

Plant Genetic Resources and Healthy Diet



MINISTRY OF AGRICULTURE
OF THE CZECH REPUBLIC

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The Minister's Foreword



The brochure that has just come into your hands, called “Plant genetic resources and healthy diet” is interesting in two respects. Its aim is to inform not only about the richness of genetic resources of agricultural crops, that are nowadays kept and utilised within specific institutes across the Czech Republic, but also, especially, about how this information is connected to the field of the food industry and currently the topical issue of healthy diet and life style in general.

The purpose of plant genetic resources collections and gene banks is the rescue and permanent preservation of agricultural crop genetic biodiversity, extension of this agro-biodiversity with new genetic resources according to the actual needs of agricultural research and breeding, and also acquiring precious new donors of genetic, biological and economic characteristics to search for solutions to today's world challenges – the changing environment and climate change, population growth, and pressure of new diseases and pests. The great variety of plant genetic resources within the Czech Republic currently contains more than 52,000 items and it has been continuously replenished. Without downplaying the whole issue of a plant gene pool, we can say that what we eat every day has its origins in plant genetic resources.

There is no doubt that health and human life quality is based on a healthy diet. Nowadays, consumers have more and more specialised requirements and there is an increase in the demand for unusual types of crops and especially those of high quality and of domestic origin. Nutritional value, that used to be ignored, is always the same as the value of commonly used commercial crops, often even higher. All the crops mentioned in the brochure are represented in the form of genetic resources in our gene banks and they are not there just to be preserved long term but also to be used in research for further usage in breeding, the food industry, pharmacy and other fields of human activity.

Finally, I would like to thank all the authors for their precious contributions and also to guarantee that the Ministry of Agriculture of the Czech Republic will keep working on the maintenance of the wide range of crop genetic diversity. This is one of our priorities that has been fulfilled since 1993 through the National Programme of conservation and utilisation of genetic resources of plants and agro-biodiversity.

A blue ink handwritten signature, appearing to read 'M. Jurečka', with a stylized flourish at the end.

Marian Jurečka
Minister of Agriculture of the Czech Republic

The Issue of Plant Genetic Resources Regarding Nutrition

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Food of plant origin is an important part of the human diet. It consists mostly of products made from cereals, pulses, oilseeds, also sugar and other sweeteners, fresh and processed fruit, vegetables, potatoes and potato products. Our diet is based on cereals that are (together with potatoes) the main source of carbohydrates (especially starch) that works as the principal resource of energy in the human diet. Cereals are processed into a large variety of products. Considering the nutritious aspect, we appreciate especially the whole-grain products containing more seed coating layers therefore more proteins, fat, vitamins, minerals, fibres and less energy. On the other hand, the white flours have a high level of energy and few nutritionally valuable substances, so their consumption should be limited. Also we cannot recommend eating a greater number of products with high levels of sugar and fat (e.g. soft bread and most types of durable pastry) because they contain a higher amount of energy and the added fat usually consists of more trans-unsaturated fatty acids (Pánek et al., 2012).

It is said that plant proteins are not fully fledged, which means they do not contain all the essential amino acids. The most frequently mentioned limiting amino acid in cereals is lysine. Pulses (ripe and dry legume seeds) are a significant resource of lysine. The seeds are the most significant supply of plant proteins (20–25%), soya has up to 40%. On the other

hand, methionine is little represented in pulses and vegetables (as is the case with cysteine). Cereals and pulses are supposed to be complemented mutually as plant resources of essential amino acids. While the isolated soya proteins seem to be almost comparable to the animal protein, the wheat protein - due to the small amount of lysine, might be up to 50% less valuable than the animal protein. Thus the lysine in the diet can be completed by higher intake of pulses e.g. beans and soya products (Pánek et al., 2012; Prugar et al., 2008).

Regarding oilseeds, poppy seed has been consumed in our country since time immemorial and recently other oilseeds such as sesame, flax, pumpkin etc. are becoming popular. Even though the vegetable oils, and nowadays also the majority of margarines, have a favourable composition of fatty acids and do not contain cholesterol, we should consume them in moderation.



Different bakery products from spelt flour

Plants and vegetable products do not supply only the basic components (carbohydrates, proteins and fats) but also many other favourable nutritious substances including vitamins, minerals, fibres and antioxidants. Vitamins work as catalysts of biochemical reactions (they participate on the metabolism of proteins, carbohydrates and fats.) They are essential to maintain the body functions and are able to provide immune reactions. The large group of vitamins soluble in water is B-complex (cereals, potatoes, pulses). Vitamin C (L-ascorbic acid) is essential for the metabolism of amino acids, bone, teeth and cartilage development. It also has antioxidant effects. We can name potatoes, tomatoes, parsley, pepper, spinach, cranberries, etc. as examples of rich natural sources.

Regarding vitamins soluble in fats (A, D, E, F, K) we can mention for example vitamin A which can be found in e.g. spinach, broccoli, parsley and other vegetables. Lack of vitamin A causes night blindness. Vitamin E has strong antioxidant effects. It is considered as an important factor that slows down ageing. The greatest antioxidant activity shows D- α -tocopherol (cereal germ oils, vegetable oils, corn, beans, spinach, peanuts, soya) (Pánek et al., 2012; Prugar et al., 2008).



Wild pea - *Pisum Fulvum* SM.

Mineral substances have an important role in prevention during atherosclerotic changes in

blood-vessels and in metabolism. They also regulate cholesterol levels and probably can have an effect on the emergence of some diseases associated with civilisation, including cardiovascular disorders. The minerals are divided into macronutrients (Ca, Mg, Na, K, P, Cl, S) and micronutrients (Mo, F, J, Cr, Mn, Se); Iron (Fe) creates transition to the microelements, sometimes it is classified as a macro element, too. Calcium (Ca) is a building material of bones and teeth and it is contained especially in fruits, cereals, beans, soya and nuts. Magnesium (Mg) works as a factor in anti-stress and anti-inflammation. Rich sources of magnesium are; poppy seed, pulses, oat flakes and wheat grains. Potassium (K) is important for intercellular metabolism. It is contained in pulses, nuts, potatoes, spinach and pepper.

Zinc (Zn) is essential for the treatment of post-operative wounds. It is sourced from wheat brans and shoots, pumpkin seeds and pulses. Iron (Fe) supports the creation of red blood cells. We can find it in whole-grain cereal products, pulses, chive, parsley or broccoli.

Selene (Se) is important in cell protection against free radicals thanks to its antioxidant properties. It is present in whole-grain products, soya, fruits and garlic.

The main sources of fibre include whole-grain products as the outer skin layers of cereal grains are rich in unstarched polysaccharides (arabinoxylan, cellulose).

Natural antioxidants are the secondary metabolites included in higher plants that liquidate harmful free radicals. Many of them are actually vitamins, for instance; vitamin C, vitamin B2 and B15, vitamin A precursors – carotenoids, xanthophylls, tocopherols, or vitamin E. Antioxidants include also a number of bioflavonoids. The main sources

of antioxidants are fruits and red wine. Regarding vegetable sources, we can mention for example; onion, garlic, tomatoes, carrots, pepper, beet-root and celery (Pánek et al., 2012; Prugar et al., 2008).

Observing the development of total food and beverage consumption during the last twenty years (1992-2012), it is in the Czech Republic obvious that it has been affected by various socio-economic factors, notably changes in purchasing power and also the alteration of priorities and attitudes. The result of these changes manifested itself by decreased demand for foodstuffs of animal origin and increasing demand for vegetable products. Total consumption of fat stagnated, but the consumption of vegetable fats and oils rose significantly (vegetable oils by 47%, vegetable fats by 20.7%). Sugar consumption lowered by 12.7%, there was a strong rise in the consumption of pasta (by 108.8%), common wheat bread (by 49%), but also durable bakery products (by 30.8%), on the other hand the consumption of bread decreased by 31.1%.

Potato consumption decreased by 18.4%. Even though the consumption of pulses rose significantly (by 62.5%), the actual level of its yearly consumption per capita is still very low (2.6 kg) and does not correspond with the health requirements.

The consumption of temperate zone fruit rose by 7.3%, tropical fruit by 38.7%.

Vegetable consumption grew by 11.6%. While in 1992 15.6% of consumption consisted of cabbage, 14.8% onion, 11.8% carrot; in 2012 the greatest share of consumption was tomatoes (13.8%), onion (12%) and cabbage (10.4%) (Štiková, 2014).

Development of food consumption changes (i.e. increase of vegetable foodstuff

consumption and decrease of food of animal origin) corresponds to the development of the nutritious assessment of food consumption in the Czech Republic. The greatest share of carbohydrate intake consists of cereal products and this trend keeps growing. Cereal proteins are also the most consumed proteins. The intake of vitamin C is mostly derived from fruits and vegetables (the share of the total intake rises) and also potato, where conversely the intake lowers (Štiková, Mrhálková, 2014).

Although these changes are generally positive, the consumers chose a small selection of the large assortment of available products. That makes the diet quite monotonous so there is a higher risk of some nutrient deficiency. Selection criterion is mainly price and also the visual quality. Nutritional value is not a priority for consumers and often even for producers. Many people seek fatty and energy-rich food, with a strong flavour, that satisfies their sensorial needs and they refuse more nutritious, but sensorially less attractive, food.



Flax fibre for nutritional use

Consumption of pastries and durable bakery is high, while for instance pulses, vegetables and often even fruit are not very popular among consumers (Pánek et al., 2012). The unbalanced and monotonous diet results in obesity, high blood pressure, tumour diseases, cardiovascular disorders, or diabetes. Frequent problems of today's population are various foodstuff intolerances and allergies. However, efforts to follow the principles of a healthy diet have grown recently. The demand for low energy foodstuffs (with lowered content of fat and sugar) with higher nutritional value has risen. Some alternative crops might work very well as a resource for such foodstuffs. They are not important just because they might enrich the food supply with new valuable products of higher value, added for both local and foreign markets, but they can also enrich the crop rotations and improve natural regulation mechanisms of the soil and vegetation (Moudrý et al., 2011).

Alternative crops might be defined as crops that replace, enhance and complete the current assortment and contribute to diversify the plant production spectrum. The term alternative food crops can mean the same as small volume crops, regarding their lower scale of cultivation and usage compared to the main crops – wheat, rapeseed etc. The majority of them have specific qualitative properties (sensorial, nutritional, medicinal). They are components of a rational diet and might also be part of healing diets and of the so called functional foodstuffs. They might well be approved of even in pharmacy and cosmetics. Special crop products can be more expensive due to their specificity, powered usually by certificated means of production, processing, labelling and even sales. Alternative crops do not usually reach high outputs. Also the intensification of inputs is generally less demanding. It predetermines the crops to be cultivated in an organic and

integrated growing system. We can divide the alternatives into reintroduced crops and newly introduced crops. Reintroduced ones are those that used to be originally grown here, but they were reduced or completely suppressed because of lower revenues, technology changes, or changes in dietary habits (e. g. buckwheat, millet, spelt wheat, emmer wheat). Newly introduced crops are the species that are successfully grown and economically used elsewhere in the world and in our country the suitable genotypes are tested to learn about their reproduction abilities, flexibility, processing possibilities and sales opportunities (amaranth, sorghum, quinoa etc.) (Moudrý et al., 2011).

A number of these crops are characterised by high nutritional value, for example spelt wheat, emmer wheat, and einkorn wheat have (as compared to common wheat) a higher content of proteins, especially essential amino acids, fibre, vitamins and minerals. There are also various ways of utilisation (grouts, extruded products, special pasta, coffee substitutes, flakes, sprouted grains, unleavened bread and other products, pizza, pancakes, etc.).



Emmer wheat landrace from the White Carpathians

Further we can mention naked barley that is typical for its positive dietetic effects. It is suitable for production of functional food – here, especially useful, is its hypocholesterolemic effect of β -glucans,

α -tocotrienols and active antioxidants included in barley grain; it is suitable for healing and prevention of cardiovascular and other diseases of civilisation.

