization into three groups, namely sugars, oligosaccharides and polysaccharides. Sugars are monosaccharides (glucose, fructose), disaccharides (sucrose) and polyols (sorbitol, mannitol). Oligosaccharides with 3-9 degree of polymerization are the results of starch hydrolysis and other oligosaccharides occuring in various plants such as sugar beet and legumes. Polysaccharides are starches (see article 5.2.3.3. Starch bearing crops as food sources) and non-starch polysaccharides: cellulose, hemicellulose and pectin, which are included in the term dietary fibre (see article 5.2.3.1. Vegetables, rootcrops).

Starches consist of long chains of glucose and have different properties while processing, according to their structure and origin. Starches are the main sources of nutritive energy for the humans. Though cereals, root and tuber crops constitute the starchy staples, about 100-150 starchy plant species are used as sources of dietary carbohydrate throughout the world. Products of some starchy crops are more commercialised, as processed wheat, maize and potato. Others, such as the majority of the tropical roots and tubers like cassava, taro, yams, when produced as food, are mainly consumed locally.

Many high fibre staple foods are bulky, and have a low energy density, which is unfavourable for children or starving people, but beneficial to others. Although fibres provide no energy contribution to the diet, they influence on digestion and health: binding more water, stool passes more rapidly through the colon, reducing the risk of many diseases of the digestive tract. Consumption of some soluble fibres may reduce serum cholesterol and prevent the related health problems. The best sources of dietary

fibres are cereals, pulses, vegetables and fruits.

After the consumption of sugars and starches they are converted into glucose that is carried by the blood to the cells in various tissues of the body, and used to gain energy. Glycaemic index (GI) indicates the rate at which the blood glucose level rises and how long it is sustained after digestion of various carbohydrate foods related to glucose. Foods with high GI are absorbed quickly, while foods with low GI are absorbed slowly. Thus specific recommendations can be given for different health status and physical activity on the basis of GI estimations. For sustained physical efforts such as hard work or sport activities as well as for appetite regulation, reducing the risk of obesity, lower GI foods are generally recommended. In diabetes GI considerations have specific role in adapting the diet to diurnal changes and physical activity. Some starchy foods have high GI, such as potato, bread, and many kinds of rice, while pasta, especially that made from durum wheat or semolina has lower GI.

GI %	**Food groups**
90-120	Honey, Cola, non-alcoholic beverages, rice-flake, boiled potato,mashed potatoes
70-90	White and brown bread, white flour, toast, nudles, plain cake, sweet flakes, sucrose
50-70	Black bread, boiled plain rice, natural fruit juice, maize, banana, oat flakes
30-50	Spaghettata and pasta semolina, ice (with cream), fruits, milk, yoghurt
< 30	Lentil, bean, soybean, radish, red beet, tomato, pumpkin, etc.

Table 1.: Foods and their GI

Generally the consumption of those carbohydrate foods is recommended, which are rich in non-starch polysaccharids and have a low GI.

In plant tissues the different type carbohydrates, sugars, starches and dietary fibres, have different roles. Plants fix the energy of sunlight making sugar from carbon dioxide and water, store this energy in form of sugars (sucrose = glucose + fructose) and starches, then use the energy stored for growth and other functions, such as bolting of beets, germination of seeds or sprouting of tubers, etc.

The major carbohydrate supplying crops are cereals, sugar crops, root crops, pulses, vegetables and fruits. Sugar crops such as sugar cane and sugar beet are rich in sugars, while many other secondary crops are used regionally to sweeten some foods, like sugary sorghum, skirret (Sisum sisarum), maple syrup, etc. Grain products and roots and tubers are rich in complex carbohydrates: starches and fibres. High calorie-yielding root crops, such as cassava, sweet potato, yams and taro, are particularly valuable in the tropics where most of the population depends on carbohydrate foods as dietary staples. However, cereals remain the principal source of food supplies, accounting for about half of daily energy intakes. About half of the projected increase in cereals will be for human consumption and about 44 percent for animal feed in the next decades. Feed use,

especially in developing countries, will be the most dynamic element driving the world cereal economy.

There is a transition in eating habits all over the world. In many countries the current staple food is not endemic, like maize and cassava with American origin are staples in many regions in Africa. This leads a reduced diversity of crops in production and also in the diet.

World sugar consumption was more than 128 million tonnes in the Millennium, with a higher growth rate in the developing than in the developed countries.

World production of centrifuged, raw sugar was 127,380,932 Mt in 2001. Sugar beet harvested was 248,247,060 Mt, from which 170,930,553 Mt was produced in Europe in 2001 (Figure 1, Figure 2). Sugarcane production area in the world is much larger compared to sugar beet, 19,179,553 ha to 6,217,628 ha. Also yield is higher, 651,242 Hg per Ha for sugarcane than for sugar beet, which was 399,263 Hg per hectare in 2001. India was the world's leading sugar consuming country, with more than 17 million tonnes. Largest export is expected from Brazil, the EC, Australia and Thailand, while the major importing countries are the Russian Federation, the EC, and Japan.

Sugarcrop	Yield (Hg per Ha)	Area (Ha)
Sugar cane	651,242	19,179,553
Sugar beat	399,263	6,217,628
Other Sugar crops	174,491	32,781

Table 2: Sugarcrop yield and area of production in 2001.