It is also possible to use it for various pharmaceutical products. Products made of young green parts of the barley plant have recently appeared in the market. The young barley is supposed to have many positive healthy effects. Naked barley shows similar favourable physiological effects on health – this emerges from the high content of high quality proteins, fats, fibres, antioxidants and vitamins (E, B). Consumption of so called buckwheat grouts (peeled buckwheat achenes) has an important role in the prevention of high blood pressure, cholesterol level, cardiovascular diseases and it strengthens the immune system. Buckwheat has these positive characteristics especially thanks to a high content of the bioflavonoid Rutin which is also part of various therapeutic products; it is at its most concentrated in leaves and flowers at the early stage of bloom – those might be used for preparing various tea blends, spices, dietetic supplements etc. (Moudrý et al., 2011).

When trying to enhance the range of plant products with various alternative crops we face many problems; usually low breeding level – low outputs, uneven ripening, unsuitable assimilates distribution, lack of cultivation experience – the knowledge about agro-technology and experience with the reactions to local agro-ecologic conditions are missing; the manner of usage and processing problems – many of these crops are not compatible with current mass production technologies, often there is also a lack of knowledge regarding culinary processing; and finally there is a problem with sales and demand – the alternative crops (products) need to be introduced to the market and we need to overcome the barrier of conservatism which

is often difficult. Mutually in this field there is occurring a range of new issues for agriculture and food industry researches.

The Genebank, consisting of hundreds of genetic resources in its collections, has an irreplaceable role in this regard. There are both the ancient, original, non-bred materials and old crop landraces that used to be utilised in our territory and abroad in the past, and also the contemporary modern varieties of these crops and the genetic resources that are freshly introduced in our country, too.



The Genebank Prague - Ruzyně

All these resources are not only stored in the Genebank, but the collections are also expanded (through gathering or exchange), tested regarding the production indicators, quality parameters. Often, with cooperation with different research institutions (universities, breeding institutes), the prospective materials are selected for new breeding, deeper research or for direct usage in agriculture and manufacturing industry.

To master all these activities, the Genebank uses its special equipment – not only their own storage facilities to preserve the samples, but also the complete equipment for material assessment both on the field and in the laboratory. The last but not least activity of the Genebank, which is becoming more and more important, is their educational and promotional work.

The Value of Landraces for Breeding and Healthy Life Style; Need for Their conservation; Collections in the Czech Republic

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Wide biodiversity on Earth, from microorganisms to maintenance of agricultural crop diversity, is the main prerequisite for sustainable development, adjustment to environmental and climate changes and for continuous functionality of the biosphere - therefore survival of humankind itself (Zedan, 1995).

Landraces and obsolete varieties of agricultural crops, formed by conscious or unconscious selection and intentional breeding activities, provide the most precious genetic resources of any nation. These materials can be considered as national cultural heritage because they either come from the local territory, or they have always been cultivated there, so they are well adjusted to the local conditions. They have wide genetic variability and most importantly, these materials are the results of breeding skills of local farmers and breeders.

It is a moral duty of any nation to preserve these genetic resources for future generations.

The value of landraces for our times is based on their variability, emerging from diverse botanic affiliation and a wide genetic basis of plants, derived from their original, natural ancestors. Contemporary globalised human



Expedition to the White Carpathians with professor Kühn

diet is based on just a few plant species that are actually well bred to maximise output. Landraces can provide special properties for breeders (the characteristics that current varieties have lost) and replenish the desired qualitative element. Diversity of landraces, especially the underutilised and minor ones, might enrich human nourishment with a wide range of vitamins, minerals, antioxidants, and many more healthy substances that have slipped away from the globalised diet over the last fifty years.

Landraces were originally gathered by old breeders, who bred new materials by selection

and stabilised them for usage. One of the oldest Czech breeders was Mr. Emanuel Proskowetz, from the village of Kvasice, who, from 1872, tried twenty new barley varieties and saved excellent types of barley from the region of Haná. Breeders were interested in landraces of the main crops, so others were ignored. The obsolete materials had progressively gone out of production. Regarding fruit species, Kohout (1959) assembled information about cultivated landraces that is now an irreplaceable resource of knowledge. The gathering of landraces in our country can be traced from the sixties, when Kühn and Tempír collected old traditional crops, especially in the Carpathian region (Kühn, 1974). These gathering activities were followed by the expeditions of Gatersleben Gene Bank led by Kühn and Hammer (Kühn et al., 1976, 1980, 1982).



Farmer in the Little Carpathians offers old emmer seeds

Changes in economic conditions in agriculture in the nineties and the invasion of foreign breeds had destructive effects on the landraces. The Gene bank of Crop Research Institute Prague and Piešťany (SK), together with the cooperation of other crop institutes, initiated intensive gathering activities in 1990 in the territory of Czechoslovakia (Holubec et al., 2010). The result is a number of valuable landraces rescued from extinction.

Emmer wheat

(*Triticum dicoccon* Schrank var. *serbicum* A. Schultz, *T. d.* var. *volgense* Flaksb)

Emmer wheat was traditionally cultivated on the Moravian-Slovak border in the White Carpathians and the Little Carpathians. Locals used to call it "rice" (rýž). Emmer wheat was available in more varieties, especially white and red. Local people appreciated emmer wheat for its perfect and unique taste properties. They used it for the production of grouts for soups and blood sausages and for the preparation of both a main dish and a side dish. In 1990 three samples of older seeds were obtained from three indigenous owners. These exemplars had not been cultivated for the previous three, five or ten years - the grains were stored in attics.

Sorghum

(*Sorghum bicolor* (L.) Moench)

Sorghum is the main food cereal crop of the Sub-Saharan Sahel region. It is cultivated especially in sub-tropical areas. In our country it used to be utilised for preparing side dishes and porridges. Sorghum forms, with a whisk-like branched inflorescence, were used for manufacturing brushes and brooms. A very interesting sorghum type, with a bushy, spindle-shaped, dark-brown inflorescence with huge seeds, was discovered in a little garden in the foothills of the White Carpathians near the village of Velká nad Veličkou in 1993. After

selection and stabilisation of this material, it was registered as a new variety called “Ruzrok”.



Sorghum landrace panicle picked in Velká nad Veličkou

Grass pea

(*Lathyrus sativus* L.)

Grass pea has traditionally been cultivated especially in Moravia. In 1990 it was found

in two little fields in the White and Little Carpathians. Here, people used to call it “chickpeas”. The true chickpea (*Cicer arietinum*) was called cicer, and was known by several local people, but we were informed it has not been cultivated for a long time. Grass peas were used for soups, together with broad beans. In the past, green young seeds were consumed raw as green peas.



Grass pea seeds from the White Carpathians

Common pea (Black seed pea)

(*Pisum sativum* L. var. *sativum*.)

Common pea is traditionally grown in the regions of Orava and Beskydy. Seeds are light to dark-brown. It is not a fodder variety, more like a garden type. Chemical content and flavour characteristics correspond with the common pea. It is used for soups and porridges. Nowadays it has almost disappeared from cultivation. In 1999 we obtained this species in the Polish part of Orawski-Beskyd Mountains, the region where a significant Slovakian minority lives.

Poppy seed

(*Papaver somniferum* L.)

Great diversity of cultivated poppies was observed in the White and Little Carpathians. Beside the common types with round and oval poppy heads, there were found other kinds with thin and long capsules (10-13 x 3-4 cm).

The latter have an intensive anthocyanin colouring of dark purple or pink hue. Seed colour was various from white, through grey and blue, to brown.

Broad bean

(*Faba vulgaris* Moench.)

A plant traditionally grown in our country, rarely found in the gardens and old back yards. It used to be grown in the regions of Moravia and Orava. The last time it was harvested, was in 1999 in the village of Piekelník in the Polish territory where a Slovakian minority lives. The common garden bean is typical for its good taste, thanks to the absence of bitter substances and a low content of glycosides. It was used especially in soups. The raw form is not suitable for direct consumption.

The erosion of grown landraces as germplasm was accelerated by all the political and

economic changes in agriculture. In the early eighties, it was still possible to walk through the landraces in backyards and fields. In 1990, in the hilly areas of the Moravian-Slovak border, it was possible to collect some traditional crops, but later in the nineties there were already fewer possibilities to do so. Since 2000, only some landraces of woody plants have been commonly found and just occasionally some pulses, vegetable, aromatic and medicinal plants in gardens.

The result of the gathering activities since 1990 to date has been the collection of 5,129 samples of seeds, including 207 materials of landraces and old horticultural crops (Holubec, Vymyslický, 2014). These materials might become a valuable genetic resource for breeding, which might be used to enrich contemporary crop assortment, in organic agriculture, or to renew traditional food production.



Broad bean, gathering in Piekelník

Old Traditional Cereal Crop Varieties and Their Value for Nutrition

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Cereals were the earliest crops to be domesticated. Their hybridisation, development and domestication occurred in the Fertile Crescent (Near East) before 9,000 BC. This region includes the eastern coast of the Mediterranean Sea, south-eastern Turkey, Syria, Iraq and western Iran. There, can be found the highest concentration of varieties of *Triticum-Aegilops* complex, i.e. an ancestor and related species of wheat and barley. There are archaeological findings of wild diploid and tetraploid wheats and barley from the period of the 19th to 11th centuries BC (Ohalo region, Israel, Kislev et al. 1992) and we can assume the indigenous people of the Fertile Crescent picked and used them. Heavy settlement of the area probably led to a depletion of the natural wheat distribution area, which might have resulted in the necessity for regular cultivation and gradual domestication of *Triticum dicoccoides* and *Hordeum spontaneum* (9.6 – 9 thousand BC), domesticated einkorn and emmer wheat in Cafer Höyük, Turkey (Wilcox, 1991), domesticated barley in Ain Ghazal, (Rollefson, 1985). Domestication is connected to significant changes of morphologic features, notably the change in brittleness of rachis, release of grain from the husk (hulled grains → naked grains) and reinforcement of glumes (limitation of shedding). These features are simply genetically based and a mutation has probably occurred. It is assumed the domestication happened in various different places independently,

especially in the Euphrates valley, in eastern Anatolia, southern Levant – Syria and the foothills of the Zargos. The naked tetraploid species of wheat first appeared in Asikliya and Abu Hureyra in the period of 8,800 – 8,400 BC (Moulin, 1993).

The presence of wild cereals in the Fertile Crescent region co-conditioned the development of civilisation in the Near East. The local people used nature's unique offer in the form of spontaneous wheat hybrids as energetically nutritionally loaded foodstuffs and these semi-finished products were valorised by the domestication process. All the products of this domestication process (einkorn wheat, emmer wheat, spelt wheat, Zanduri, timopheevi,...) in the Near East and secondary centres as well, are nowadays valuable for their genetic endowment and thus for the complex nutrition of humankind. These genetic resources, stored in the gene bank, were evaluated regarding a quality and healthy diet. Prospective materials passed a selection process and are suggested for cultivation in the form of new varieties.

Einkorn wheat

(*Triticum monococcum* L.)

Einkorn wheat has been widespread in the Near East and in Europe for thousands of years. Together with emmer wheat, it is one of the oldest domesticated wheats - dating

back 10 – 12 thousand years. Nowadays, the einkorn wheat is cultivated only on a small area in some regions and especially in the low – input or organic agricultural systems. Considering the increasing demand for traditional foodstuffs and for “food of a higher natural character”, consumers are interested in einkorn wheat. It also relates to the higher demand for whole-grain products and the general orientation to a healthy life style. Einkorn – as with emmer or spelt – comes from the family of hulled wheat, which means the grain is protected with glumes after the harvest. The spikelet needs to be peeled before food processing.

In the Gene bank, a line called “Rumona” was selected from material collected in the Pannonian region, and is now ready for registration. It is generally dedicated to organic farming.

Emmer wheat

(*Triticum dicoccum* (Schrank) Schuebl)

Emmer wheat is hulled wheat, cultivated traditionally and used for human nutrition.

Emmer domestication is connected with the primitive beginnings of agriculture. It subsequently spread to the Middle and Far East, to Europe and North Africa. It was grown together with barley. The ancient Romans utilised it for porridges, grouts and bread baking. Emmer wheat is still cultivated as a minority plant in Ethiopia, India, Italy and Turkey. Regarding the growing market for various and healthy foods, the demand for this wheat species rises. Emmer flour is very valuable thanks to its nutritional quality. It excels especially in having a high content of proteins, phosphor, zinc, copper, potassium, magnesium and manganese. It is a perfect source of pantothenic acid, niacin, and vitamin B2. Compared to wheat flour, it also contains more lysine. Emmer is particularly suitable for unleavened products (e.g. Arabian unleavened bread). Among other products, a wide variety of unleavened bakery goods such as biscuits, characterised by specific sensory qualities (smell, brittleness etc.) can be found. Emmer flour is suitable for the preparation of other articles such as pizza, breakfast cereal products, extruded products, pies etc. (Konvalina et al., 2010).



Landrace of Emmer wheat

From within the landraces genetic resources collection of the Gene bank, a new variety, “Rudico”, was selected by bulk positive selection. “Rudico” is resistant to fungal diseases and lodging and it has a high revenue potential within these wheat species. It is intended to be used as an addition to breakfast cereals and biscuits.

Spelt wheat

(*Triticum spelta* L.)

Spelt wheat is considered to be a cultivated wheat, found mainly in old Europe. Spelt consists of two genetic types; the Asian and the European. It appeared in the Alps (Switzerland and Germany), Poland, England and Scandinavia. In the past, spelt was relatively widespread in central Europe thanks to its hardiness and ability to provide a satisfactory output on poor soil. As a result, it has been spreading into the areas of central and western Europe, especially in Germany, Switzerland, Austria, Czech Republic and Hungary. In the Czech Republic the cultivated areas keep increasing.

From the Gene bank’s genetic resources, a new breed of spelt called “Rubiota” was selected (by bulk selection). It is a valuable raw material for nutrition, especially for breaded foodstuffs and breakfast cereals. It is characterised by a high content of mineral substances and great antioxidant activity.

Foxtail millet

(*Setaria italica* (L.) P. Beauv)

Foxtail millet is a species from China, India and Asia Minor. Its original form has not been determined exactly yet, because it is a very old cereal – historical evidence exists from 5,000 BC. Foxtail kernels are used for human consumption as well as for feeding farm animals, mainly poultry.

The hull adheres to the grain, therefore the caryopses need to be peeled before human consumption. The chemical composition of foxtail millet kernels is similar to millet. There are 14.2% proteins, 4.7% fat, 11.3% fibre, 2.1% ash. There is a low content of gluten so the foxtail kernels are suitable in the case of celiac disease.



Foxtail millet “Ruberit”

The new cultivar, “Ruberit”, was selected from the genetic resources of the Gene bank. This prospective variety enriches the portfolio of crops that might be cultivated for its grains to be used in the food industry.

This crop is especially valuable because the products made from the grain (flour) can be used by people suffering from celiac disease. This plant is suitable for both the human diet and as fodder.



Foxtail millet, Ruberit, fetus detail

Sorghum

(*Sorghum bicolor* (L.) Moench)

Sorghum is one of the oldest crops. Today its grain variety is the fifth most commonly grown cereal in the world. The possibilities of usage of all its forms are very variable. In

the food industry, sugar sorghum is utilised for the production of syrups, candies, spirits and beer, because it ferments quickly and easily. Flour and grouts are commonly used for porridge preparation. Clinical testing has proved sorghum as being suitable food for celiac disease patients.



Sorghum "Ruzrok"

Quality Trends of Wheat Grain

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The quality of grain is an important requirement that significantly affects the economy of crop cultivation. Generally, the quality can be understood as a multi-criteria parameter that might be simply defined as a level of consumer's satisfaction (Celba et al., 2001).

The wheat grain has a number of different final uses, therefore it is necessary to look at its quality from different aspects.

The term wheat grain quality can be divided into several specific qualitative areas including especially the hygienic, nutritional, technological and sensorial qualities.

The crucial criterion for economic evaluation is, first of all, the technological quality of grain. Within this criterion some hygienic aspects are also regarded, such as the occurrence of mould, content of mycotoxins etc. On the other hand, the nutritional grain quality parameters are not taken into consideration

at the time of purchase, while much more than 50% of total production is used for feeding purposes.

The assessment of the technological grain quality defining the basic wheat categories for food (as opposed to non-food purposes i.e. fodder) is the most sophisticated branch of grain quality evaluation. Food quality in the Czech Republic is defined exactly by the norm ČSN 46 1011-2 "Food Wheat", that came into force on July 1, 2002. Compared with the previous norm, the way of assessing the quality of food wheat was changed in accordance with European Commission regulation (ES) 824/2000 from April 19, 2000 that introduces processes of cereal uptakes by intervention agencies and determines analyses for grain quality assessment. At the same time there was a division of food wheat into the bakery wheat and pastry wheat (for production of biscuits, cookies and crackers) defining the lowest parameter values for both categories (Table 1).

Table 1: Basic values of chosen indicators of food wheat quality

Quality index	Bakery wheat	Pastry wheat
Humidity [%]	Max. 14	Max. 14
Volumetric weight [kg.hl ⁻¹]	Min. 76	Min. 76
Content of N-substances in the dry matter [%]	Min. 11.5	Max. 11.5
Index of sedimentation [ml]	Min. 30	Max. 25
Number of decline [s]	Min. 220	Min. 220

Also, in the case of breeding and testing new varieties, technological (bakery) criteria prevail absolutely. This mainly includes direct baking test (Rapid Mix Test), content of crude protein, Zeleny sedimentation test, falling number, test weight and water absorption of flour.

Achieved numbers are the core values for classification of the variety tested into the corresponding quality group (E, A, B resp. C). The C species are inappropriate for production of leavened dough (Table 2) (Novotný, 2006).

Table 2: Minimal requirements for classification varieties into groups

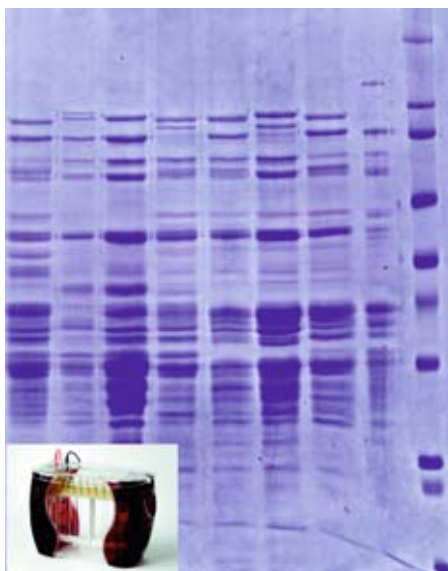
Quality group → Expression of values ↓	E – elite quality Points (1-9) Absolute value		A – high quality Points (1-9) Absolute value		B – bread quality Points (1-9) Absolute value	
Volumetric yield [ml]	530	8	500	6	470	4
Crude proteins content [%]	12.6	6	11.8	4	11	2
Zeleny test [ml]	49	7	35	5	21	3
Decline number [s]	286	6	226	4	196	3
Volumetric weight [s]	790	7	780	6	760	4
Flour binding capacity [%]	55.4	7	53.2	5	52.1	4

However, the differentiation of the final technological quality of wheat grain, formulated by the processing companies, is much broader.

Individual varieties might be classified into more product categories. For example, within the pastry application, the producers specify optimal technological properties of grains for production of wafers, biscuits or crackers. There are also some specific requirements for wheat grain dedicated for dough or also for an industrial application (starch or alcohol).

Even though these technological requirements are the subject of crucial business relationships among wheat producer, following processor (e.g. mills) and final customer, they are not included in the mandatory standards and these parameters are often not even officially accessible to the wider professional community including breeders.

Wheat breeding has a long successful tradition in the Czech Republic and our varieties continue to be an important part of the contemporary assortment. To maintain the position of home breeding and reaching further progress, the suitable genetic resources (donors with required traits and properties) are very important (among other things). Wheat breeders are interested in such materials and especially the demand for genetic resources with a high content of proteins and a specific composition of starch (proportion of amyloses and amylopectin) is growing. The selection of these donors in a large crop collection is very difficult. After the routine description of the collection, it is necessary to have detailed evaluation of the potential materials. However the suitable evaluation and selection methods are often missing (especially if there are new requirements on the product quality).



Picture 1: Electrophoresis of wheat grain storage proteins (SDS-PAGE)

Mastering these tasks also often relies on the use of effective prediction methods to assess the technological quality.

General trends aim to minimise the consumption of analysed grain, the complexity and high speed of the whole assessment, leading to lower final costs of the technical evaluation.

Generally, the most attractive and the most developed methods in this branch are genetic (molecular) procedures. The advantage is the direct attachment to the genetic characteristics, relative rapidity of the analysis, and also the minimal need of samples (for example part of a leaf, grain etc.).

On the other hand, even those procedures face the specifics of the technological quality mentioned above, which are influenced by the high complexity of the required traits with significant effect of the external non-genetic factors.

So far, such routine procedures are utilised especially those for proteins (Picture 1), respectively the molecular markers for prediction of baking quality of the grain tightly attached to the gluten characteristics that have a crucial influence on the final yield and shape parameters of the baked bread. Molecular markers that predict some of the key characteristics of the grain (e.g. grain hardness, starch composition) with the significant impact on its final technological usage are also available (Giroux, Morris 1998; Graybosch, 1998).

The other popular and recently well developed group of technological quality of wheat assessment methods is the spectrometric methods in the near infrared region (so called NIR spectrometry). The ability of specific absorption of the range of technologically important components of the grain in the infrared spectrum enables quick estimation of e.g. the content of nitrogenous substances, starch, grain moisture, water absorption or the gluten content and grain hardness. Some opportunities are especially appreciated here - such as; the possibility of non-destructive measurements (measure of the intact grains), high speed of the method and also, in spite of the expensive initial investment, the following low cost analysis and waste-less process of the assessment (Picture 2).

In many cases, the prediction of more complex physical-chemical and rheological properties in this system fail and we need to get back to traditional laboratory methods. Even within these traditional processes, currently, there are ongoing trends focused on miniaturization and complex evaluation affecting more components and properties of the grain simultaneously. Briefly, we can mention for example, the method of retention capacity of flour (so called SRC-test) based on the centrifugal binding capacity of flour in different solvents, giving the ability to specify some properties of the protein-starch



Picture 2: Measuring the intact grain using NIR spectrometry

complex, including the influence of non-starch polysaccharides (Guttiery, Souza, 2003). There are also (micro)rheological devices evaluating the properties during kneading of the dough for example ReoMixer (for 10 grams of flour) or Mixolab system (for 45 grams of flour) with the possibility of a controlled increase and decrease of temperature during the kneading of the dough and assessment of the effect on the characteristics of proteins and starch (Picture 3) (Kahraman et al., 2008). High diversity of technological processing of the wheat grain nowadays brings a positive

nutritional impact on consumers. Compared with the end of the eighties, there has been a favourable trend of growing consumption of the whole grain bakery products characterised by a provably lower glycaemic index ($GI = 40\text{--}60$) in comparison to white flour baking products ($GI \sim 80$). There are also some other positive steps leading to the enrichment of bakery products by reintroducing, in the desired proportion, previously removed grain coating layers, which are high in fibre.

The processes of precise grinding of grain in order to separate its parts e.g. in the area of the aleuronic layer rich in proteins and substances with high antioxidant activity for their subsequent fortification for bakery products (Dexter, Wood, 1996) also seem to be full of potential.

Direct genetic influence of nutritional parameters of wheat in the breeding process has been of only minor significance so far. More significant breeding steps, regarding nutritional grain quality, are rather connected to the usage of other kinds of wheat (spelt wheat, emmer wheat, einkorn wheat). Within common wheat, we can mention in passing, recently gained varieties with specifically different colouring of the grain (yellow, purple, blue-grey, blue) characterised by a higher content of vitamins and antioxidants (polyphenols, anthocyanin, lutein etc.). As an example, we can note for instance one variety called Citrus with yellow grains and the variety Skorpion with blue grains (Picture 4). This variety was bred in the Czech Republic but registered in Austria as RU 440-6 in the official examinations of assortment for organic farming (Martinek et al., 2012). Many published wheat genotypes with interesting traits, for example; the high content of amylose (respectively resistant starch) or genotypes with elimination of allergically affecting groups of gliadins suitable for those suffering from gluten intolerance, have not proceeded to the



Picture 3: Rheological system Mixolab

wider agricultural practice yet (Regina et al., 2006; Waga et al., 2013).

On the other hand, regarding the growing pressure from consumers for healthy nutrition, it is expectable that the significance of the

wheat grain nutrition quality will rise. Thus, potential breeding activity will not be possible without properly monitored collections of genetic resources, including also new donors with demanded nutrition properties of wheat grain.