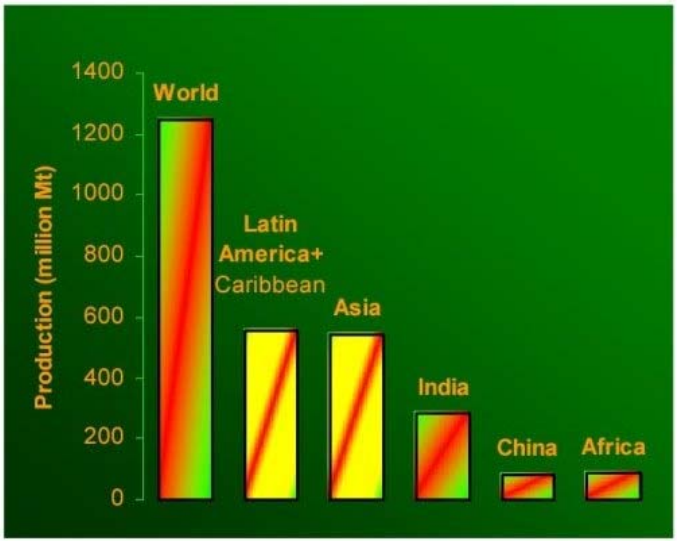

Figure 1.: World sugarcane production in 2001. (Source: FAOSTAT)

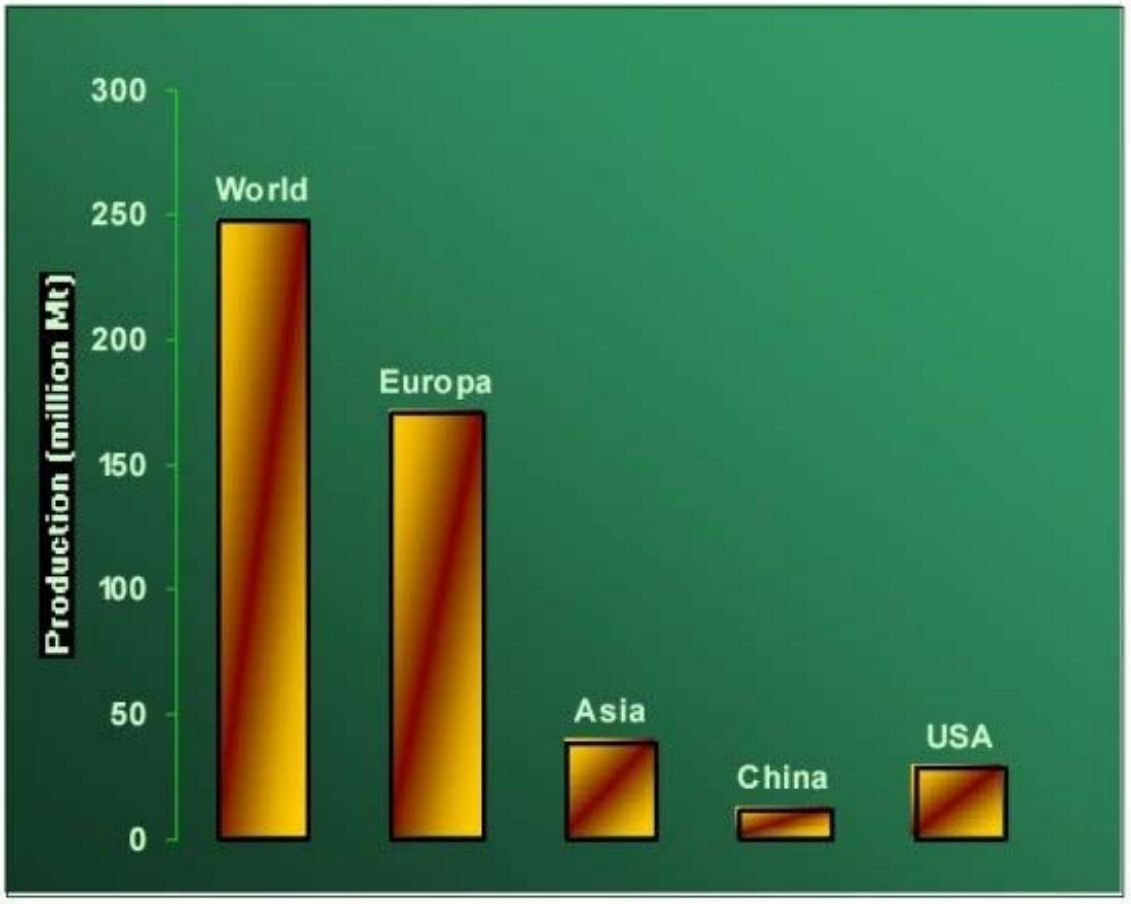

Figure 2: World sugarbeet production in 2001. (Source: FAOSTAT)

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Biographical Sketch

Krisztina R. Végh is a research worker in the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences (RISSAC) Budapest, Hungary. She completed her MSc in Biology in Budapest Science University (ELTE) Hungary. Her PhD thesis analysed the nutrient dynamics in the rhizosphere, by using measurements and modelling. Her interests also include system modelling in sensitive environments, in drought-prone areas, and, in nutrient deficient conditions. She has conducted several research projects on plant nutrition, water use and drought tolerance, and cooperated in both Hungarian and international research. She has worked in Uppsala, Sweden, in Tokyo, Japan, and now she works in joint projects on sustainable plant nutrition, together with Indian universities and research institutes.