Examples of chosen wheat grain species unusually coloured, *T. aestivum*: Indigo, Skorpion and Citrus

Barley, Oat and Rye – Important Components of Human Healthy Diet

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Cereals are one of the oldest raw materials that humans use for their sustenance. Composition of cereals in the human diet has changed a lot during the last few decades; from barley, millet and rye towards wheat, rice and maize. With an increasing significance of wheat as part of direct human nutrition in European countries, the importance of barley (*Hordeum vulgare* L.) in particular decreases. On the other hand, it has been becoming more and more important as a raw material for beer production. Currently,

the higher consumption of barley is evident only in the regions where it still creates part of traditional dishes; e.g. Africa or Tibet. In recent years the qualities of barley have been revealed again even in the rest of the world, and it has been slowly reappearing in the human diet. For food industry purposes, so called naked/hull-less barley without adhering lemma was traditionally cultivated, because its grain (similar to wheat grain) does not need any other processing connected to husk removal by grinding. According to preserved



Barley landraces

records within the ‘Collection of genetic resources of spring barley’, this hull-less type of barley used to appear in our country, too (e.g. local varieties Prokúpek’s naked, Michalovice naked). Naked barley has returned to Czech fields with the registration of two Czech hull-less varieties; AF Lucius (registered in 2009) and AF Cesar (registered in 2014).

Another important cereal for a healthy human diet is oats (*Avena sativa* L.) which, in terms of food value in comparison with barley, has a higher content of the essential amino acid of lysine and about twice as much fat. Oats also have a relatively large amount of protein. In “Collection of genetic resources of oat” the highest levels of protein (>17%) were found for example in Japanese genetic resources; Bandai Hadaka, Han Hadaka, Mizuhara 291 or the US species of Bob, Borline and Canuck.

Recently, a sufficient dose of fibre in a healthy diet has been emphasized. A number of scientific experiments proved the very positive effects of non-starch polysaccharide β -glucan (which creates soluble dietary fibre) on the human digestive system. The European Food Safety Authority (EFSA) confirmed the results of long-term researches that say the

daily intake of 3 grams of β -glucans lowers cholesterol and corrects blood glucose level. Regarding cereals, such a significant amount was revealed only in the case of oats and barley (Table 1). β -glucans are also present in some mushrooms, lichens, and yeast. Nevertheless, cereal β -glucans are more suitable and more easily digestible for humans. Even though the content of β -glucans in barley grains might be significantly affected by the growing conditions, it is scientifically proved, that higher contents of β -glucans appear in grains of the barley genetic resources that have changed the ratio of the main substances of starch – amylose and amylopectin – and have a so called “waxy” type of starch. While in our country the breeding of barley is primarily focused on malting quality, for example in the USA one of the main purposes of breeding is the creation of special food varieties. Genetic resources of barley, with a combination of hull-less grain and waxy starch, are very appropriate for the food industry even within Europe. We can find a number of varieties possessing qualities suitable for the food process in the “Collection of genetic resources of spring barley”. There are also breeding lines of Czech origin that are already adapted to our climatic conditions (Table 2.). Czech hull-less barley variety AF Cesar, which is also included in the collection, is currently utilised in the local food industry due to its increased content of β -glucans. Within “Collection of genetic resources of oat” higher contents of beta-glucans were found in several varieties e.g. CZ Izák, Abel, Mojacar, Baragan 114, OT 258, Neon and Master. As is the case with barley, there also exists a hull-less grain type of oat which is easily digested, and compared with hulled varieties, contains twice the amount of proteins and essential amino acids of lysine and methionine, which predetermines this type of oat to food processing usage.

In our country, wheat is mainly used for bakery production. Foodstuffs made of wheat have a quite high glycaemic index, expressing

Table 1: β -glucan content in cereal grains (%)

	β-glucan content	
Cereal	Total	Soluble
Barley	4.95	3.28
Oat	3.83	2.42
Rye	2.15	0.77
Wheat	0.74	0.65
	Arabinoxylan content	
Cereal	Total	Soluble
Barley	6.47	0.55
Oat	8.69	0.57
Rye	9.65	2.95
Wheat	7.53	1.34



Hull-less barley grain

how quickly the blood sugar level rises after consumption. The increasing value of this index means a greater and faster increasing level of blood glucose. Soluble dietary fibre was acknowledged as an agent that helps to slow absorption of products from saccharides digestion. That is the reason why the foodstuffs with soluble fibre usually have a lower glycaemic index. The positive effect of food

fibre is based on the prevention of a number of civilisation diseases such as cardiovascular diseases, inflammatory tumour disease of digestive tract, diabetes. - type 2, obesity etc. However, we cannot make bread using barley or oats in the classical way because their protein fraction does not have the same properties as the wheat gluten, therefore it is usually mixed with wheat flour. To keep the desirable volume of loaf, colour and flexibility of crust, only 15–20% of barley flour is added. Another alternative is adding specially prepared whole grain barley flakes that provide the required dietary fibre. Regarding bread production in our country, there is also a longstanding tradition and great significance in the use of rye (*Secale cereale* L.), which is used by almost 90% of the food industry here. Rye and rye flour have (comparing with wheat flours) a lower content of proteins and a higher amount of arabinoxylans, that are part of fibre (like β -glucans). Therefore, consumption of wholegrain foodstuffs made of barley, oats and rye brings many positive effects to humans and they should become a staple part of everyone's daily diet as a part of healthy nutrition.

Table 2: β -glucan content in genetic resources of spring barley

Genetic resource title	Country of origin	β -glucan content (%)
CDC Candle	CAN	6.45
HB803	CAN	7.46
Merlin	CAN	5.72
CDC Alamo	CAN	7.41
Wanubet	USA	7.60
KM 2645.4 2.3.4.6	CZE	7.96
KM 2460.4 1.7.2.11	CZE	6.88
KM 2551.469.1.02-2	CZE	7.30
AF Cesar	CZE	6.80
Annabell	Control variety	4.72

The Importance of Potatoes for a Healthy Diet

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Potatoes fulfil three different functions in the human diet; volumetric, satiating and protective. Volumetric function means the potatoes assure a sufficient volume of food to fill the digestive tract; satiation is assured by suitable content of energetically valuable components; and the protective function means there is appropriate content of vitamins, minerals and other bioactive and positively affecting substances (Table 1). Energetic value of boiled potato tubers is rather low (Table 2). The tubers represent a plant product with a high content of starch but especially water, whose amount varies in the range of 70–80% of the fresh weight. Dry matter content relies especially on the genotype, level of tuber ripeness, course of weather conditions during its growth and growing technology. Regarding chips and fries, the dry matter impacts on crispiness. Dry matter content of tubers bred for direct consumption determines the cooking type classification (Table 3). It facilitates consumers to have an overview of potato varieties – basically we distinguish two types; floury (more dry matter) and waxy (less dry matter). Starch creates a significant part of the tuber's dry matter. Tuber varieties for fresh consumption contain 11–16% of starch, sometimes even more. The starch works as the main storage material of the plant organism because it is a prompt stock of glucose.

In potato tubers there are even more polysaccharides that create cell walls

and intercellular components. These polysaccharides are labelled as fibre (rough fibre, cellulose, hemicellulose, pentosan and

Table 1: Detailed information about content of chosen substances in potato tuber (Bárta, Bártoová, 2013)

Substance	Content expressed in mg/100g of fresh weight
Vitamin C	8–54
Vitamin B1	0.02–0.2
Vitamin B2	0.01–0.07
Vitamin B6	0.13–0.44
Vitamin E	~ 0.1
Folic acid	0.01–0.03
Carotenoids	0.05–2
Tocopherols	up to 0.3
Polyphenol	123–441
Phosphor	30–60
Potassium	280–564
Calcium	5–18
Magnesium	14–18
Iron	0.4–1.6
Zinc	~ 0.3
Nitrates	< 500
Steroidal glycol-alkaloids	< 20

pectin). Fibre function is based on assuring good distribution of the nourishment in the stomach and intestines and it enables peristalsis and the right placement of ingested matter.



Examples of the utilisation of potatoes

Nitrogenous substances (crude protein) are one of the most important compound complexes included in a potato tuber. It helps create nutritional and caloric value of the tuber. Usually the mean value of crude protein content is considered as 2% of the original mass i.e. 10% of the dry matter. The most important share of nitrogenous substances is created by proteins. Their amount strongly fluctuates from 34%–70% (about 58% of the total amount of crude proteins). Regarding the nutritional aspect, potato proteins are one of the best quality vegetal proteins. Especially appreciated is the high amount of lysine because it is quite unique for plant proteins. Cysteine, methionine and sometimes even isoleucine are considered as the crucial amino acids of potatoes.

Concentration of fats is very low; in tubers there is about 0.1% fat in the fresh weight. Its share on nutritional value is very low. The greatest amount of fat is located in the skin.

Regarding sugars there are monosaccharides, glucoses, fructose, and disaccharide sucrose (about 5% sugar in tuber fresh weight). Sugars help improve the taste of cooked potatoes by softening them. A high content of so called reducing sugars (glucose, fructose) is not desirable for processing potatoes into food products. In crisps and fries, the high content of reducing sugars causes a reaction with amino acids, creating brown products. It lowers the quality of products, not just the colour but also the taste.

Vitamin composition makes potato an extraordinary foodstuff. The most important is vitamin C, which is a significant antioxidant, and some groups of vitamin B; thiamine (vitamin B1), riboflavin (vitamin B2), and nicotinamide (vitamin PP, equals vitamin B3).

It has also been proved to have a content of fat soluble vitamins; carotenoids (provitamins A), tocopherols (vitamin E), vitamin K; and water soluble vitamins; pyridoxine (vitamin B6), pantothenic acid (vitamin B5) and so on. In the flesh of all potato tubers, there are plant pigments that cause its colouring. Carotenoids make the tuber flesh yellow. Skin and flesh of some varieties appear to be red or blue. Such colouring is caused by anthocyanins. Minerals in a potato tuber represent a complex of many elements. Average content of mineral substances is 1.1%. The most important mineral substance is potassium. There is about 1.7–2.0% in dry matter, which makes up about half of all the minerals. There are also phosphorus, magnesium, calcium, sulphur, sodium, iron, manganese, zinc and copper. Selenium has a special role in that it works with vitamin E in the cells' antioxidant defence system - it stops the reactions of free radicals. Potato tubers are an important source of antioxidants in human nutrition. The main antioxidants in tubers are polyphenols and vitamin C. Other antioxidants are represented

by carotenoids, anthocyanins, α -tocopherols and a little bit of selenium and α -lipoic acid. There are even more nutritionally interesting substances in potatoes, such as; organic acids (citric acid, oxalic acid, malic acid etc.), phenols, and aromatic substances.

The collection of potato genetic resources is a unique and irreplaceable source of genes and genetic complexes for the further amelioration of biological and economical potential of new potato species. Long term, the potato gene pool collection is maintained, regenerated and assessed in the Potato Research Institute in Havlíčkův Brod. Nowadays there are 2,497 samples representing 1,284 varieties of *Solanum tuberosum*, 491 tetraploid hybrids of *Solanum tuberosum*, 270 dihaploids, 334 genotypes of 5 cultivated and 23 wild species

and 118 interspecific hybrids of the *Solanum* genus in the *in vitro* genebank.

Materials maintained in the genebank are available for research, breeding and education and are provided especially to practical breeders, research institutes, universities, museums, and botanical gardens across the Czech Republic and even abroad.



Diversity of potato tuber morphology

Table 2: Typical nutrition values of potatoes prepared in different ways (in 100g)

	Boiled unpeeled	Boiled peeled	Baked unpeeled	French fries
Energy (kcal)	66	77	85	280
Proteins (g)	1.4	1.8	2.6	3.3
Carbohydrates	15.4	17.0	17.9	34.0
Fats (g)	0.3	0.1	0.1	15.5
Fibre (g)	1.5	1.2	3.1	2.1
Potassium (mg)	460	280	547	650
Iron (mg)	1.6	0.4	0.9	1.0
Vitamin B1 (mg)	0.13	0.18	0.11	0.08
Vitamin B6 (mg)	0.33	0.33	0.23	0.36
Folic acid (μ m)	19	19	44	31
Vitamin C (mg)	9	6	14	4

Source: European Food Information Council Newsletter, 2010

Table 3: Characteristics of different cooking types of potatoes

Characteristics	Cooking type				
	A	AB	B	BC	C
Consistency	Very firm	firm	Medium firm	fluffy	fluffy
Structure	Soft – medium rough				Soft – rough
Mealiness	Very weak		weak	medium	strong
Humidity (Moisture)	medium	Weak – medium			
Taste weaknesses	Negligible – medium				
Darkening of potatoes after cooking	Very weak – medium strong				
Quality stability	Medium – very high				
A,AB (BA)	Characterizes varieties with firm or very solid firm flesh that is very slightly floury, waxy and which is not possible to overcook, i.e. varieties suitable for side dishes or salads.				
B (BC)	Here belong the varieties with medium solid to fluffy flesh, slightly to medium floury, suitable for side dishes, soups and eventually for preparation of dough or mashes				
C (CB)	Varieties with fluffy to strongly floury flesh, suitable for mashes and dough				



Potato in vitro genebank

The Significance of Legumes and Pulses for our Health

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Legumes are a large family of crops, cultivated all around the world, not only for food and feed purposes, but also to be utilised in various industrial sectors. The term “pulses” is used for the ripe dry seeds of legumes. Legumes belong to the *Fabaceae* family, sometimes called *Papilionaceae* or *Viciaceae*. Traditionally, in the Czech Republic, they have been cultivated for several centuries. Legumes are a source of vegetable proteins both for fodder and the food industry. On a global scale, the yearly consumption of legumes is about 57 million tons. The average per capita consumption differs in various regions. According to FAO, it ranges from two to twenty or more kg. The world average is about 7 kg. In the Czech Republic, the consumption of legumes is quite low – about 2.5 kg per capita per year. At least the trend is rising slightly. In Czech conditions, the main edible legumes that are available are: peas, beans, lentils and soya.

In the Czech Genebank there are 4,890 accessions of legumes stored, 2,021 more accessions labelled as forage crops, wild species, landraces, breeding materials or advanced varieties in the collection of the *Fabaceae* family. The most numerous species in the collection is the pea, *Pisum sativum* L. (42%) and common bean (23%). These genetic resources are important especially for breeding in order to increase the yield potential of varieties and chiefly to get better yield stability. Users, growers, processing companies or consumers prefer the varieties

with specific growth characteristics, seed colour and its stability, optimal boiling capacity etc. These preferences are causing a reduction in genetic diversity and increasing the danger of loss of some valuable characteristics (e.g. pest and disease resistance) and a gradual reduction in yield potential of the gained progenies. In the history of pea breeding in the Czech Republic, one of the most successful varieties has been the yellow seeded field pea called “Bohatýr” (1980), bred in the breeding institute in the village of Lužany near the town of Přestice. For a long time it was an important article for the Czechoslovak foreign trade.



Wild species of Pisum abyssinicum BRAUN

An important event was the discovery of semi-leafless (afila) growing types of peas, whose leaves are transformed into tendrils. It is a spontaneous mutation which was discovered in 1949. It was only in the late sixties that it was included in breeding programs. Nowadays, on the whole, it is only the semi-leafless varieties that are cultivated because (compared with

other “classic” varieties) they are resistant to lodging, therefore there are minimal harvest losses (compared with the past).



Pea - *Pisum sativum* L.

The composition of pulses

Pulses contain important substances that can contribute to keep oneself healthy. Those are especially proteins, fibre, vitamins, minerals and other so called bioactive substances whose value has been researched recently. These substances act synergistically so the consumption of pulses might act protectively against developing some of the civilisation diseases – cardiovascular disease, breast cancer, large intestine cancer, other types of cancer and diabetes.

Pulses are one of the cheapest and richest sources of proteins (the raw material contains about 20–25% proteins, soya even up to 40%), that might be used as a substitute for the relatively more expensive animal proteins, which are not affordable for some social groups. The composition of pulse proteins is similar to that of animal proteins, however it is not equivalent because of the lack of the essential amino acid methionine. In comparison, cereals contain enough methionine but there is a lack of the essential amino acid lysine, which is abundantly present in pulses. That is the reason why, in a balanced diet, cereals and pulses are supposed to be combined, usually in the ratio of 2:1. That is how we can ensure a sufficient amount of high quality proteins. One cup of cooked pulses

(about 180 g) provides, on average, 14–16 g of proteins. Raw pulses contain about 1–2% of proteins, except soya (20%). Pulse fat is very valuable because it consists of up to 60% polyunsaturated fatty acids. The majority of animal protein resources have much more fat. The main carbohydrate in pulses is starch.

Other important components are oligosaccharides (galactosides – raffinoses, stachyoses, verbascoses), that create 25–46% of the total carbohydrates.

Pulses are also an important source of fibre (non-starch polysaccharides).



Common vetch - *Vicia sativa* L.

In the Czech Republic, according to nutritional recommendations, the suggested daily intake of fibre is 30 g, which corresponds to the 3.8 g/MJ equivalent to 16 g/1000 kcal for women and 2.9 g/MJ equivalent to 12.5 g/1000 kcal for men. One cup of cooked pulses (160-200 g) contains around 15 g of fibre.

Unlike cereals, pulses contain more mineral substances that are maintained even during the heating treatment. Pulses supply iron, phosphorus, potassium, magnesium, manganese and, to a lesser extent, zinc, copper and calcium. Further it is stated they are an important source of molybdenum, cobalt, boron and also selenium. They are very low in sodium. Pulses are a good source of B-group vitamins. They also contain a low amount of the provitamin A, vitamin C and vitamin E.

They are rich in many bioactive substances (influencing gene expression) that might have a significant metabolic or physiological effect, both positive (prevention of some chronic diseases) and negative (food toxicants). For instance soya is a rich source of phytoestrogens. Therefore, the consumption of soybean might have many beneficial effects, including the modification of the risk of cardiovascular diseases and some types of cancer. However, these effects have not been clearly proven yet. Pulses are a good source of polyphenols that belong to the most important antioxidants in the human diet: for example, lectins and tannins that are primarily antinutritive factors and can decrease the digestibility of proteins and carbohydrates. There is a large number of polyphenols in the coloured seeds because the presence of polyphenols is related to the colour of seeds (e.g. common bean). Though the tannins contained in the pulses can also have beneficial effects – they are characterised by antioxidant activity.

Among other unfavourable polyphenols, we classify vicine and convicine, contained in broad beans (*Vicia faba* L.), which cause hemolytic anaemia in individuals with a hereditary deficiency of glucose-6-phosphate-dehydrogenase. This enzyme

- G6PD - is essential for assuring a normal life span for red blood cells and for oxidizing processes.



Broad bean - *Vicia faba* L. (*faba bean*)

This enzyme deficiency causes the sudden destruction of red blood cells and leads to hemolytic anaemia. This disorder is called favism. G6PD deficiency is most prevalent in African population (up to 20%), less in Mediterranean region and in south-eastern Asia. L-DOPA (levodopa) is a precursor of dopamine and it is utilised to improve the clinical manifestation of Parkinson's disease. L-DOPA is contained in some pulses, for example in the broad bean (*Vicia faba* L.) and in the velvet bean (*Mucuna pruriens* L. DC.).

The most important nutritional advantages of pulses

- **High content of proteins.** Pulse proteins are almost fat free (1-2%).
Actually the majority of animal sources of proteins contain much more fat.
- **Low glycemic index (20-40).** Suitable for diabetic patients or as a prevention of Diabetes mellitus. By including pulses in the diet we are able to improve the glycemic response.
- **High content of fibre.** There is ongoing research into the likely influence of fibre on: the cholesterol level; glucose metabolism; support of growth of favourable large intestine microflora; decrease the time taken by chyme passing through the intestine and the role of fibre in preventing constipation.
- **Isoflavones and soya protein.** There has been research on their possible effects on lowering cholesterol level, maintaining bone density and lowering climacterium symptoms.
- **Content of antioxidants – anti-cancer effects.** Regarding this, there are other bioactive components of pulses, vitamins and minerals that are characterised, for example, by their antioxidant activity.

Table 1: Content of nutrients in some kinds of boiled pulses seeds (g/100g)

Pulse type	Water	Proteins	Energy (kJ)	Fat	Ashes	Carbohydrates	Fibre
Peas	69.49	8.34	494.00	0.39	0.68	21.10	8.30
Beans	69.00	8.33	494.00	0.45	1.14	21.09	7.00
Lentils	69.64	9.02	487.00	0.38	0.83	20.13	7.90
Soybean	62.55	16.64	725.00	8.97	1.91	9.93	6.00
Chickpeas	60.21	8.86	686.00	2.59	0.92	27.42	7.60
Broad bean (<i>Vicia faba</i>)	71.54	7.60	460.00	0.40	0.81	19.65	5.40

Source: U.S. Department of Agriculture, Agricultural Research Service, USDA Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 27 [online]. August 2014. <http://ndb.nal.usda.gov>

Table 2: Content of mineral substances and trace elements in boiled pulses seeds (mg/100g)

Pulse type	Ca	Fe	Mg	P	K	Na	Zn	Cu	Mn	Se
	µg/100g									
Peas	14.0	1.3	36.0	99.0	362.0	2.0	1.0	0.2	0.4	0.6
Broad bean (<i>Vicia faba</i>)	36.0	1.5	43.0	125.0	268.0	5.0	1.0	0.3	0.4	2.6
Common bean	63.0	1.1	56.0	102.0	370.0	6.0	0.6	0.1	0.4	1.2
Soybean	102.0	5.1	86.0	245.0	515.0	1.0	1.2	0.4	0.8	7.3

Source: U.S. Department of Agriculture, Agricultural Research Service, USDA Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 27 [online]. August 2014. <http://ndb.nal.usda.gov>

Chart 1: The trend in consumption of legumes 2003–2012 in the Czech Republic



Source: Czech Statistical Office. Food consumption 1948-2012. Table 13; Pulses and Potatoes. January 31, 2014.

High Quality Oil for Human Diet

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Humankind has always used oil for nourishment as a source of easily accessible and often irreplaceable substances. Its main components are fatty acids (FA). Regarding chemical aspects, FA might be distinguished according to its chain length and number of bindings to saturated and unsaturated FA. Generally we can say that the more double bonds in the chain, the more liquid the oil is. Saturated FAs do not contain any double bonds and they generally prevail in animal fats. Lower saturated FAs are present for example in milk and are easily digestible. On the other hand, higher saturated FAs are solid at room temperature, harder to digest, and are principally present in animal fats and only partially in vegetal oils. In food they are often together with cholesterol. They support the rise of blood cholesterol, obesity and arteriosclerosis development. In spite of this, thanks to their great stability, they are suitable for frying but during the long thermal load they produce dangerous trans-fatty acids. Saturated FAs include for example palmitic acid, stearic acids and arachic acid.



Black mustard

Unsaturated FAs can be found mainly in fats of vegetal origin and in fish oil. The most important representatives of mono-saturated acids are the oleic acid that is present in commonly available vegetal oils. It lowers the cholesterol level, favourably affects the occurrence of ischemic heart diseases and it is quite resistant to oxidation. The other representative of unsaturated FA is the unhealthy erucic acid. Its presence in the oil is highly undesirable because it invokes a number of negative effects on a human organism (e.g. lipid accumulation in the heart). Higher unsaturated FAs have a number of positive healthy effects (mentioned above). Some of them are essential which means the human body is not able to produce them by itself and can only receive them via nourishment. Such acids are for instance linoleic acid. The form alpha of this acid (ALA) is marked as Omega-3 fatty acid. Furthermore the linoleic acid (LA) so called essential fatty acid which is labelled as $\omega - 6$ fatty acid is of vital importance to all mammals and its lack causes hair loss, dryness and brittleness and poor healing of wounds. Industrially it is utilised to produce soaps, emulsifiers and quick drying oils. Excessive intake of linoleic acid might lead to development of heart illnesses.

Rape

(*Brassica napus* L. – oilseed rape)

We cannot find the wild form in nature because it emerged from crossbreeding of two different species. Rape grain of the modern variety contains up to 50% oil. The highest

proportion is oleic acid (63%), linoleic acid (18%) and linolenic acid (9%). The content of the erucic acid is almost zero.



Winter rape seed - *Brassica napus*

In Table I there is a comparison of the composition of FAs in an assortment of commonly known oils readily available to consumers, according to analyses summarised by the Research Institute of Oilseed Crops in Opava. It is clear that olive oil, which is always promoted as a very healthy option, contains the largest share of oleic acid with good nutritious value, on the other hand the representation of both linoleic and linolenic acid is the largest within all kinds of oils. From this viewpoint the olive oil does not seem to be the most valuable. In the kitchen it would be possible to use it for frying. Sunflower oil contains the greatest amount of linoleic acid therefore it is suitable for cold dishes. It is not at all appropriate for frying. The best compromise is (the often neglected and despised) rapeseed oil which has a quite high content of oleic acid. Its stability during frying

and favourably high percentage of linoleic and linolenic acids let us recommend rapeseed oil for common usage in the kitchen thanks to its universal composition. But beware! It is important to read the ingredient label on the products. Often cheap and poor quality palm oil is mixed with rapeseed oil which significantly lowers the final quality. The collection of genetic resources includes 600 genetic resources of winter varieties and 200 spring varieties of rapeseed. Historically, the oldest materials produced by Czech breeders are stored here. The collection includes high erucic and high glucosinolate types, as well as the most modern varieties of the type '00', plus genetic resources collected from all over the world and breeding materials of interest that are still being worked on.

Turnip-rape

(*Brassica rapa* ssp. *Oleifera* – fallow rapeseed, winter and spring forms)

The size of land for cultivation used to be of major significance especially in India, Canada and even Poland. It was not as well-bred as the winter rapeseed, but erucate-less genetic resources with a lowered amount of glucosinolates also exist. Grain consists of about 40% oil. The main component is the oleic acid (23%). Linoleic and linolenic acids are abundant. On the other hand, the high content of erucic acid is a rather negative parameter, because this acid is not suitable for human nutrition and is more suitable for oil production and the automotive industry.

Camelina

(*Camelina sativa* L. – gold-of-pleasure, Leindotter)

Camelina is an old oilseed crop. In the past it was widely cultivated in Europe. The oil was utilised for providing light; poor people even consumed it. In the fifties, this species made a comeback to our fields as a replacement for winter rapeseed. Camelina's seed contains

36% oil. It has a very favourable composition of fatty acids, i.e. 16% of oleic acid, 18% of linoleic acid with no erucic acid. A disadvantage is the presence of glucosinolates that give the oil an unpleasant radish taste. That is why the oil is used solely for alternative medicine and for technical purposes – polishes, oil varnishes, and soaps.



Camelina - Camelina sativa L.

In the National Programme collection, there are ranked 88 genetic resources of *Camelina*, especially its spring forms. Those are the old restricted varieties, unfinished breeding material as well as the newest varieties.

Poppy

(*Papaver somniferum*)

The poppy is a traditional Czech crop dedicated to the production of seeds. We are one of the best producers in the world. It is our “Czech treasure” that inherently belongs

to our national identity. Commonly known blue-seeded varieties are accompanied by white-seeded and ochre seeded poppies whose grains taste like nuts and can therefore be used as a good substitute. Beside seed production, poppy heads are used for alkaloids isolation (morphine, thebaine, codeine). Special high-morphine-content poppies are bred for this purpose. Poppy seed grain consists of 43% oil, the greatest proportion being linoleic acid (71%), thus the dried oil degrades easily and is – prone to rancidity.

It is propagated for its precious properties by those who support and promote a healthy diet.



Poppy seed - Papaver somniferum

Of significant benefit to the human diet is the content of calcium in the seeds. The seeds contain 1.400 mg of calcium in 100 g which is twelve times more than milk. It is the optimal alternative for individuals who are allergic to cow's milk, growing children and also menopausal women. There are recipes to make a milk substitute out of poppy seeds by soaking them in boiled water, mixing it

and filtrating through canvas. Poppy grains do not contain morphine. Currently there are 193 genetic resources of poppy seeds in the National Programme collection.

White mustard

(*Leucosinapsis alba* L.)

White mustard, together with rape seed and poppy seed, belongs to the main oil crops of our production. It is cultivated for its seeds to make mustard, produce spices or to use as a green manure. Its composition is similar to turnip-rape oil. It is also high-erucic which excludes it from use in the human diet. There is about 30% oil in the seeds. At the same time, it contains an extremely high amount of glucosinolates that (in this case) are used for the production of mustards due to its acrid taste, particularly the full fat mustards (made 100% of the white mustard) and wholegrain mustard (made of white mustard and Indian mustard). In the National Programme collection, there are seed materials and also the materials for green manure production. In total, more than 100 genetic resources are stored.

Chinese mustard

(*Brassica juncea* – mustard greens, Indian mustard, Chinese mustard, leaf mustard)

Cultivation acreage in the Czech Republic is very small. Oiliness of the seeds is 33% with equal shares of oleic acid, linoleic acid and about 12% linolenic acid. Unfortunately it also contains 31% erucic acid, therefore it is used in the same way as white mustard. However it is more acrid, so it is used in the production of special mustards – wholegrain and Dijon (made of seeds without seed coats). In alternative medicine it is used for healing the inflammation of muscles and tendons by means of a poultice made from ground seeds. There are 84 genetic resources of its yellow-seeded and brown-seeded versions in the National Programme collection.

Black mustard

(*Brassica nigra*, *Sinapis nigra*)

This is a minority cruciferous crop. Seed oiliness is about 29%. Fatty acid composition is similar to that of Indian mustard. Even though there is less erucic acid, it is not directly edible. It is used in the production of special mustards and in alternative medicine for external poultices. The National Programme collection includes 26 materials.

Rocket salad

(*Eruca sativa* – salad rocket, arugula)

Rocket salad has its origins in Afghanistan. Subsequently it developed naturally from its weed form. It contains a lot of erucic acid – up to 50%. The oil is used for technical purposes. Recently, consumption of its leaf rosette has increased as part of salads, for its specific flavour and high content of vitamin C. It contains alkaloids which stimulate digestion. It is a minority item of the National Programme collection. There are just 15 genetic resources.



Rucola - *Eruca sativa*

Crambe

(*Crambe abyssinica* – colewort, crambe)

Crambe comes from Ethiopia and is able to grow even at high altitudes. The *Crambe* family consists of about 30 species. As an oil crop we use *Crambe abyssinica*, as a legume we use *Crambe maritima*. *Crambe* is able to survive in dry areas without problems however it is not cultivated here under operational conditions so far. As an oil crop it contains about 30% oil, with a quite appropriate composition of fatty acids except for 61% of erucic acid. The oil is used for technical purposes. There are 12 materials in the collection.



Crambe - *Crambe abyssinica*

Table 1: Fatty acids composition in commonly available oils (%)

Warm meals – oleic acid					Cold dished – linoleic and linolenic acids					
	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Arachidic acid	Eicosenic acid	Ecodiene	Behenic acid	Erucic acid
Olive oil	9.9	2.7	79.7	6.3	0.6	0.4	0.3	traces	0.1	0.1
Rapeseed oil type '00'	3.3	1.6	67.8	18.9	5.7	0.7	1.1	0.1	0.4	0.1
Sunflower oil	5.7	3.3	26.5	62.6	0.5	0.4	0.3	traces	0.6	0.1
Favourable composition of fatty acids predetermining the possibility of usage										

Diversity of *Allium* Species

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The genus *Allium*, that also includes bulb vegetables – garlic (*Allium sativum* L.), (common) onion (*Allium cepa* L.), shallot (*Allium ascalonicum*), chive (*Allium schoenoprasum* L.), bunching onion¹, pearl onion (*Allium porrum* L. var. *sectum*), tree onion² and ramsons (*Allium ursinum* L.)³ - is very extensive and includes up to 780 species (Friesen et al., 2006). It consists

of about thirty edible and twenty ornamental species (Moravec, 1994). The Genus *Allium*, is geographically quite widespread but not evenly. The greatest number of species grows in the south to the north zone of the northern hemisphere. The area with the highest number of species, located in the belt around the 37th northern latitude, stretches from the



Cross-section of the garlic bulb

¹⁾ *Allium fistulosum* L. – Welsh onion, Japanese bunching onion, green onion, escallion, salad onion

²⁾ *Allium cepa* x *proliferum* – *Allium cepa* L. var. *viviparum* topsetting onion, walking onions, Egyptian onion

³⁾ *Allium ursinum* – ramsons, buckrams, wild garlic, broad-leaved garlic, wood garlic, bear leek, bear's garlic

Mediterranean to Iran and Afghanistan. The region growing an especially large diversity of *Allium* species is in Iran, northern Iraq, Afghanistan, Kazakhstan and western Pakistan. The further from this diversity centre, the lower the number of varieties (Hanelt, 1990).

The *Allium* species are typical for their great adaptability. The main varieties grow on open, sunny, rather dry sites. The representatives of the family are characteristic plants of steppes, semi-deserts, dry mountainous slopes, rocks, coastal cliffs and sunny Mediterranean wood steppes. In more humid climates, they grow in drier places such as open meadows, pastures, stony slopes - especially limestone. Another member of the *Allium* genus – ramsons, is the characteristic species of the ground flora of

European moist broad – leaved forests.

Allium species also have various life cycles. There are types with a spring, summer or autumn flowering period. We can also distinguish the species into those having an annual life cycle, several year life cycle or perennials. Ephemeral types grow in arid areas of Asia (Hanelt, 1990).

The most widely known, and economically important, cultivated species are the onion (*Allium cepa* L. - bulb onion, common onion) and the garlic (*Allium sativum* L.) – humans have used them throughout history. Historical sources claim the cultivation and consumption of *Allium* species has a very long tradition. The first evidence of garlic is found in references 6 000 years old, Sumerians, Egyptians, Chinese, Indians and Jews were using it. (Lužný, 1982).



Shallot

Slavs have always liked garlic. They probably started using it together with the Byzantine culture. However it is likely they had utilised garlic even before that – particularly the local forms of botanical species occurring in the Carpathians. This hypothesis is confirmed by the Baalberge culture pot, discovered in the Czech town of Kyjov where the remains of a garlic plant from about 2000 BC were found. Utilisation of garlic in our territory is also described in Mattioli's Herbarium from 1596 (Lužný, 1982).

The use of *Allium* species

Allium species have been cultivated as a vegetable since ancient times, for their bulbs (common onion, tree onion, shallot, pearl onion), for their cloves (garlic), for their leaves (chive, shallot, bunching onion, garlic), for their pseudostem (leek, bunching onion) and for their flower scapes and bulbils (garlic).

Garlic found its place in folk medicine several hundred years ago. Thanks to its antibiotic, antiviral and antifungal properties, it was and still is used to heal diseases such as the common cold, viraemia, bronchitis or fungal skin diseases (Podešva, 1959). Louis Pasteur was the first to describe the antibacterial effects of garlic and onion juices. *Allium* species, especially garlic, kill many gram negative and positive bacteria. In the *in vitro* conditions, it was proved that *Helicobacter pylori* is sensitive to garlic extract in a quite

low concentration. Even some antibiotic-resistant germs of *Helicobacter pylori* are garlic sensitive (Sivan, 2001). Garlic continues to be the object of research.

It transpires garlic supports fat reduction and affects blood clotting, too (it acts against blood platelets). Its impact on the cardiovascular system is currently being researched (Keusgen, 2002).

Genetic resources of *Allium* species

The germplasm of *Allium* species is maintained by the Crop Research Institute (CRI), Section of Applied Research of Vegetables and Special Crops in Olomouc. Olomouc has a long tradition with these activities. The foundations of the collections were laid back in 1951 when the Research institute of vegetables, growing and breeding, was established. The genetic resources collection consists of 816 genotypes of 6 varieties (Table 1). The oldest preserved materials in the collection predate 1954. International and national rules are observed during cultivation and while working with collections, also the general agro-technology rules, according to particular species, are carefully followed. The greatest and most demanding is the collection of garlic, which consists of 634 genotypes from 29 countries from all over the world. An important part of the collection is created by the landraces from southern Moravia and the White Carpathians, the old and contemporary Czech varieties.

Table 1: Structure of the genetic resources collection of bulbous vegetables

Variety	Number of genotypes
Garlic (<i>Allium sativum</i> L.)	634
Shallot (<i>Allium ascalonicum</i> L.)	130
Common onion (<i>Allium cepa</i> L.)	28
Chive (<i>Allium schoneoprasum</i> L.)	4
Leek (<i>Allium porrum</i> L.)	5
Spring onion (<i>Allium fistulosum</i> L.)	15

Lesser Known and Neglected Vegetables and Their Importance in a Healthy Diet

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Consumption of vegetables is an integral part of a healthy diet. Even though there are plenty of new exotic species available on the market, there is also rising consumers' demand for vegetables that used to be grown in our country traditionally and nowadays are less known or almost forgotten. The collection of vegetable genetic resources maintained within the National Programme currently consists of over ten thousand accessions including a range of lesser known species (Table 2) with specific taste and nutritional qualities that might considerably enrich the diet of a Czech consumer. Of these, leafy vegetables are the most numerous represented, namely by species: endive (*Cichorium endivia*), garland chrysanthemum (*Chrysanthemum coronarium*), New Zealand spinach (*Tetragonia tetragonioides*), asparagus (*Asparagus officinalis*), Swiss chard (*Beta vulgaris* subsp. *vulgaris* convar. *cicla* var. *cicla*), rhubarb (*Rheum rhabarbarum*), rocket (*Eruca sativa*), garden cress (*Lepidium sativum*), and curly kale (*Brassica oleracea* var. *sabellica*). Among other less known leafy vegetables, not included in the Czech collection of genetic resources, are watercress (*Nasturtium officinale*), corn salad¹ (*Valerianella locusta*), and Florence fennel (*Foeniculum vulgare* var. *azoricum*). Root

vegetables are represented by black salsify (*Scorzonera hispanica*), Jerusalem artichoke (*Helianthus tuberosus*), Swedish turnip (*Brassica napus* subsp. *rapifera*) and white turnip (*Brassica rapa* subsp. *rapa*), the latter two are known also as brassicas. Regarding fruiting vegetables, we maintain genetic resources of cape gooseberry² (*Physalis peruviana*), and perennial vegetables are represented in the collection by globe artichoke (*Cynara scolymus*).

Endive is used raw for salad preparation. It is a great source of vitamins A, C, B1 and B2, folic acid, manganese, chrome, potassium, sodium, phosphorus and fibre.

It contains the bitter glycoside intybin that is not lost during food preparation and stimulates the secretion of bile and appetite. Garland chrysanthemum is rich in vitamins A, C and minerals. Its leaves are used for salad preparation. New Zealand spinach contains a high level of vitamin C, beta-carotene and oxalic acid. Edible leaves and shoot tips are consumed in salads or can be prepared as spinach. Asparagus is rich in vitamins A, C, E, B-group vitamins, calcium, iron, magnesium, zinc, potassium, sulphur and phosphorus. It has diuretic, detoxifying and anticancer effects.

¹) Also known as common cornsalad, lamb's lettuce, field salad, nut lettuce, etc.

²) Also known as Inca berry, Aztec berry, golden berry, giant ground cherry, etc.



Rocket (Eruca sativa)

Young shoots are used as a vegetable. Swiss chard is similar to spinach in appearance and taste. There are two types of Swiss chard: the stalk (asparagus) type from which the peeled, boiled leafstalks (petioles), prepared as asparagus, are consumed, and the leafy type whose raw or steamed leaves can be prepared as spinach. Swiss chard contains high amounts of vitamin C and minerals (calcium, potassium, magnesium and iron). It is suitable for slimming diets, prevention of tumour diseases and it affects vascular and nervous systems positively. From rhubarb, cooked petioles containing beta-carotene, vitamin C

and minerals are consumed. Garden cress is a good source of vitamin C, K, B-group vitamins, beta-carotene, iron and magnesium. It has a pleasing piquant taste and it is used fresh for flavouring dishes. Curly kale contains a huge amount of beta-carotene, vitamin C, E, B-group vitamins and minerals such as potassium, calcium, phosphorus, magnesium and iron. Leaves, or the whole top rosettes of curly leaves, are prepared like spinach or kale. Black salsify has a high content of inulin, which makes it suitable especially for diabetics and potassium that strengthens heart activity. It is also useful for patients suffering from

rheumatism. The roots are consumed raw as an ingredient in salads, or cooked. Jerusalem artichoke tubers can either be used in a similar manner to potatoes, or can be added to salads. They contain, especially, a high amount of inulin, vitamin C and potassium, they reduce cholesterol levels in blood and are good for diabetics, asthmatics and rheumatics. Swedish turnip is consumed boiled, in soups, sauces and side dishes. Young roots are tasty even in a raw form. White turnip is eaten either raw or cooked. Before the discovery of America, it had the same role as potatoes. Regarding cape gooseberry, raw or canned fruits with a taste similar to strawberries and a smell like pineapple are consumed. Fruits contain vitamin C, beta-carotene, pectin, rutin, potassium, calcium and phosphorus. They are diuretic and support metabolism.

The globe artichoke contains B-group vitamins and beta-carotene. Its flower heads support bile secretion and reduce blood cholesterol. We consume, as a vegetable, the fleshy receptacles of immature flower heads and bracts, both either raw or cooked. Rocket (garden rocket, salad rocket, arugula) belongs to the neglected leafy vegetables. Traditionally, it has been cultivated in the countries of its origin in southern Europe and western Asia, and it is only imported into our country. The popularity of rocket has been growing recently, especially in Central Europe. It has been introduced to the market as a so-called “4th generation” vegetable which is marketed after cleaning, leaf cutting and packaging into plastic bags for its longer shelf-life. Until the 1990s, rocket was cultivated only in small areas and mostly was collected in the wild. Nowadays, its cultivation area has been growing. In Asia (especially in India and Afghanistan) it is grown as an oil seed crop. The seeds contain up to 29% oil with high amounts of erucic acid and therefore the oil is not suitable for consumption. Rocket contains many healthy substances such as glucosinolates, carotenoids, flavonoids,

vitamin C, minerals and fibre. It is widely used for its anti-inflammatory, astringent, tonic, stimulating, stomachic, diuretic, laxative and anti-scorbutic effects. Recent studies showed antisecretory, cytoprotective and antiulcer activities and it is believed also to have aphrodisiac properties. Rocket leaves that are harvested at a young stage have a slightly bitter and pungent taste. It is consumed raw as a green, as part of a salad mix, as a cooked green, and now is very popular as a garnish. It is added to meats, spaghetti or pizza, in soups and sauces, just before the end of their preparation. Rocket is appreciated not only for its flavour properties but especially for its high content of vitamin C (Table 1). Current research has been focused on evaluation of the vitamin C content in different rocket genotypes. The obtained values for the amount of vitamin C, compared to the literature data, revealed that the plants grown in our climatic conditions reach standard results in this parameter, which, however, differ depending on the genotype, cultivation technique and the term of harvest.

Table 1: Comparison of vitamin C content in different species of fruits and vegetables

Vegetable (resp. fruit) species	The content of vitamin C (mg/100 g of fresh mass)
Lemon	50*
Blackcurrant	200-210*
Broccoli	113*
Brussels sprout	87-109*
Tomato	20-25*
Rocket	47-153
Lettuce	15*
Rosehip	1000*
Spinach	51*
Cabbage	46-47*

* Davey et al., *J Sci Food Agric* 80:825-860

Table 2: Lesser known and/or neglected species represented in the collection of genetic resources of vegetables

Family	Common name	Latin name	Number of accessions
Asteraceae	Globe artichoke	<i>Cynara scolymus</i> L.	3
	Black salsify	<i>Scorzonera hispanica</i> L.	4
	Endive	<i>Cichorium endivia</i> L.	26
	Jerusalem artichoke	<i>Helianthus tuberosus</i> L.	5
	Garland chrysanthemum	<i>Chrysanthemum coronarium</i> L.	1
Aizoaceae	New Zealand spinach	<i>Tetragonia tetragonioides</i> (Pall.) Kuntze	15
Asparagaceae	Garden asparagus*	<i>Asparagus officinalis</i> L.	4
Chenopodiaceae	Chard	<i>Beta vulgaris</i> subsp. <i>vulgaris</i> convar. <i>cicla</i> var. <i>cicla</i>	28
Polygonaceae	Rhubarb*	<i>Rheum rhubarbarum</i> L.	24
Brassicaceae	Rocket**	<i>Eruca sativa</i> Mill.	15
	Cress	<i>Lepidium sativum</i> L.	1
	Curly kale	<i>Brassica oleracea</i> L. em. DC. var. <i>sabellica</i> L.	15
	Swede, turnip	<i>Brassica napus</i> L. subsp. <i>rapifera</i> Metzg. ap. Sinskaja	14
	White turnip	<i>Brassica rapa</i> L. em. Metzg. subsp. <i>rapa</i>	8
Solanaceae	Cape gooseberry	<i>Physalis peruviana</i> L.	17

* Accessions are maintained as vegetable genetic resources in the Faculty of Horticulture of Mendel University in Lednice

** Accessions are maintained as oilseed crops genetic resources at the OSEVA PRO, Ltd., Research Institute of Oilseed Crops in Opava

Common Buckwheat, Common Millet and Amaranth – Original and New Alternatives for a Gluten-free Diet

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Nowadays, the pace of life is becoming faster and faster and that is why some of the negative health effects are increasing as well. A higher frequency of so-called civilisation diseases such as obesity, diabetes II, hypertension, high cholesterol levels or some food intolerances are evidence of this. The number of people preferring to consume healthy food, naturally rich in healthy substances, is also increasing. Some of the crops fulfilling these parameters are originally cultivated common buckwheat and common millet or the species from the New World – amaranth.

Common Millet

(*Panicum miliaceum* L. – common millet, white millet, hog millet, proso millet, broomtail millet)

Common millet is one of the oldest cultivated crops; it was domesticated even earlier than wheat. The first preserved remains of its cultivation come from the late Neolithic Age from China. The mythological Chinese emperor, Shennong (sometimes also called “Divine farmer” or “God of five crops”) considered common millet as one of the five basic crops, the other four being; rice, soya, foxtail millet and common wheat. Common millet was spread via the trade routes to India

and then further west. In the territory of the contemporary Czech Republic, there were found archaeological remains of common millet dating back to the late and earlier Bronze Age, specifically from the so-called Urnfield culture. For centuries, common millet cultivation spread throughout Europe. Charles the Great (around the year 800) even appointed common millet as a Lenten dish. Millet needs pure weedless soils therefore it became an expensive cereal during the Middle Ages, it was even much more expensive than common wheat. Matthioli wrote about it; “Common millet belongs to grains used for cooking and eating and it is commonly known. It does not require high initial costs because a small amount of seed is enough to sow a large parcel of a field. Common millet has both culinary and medicinal uses. Common millet grains are utilised to prepare different porridge style dishes.” Gradually, its utilisation decreased because the porridge-like food was replaced with white flour bread as the white flour had become more and more affordable.

For Human nutrition, the peeled caryopsis – millet grains, are used. They are very nutritious, tasty and easily digested. In comparison with other cereals, they contain more vitamins, especially A, B1 and B2, and minerals – notably

iron. Common millet grains are a good source of minerals – mainly phosphorus, potassium, calcium and sodium. It is also characterised by a high amount of carotenoids.



Common millet - Panicum miliaceum L.

Regarding the basic components, the most frequent are carbohydrates (70–73% carbohydrates, thereof 9–11% fibres and 62–66% starch), 10–11% proteins, 3.7–4.6% fat. Fats composition is very high quality because there is a higher amount of unsaturated fatty acids. Unfortunately this is one of the aspects that cause a relatively short storage life of millet grains and millet flour as well. It has a tendency to turn rancid. The second greatest group is proteins. Regarding the structure, the most important is the amino acid content, leucine, isoleucine, valine and also phenylalanine. Lysine is a scarce amino acid, as in other cereals, but millet has a higher content when compared with others (for instance common millet has 3.63% lysine whereas wheat has just 2.6–2.8%). Common millet can also be utilised as an alternative to malt. It is important especially for patients with gluten intolerance because there is no gluten in the grains.

Common Buckwheat

(Fagopyrum esculentum Moench.)

Common buckwheat, like common millet, comes from China where it has been

grown for three thousand years. The oldest archaeological common buckwheat findings, within the Czech territory, come from the cadastre of Prague Castle. They are dated to the turn of the 9th and 10th centuries. The oldest references prove it was cultivated in the Opava region from the end of the 12th century. The greatest boom of its cultivation was during the 16th and 17th centuries particularly in Těšín region and in Wallachia. The cultivation and utilisation of common buckwheat were already mentioned in Matthioli's herbarium from 1596 which says; 'Here in Bohemia there is an abundance of buckwheat. It is a homemade common dish. The word is it is also used to bake bread.' During the following centuries, its popularity declined as was the case for common millet and it remained important only in the mountainous and foothill areas.



Buckwheat – Fagopyrum esculentum Moench.

Common buckwheat is an important crop, usable in many different ways. The best-known use is as a foodstuff. It belongs to a group of so-called pseudocereals – the crops that do not belong to the family of

grasses and therefore they are not true cereals but are processed in the same or in a similar way. With buckwheat, we use the peeled achenes. They are rich in vitamins C, E and group B, minerals, especially magnesium, potassium and phosphorus but also zinc and selenium. The common buckwheat plant also contains a significant amount of rutin which can contribute to the prevention of cardiovascular diseases and atherosclerosis. It positively affects blood-vessel dilatation which helps during the treatment of varicose veins. The achenes contain no gluten either, so they are suitable for a gluten-free diet. They are used both as a side dish or the main dish. The flour is added to bread and pasta. Young leaves and shoots might be consumed as a vegetable. Sprouted Common buckwheat is also appropriate for direct consumption - it is utilised like soya sprouts. Matthioli mentioned in his herbarium that: 'Buckwheat grains are better and more practical than common millet grains.' Buckwheat is also a significant honey plant, supplying dark brown honey, rich in rutin.

Amaranth

(*Amaranthus* sp.)

Genus *Amaranthus* is part of the family *Amaranthaceae*, which has about 60–87 species (the number varies according to different sources of information). This family includes several species that are grown for grains but which can also be utilised as spinach or as a leafy vegetable. Its origins are not yet clear. According to information registered in the so-called Berlin Codex, amaranth was part of religious rituals of the god Huitzilopochtli (god of war, sun, human victims and patron of the city of Tenochtitlan – today Mexico City). During the rituals, the amaranth seeds were used in combination with human blood as a sacrifice. After the conquest of the New World by Spaniards, any growing and utilisation of amaranth was prohibited.



Amaranth – Amaranthus sp.

Its cultivation continued only in remote mountainous areas. At the end of the 18th century, it came to Europe and Asia, through botanical gardens, as an ornamental plant. Species grown for grain are red amaranth (*A. cruentus* L.), prince's feather (*A. hypochondriacus* L.) and pendant amaranth (*A. caudatus* L.).

Some grain types might be cultivated as leafy or spinach vegetables, for example, Chinese amaranth (*A. tricolor* L.). Seeds have a high protein content (16–18%) with a very favourable composition of amino acids, notably lysine and methionine. There is 6–8% oil in the seeds. Amaranth oil typically contains no cholesterol but it includes squalene, a precursor of certain steroid hormones. Squalene helps skin to regenerate and slows down its aging. It is connected with lowering the risk of cancer and boosting immunity as well. Amaranth grain also contains starch – its grains are much smaller than those of potato starch. Furthermore, it is suitable as a pharmaceutical filler, or for paper surface treatment. Seeds also contain a higher amount of iron, phosphorus, magnesium, potassium, zinc and vitamins A and C.

The Most Precious Fruit for Health; Significance of Minority Species

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As we all know very well, fruit is a significant component of the human diet that works to prevent many civilisation diseases.

Fruit is rich in soluble fibre, it contains a great amount of biologically active substances i.e. vitamin C and E, carotenoids, flavonoids and many others. Besides common fruit trees widely cultivated in our fields, there are many non-traditional species of fruit that are still of only marginal significance, but in the future they might become a suitable alternative (not only) to enrich our diet. These less commonly grown fruits were established during several decades on experimental and demonstration fields belonging to the Faculty of Horticulture, MENDELU. Currently several species, that are going to be introduced in this article, can be found there.

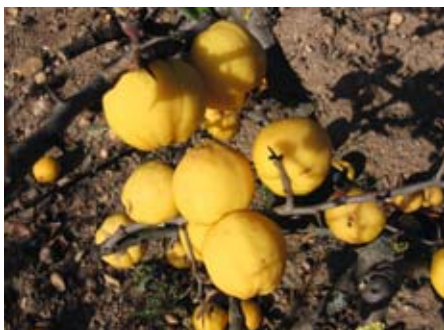
Quince

(*Cydonia oblonga* Mill. – quince tree)



Quince – *Cydonia oblonga*

It comes from the region of Iran, Transcaucasia, and southern Arabia, it is grown in Turkey, Russia and notably in the Balkan states. Actually it is one of the oldest cultivated plants. Romans called the fruit “Venusian apple”. The abbess from the cloister of Hildegard from Bingen (1098–1179) used the quince fruit in many pharmacopoeias within their medical practice (Zentrich, 1992).



Quince - fruit - *Cydonia oblonga*

Quince fruit has very aromatic, bright yellow, pome fruits which are multiple bulbous and tomentose. Quinces are not normally suitable for direct consumption in a raw form. Its pulp has a rather dry consistency, poor juiciness, and often a bitter, dry and astringent taste. However, it is a valuable canning ingredient, suitable for the preparation of compotes, jams, marmalades, jellies, ciders and wines. The fruit is good for drying and might be utilised for the preparation of popular “quince cheese”, too. Quinces used to be processed into tasty,

durable pastry with a typical unique smell and flavour. The fruits contain sugars, organic acids, vitamin C, pectin, essential oils, tannins and so forth.

The seeds contain a viscous matter, greasy oil, glycoside amygdalin, albumin and tannins. The abundant representation of substances offers a variety of opportunities of usage also in alternative medicine or cosmetics (facial lotions, ambient deodorants etc.).

Cornelian Cherry

(*Cornus mas* L.)

It is a fruit tree full of potential, supplying very valuable fruit, with a high biological value. Cherries are usable for direct consumption and for many different kinds of processing as well. The plant's homeland is southern Europe, Asia Minor in particular. Archaeological findings from the Great Moravian fort near Mikulčice proved its prehistoric existence in our country. In the early Middle Ages, the fruits were directly consumed and used in alternative medicine (Tetera et al., 2006). Regarding nutritional value, the cherries are a low calorie fruit with a high supply of calcium, magnesium, phosphor and especially potassium. It is possible either to consume the fruits in their raw form or process them into compotes, jams, marmalades, cherry syrup, or ferment them into wine and also liqueur. It might be dried or



Cornelian cherry - *Cornus mas* L.

pickled as a substitute for olives. Its juice combined with water and ice is used to make the traditional Iranian refreshing beverage called "Sherbet". In Transcaucasia it is dried and crushed into powder that serves as a spice to season roasted meats, sauces, soups and salads. It is used to highlight the taste of drab apple or pear compotes. (Lánská, Žilák, 2006).

Medlar

(*Mespilus germanica* – common medlar)

Medlar has recently seen a gradual comeback among lesser known fruit species. Its original region is in the zone of south-western Armenia and northern Iran. In previous centuries, medlar appeared in cloister and commercial gardens, in chateaus and other ornamental parks, but also in vineyards.



Medlar - *Mespilus germanica*

The fruits are low-calorie, with an exceptionally high content of fibre and the lowest content of carbohydrates. The content of mineral elements is high; especially the amounts of calcium, magnesium, phosphor and potassium. The fruit consists of 75% water, 10% sugar, 7.5% fibre, 1.4% acids (prevailing malic acid). It is used in a variety of pickled products; compotes, jellies and even in a delicious schnapps. Raw fruits are tough and unsavoury. For direct consumption,

it is suitable to eat overripe fruits after being frosted, when the pulp becomes slightly rotten and can substitute the pyriform damson with its bitterly wrapped, piquant pulp.

Black Mulberry

(*Morus nigra* L. var. *Trnaviensis* DOMIN)

Is one of the most ancient utility trees that has been grown since time immemorial. Mulberry cultivation, related to silk, spread through Europe in the 16th century. We can distinguish several types of mulberries, according to the colouring of its multiple fruits; white mulberry (*Morus alba* L.), red mulberry (*Morus rubra* L.) and black mulberry (*Morus nigra* L.). White mulberry comes from the east-Asian genetic centre and its cultivation has been connected with sericulture and thus with silkworm breeding. Red mulberry originates in North America and is more scarce. Black mulberry comes from the Middle-Asian genetic centre. Mulberries contain around 18% sugars, vitamin B, C, E, organic acids, pigments, essential and mineral substances. The fruit has anti-inflammatory and disinfecting effects. The content of healing resveratrol in the dark fruits is often emphasized. Sorosis is suitable for both direct consumption and various types of canning process, including drying. The dried fruits are remarkably sweet, although with a certain level of sourness and a pleasant fig flavour.

Japanese quince

(*Chaenomeles japonica* (THUNB.) LINDL)

This species is very undemanding for habitat. A noble Latvian variety, called "cido", was bred from a shrubby type of quince from Japan. It contains more vitamins than lemon ("northern lemons"). A high content of aromatic substances and organic acids is also valuable. The scented fruits have a high proportion of pectin. The pleasant aroma of the fruit recalls pineapple, which is why the

products have a strong flavour. Fruits are unsuitable for direct consumption but they might be conveniently used for preserving.

Apple Rose

(*Rosa pomifera* HERRM.)

Apple rose is the most undemanding fruit species which becomes fertile while still young. The fruits contain a significant amount of biologically active substances, namely vitamin C (up to 1200 mg in 100 g of pulp). Furthermore, sugars, acids,



Apple Rose - *Rosa pomifera* HERRM

pectins, tannins, carotenes and many more are also represented. The fruits provide important raw material for processing, they contain 47.5% seeds, 22% pulp, and 30% water. They are utilised for drying and to produce rosehip puree, marmalade, spread, jam, jelly, syrup, juice and wine.

Chokeberry

(*Aronia melanocarpa* (MICHX.) ELLIOT)

Its homeland is North America where it appears in the wild. Chokeberry acclimatised in eastern USA, over Canada, down to Florida. Berries are considered valuable for health. There is a high amount of various flavonoids. Fruits contain a number of vitamins; vitamin C, PP, B2, B9, provitamin A and also rutin, that is used as a cure against stomach ulcers, arteriosclerosis, hypertension, and other

illnesses. Sugar content is around 10%, acid up to 1%, and pectin 0.75%. The quantity of tannins decreases gradually on ripening, up to 35%. The contained amount of mineral elements is also significant.



Chokeberry - *Aronia melanocarpa*

Fruit can be processed into juices, compotes, jellies, marmalades, jams, candied fruit, liqueurs and wines. It can also be consumed in its raw form. Its ruby red pulp is sweet, but due to the tannins, it has a slightly bitter taste. Chokeberry belongs among significant medicinal plants. There are plenty of possibilities for canning processes.

European Cranberry Bush

(*Viburnum opulus* var. *Edulis* L. – water elder, cramp bark, snowball tree, guilder rose)

This plant originates in Europe and west Asia. It belongs among highly freeze-resistant species. Berries contain minerals, with an extraordinarily high amount of iron (supposedly the highest quantity of iron in soft fruits), magnesium, zinc, phosphorus and potassium. Not only are the fruits rich in vitamins, but also the flowers and bark. European cranberry has a high Vitamin C content and high levels of sugar, pectin and tannins, too. It is used in alternative medicine with effective results. The ripe berries are too bitter to be eaten directly. Bitterness might be

eliminated by boiling. Consequently the fruit is usually processed into syrups, jellies and marmalades, preferably in combination with apples.

Serviceberry

(*Amelanchier* Med.)

Serviceberry is a very common species in North America, Canada, UK, Netherlands and even Siberia. Fruits have a typically high medicinal and dietetic value. It is a very popular plant, often confused with blueberries. Therapeutic dietetic values; sugars 14–19%, acids 0.4–0.5%, pectins 0.8–1%, vitamin C 37–61 mg, vitamin B2 60–150 mg, flavonoids 1%, regarding minerals there are; copper, iron, magnesium. Fresh berries are good for direct consumption and also suitable for compotes, juices, jellies, and for drying, too. Fruits can be easily stored and maintained fresh.



Serviceberry - *Amelanchier lamarckii*

It can be used in medicine, particularly when healing eye diseases, stomach, and digestive problems. The plant also works against inflammation.

The Importance of Common Sea-buckthorn for Humans

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The importance of lesser known species of fruit trees is based on their biological value for either direct consumption or for further processing in the food industry or pharmacy. The berries have always been used in popular medicine or alternative healing professions to cure various diseases or prevent infections. The content of the biologically active substances with therapeutic effects is obvious, therefore more research in this field is



Common sea-buckthorn fruit (*Hippophae rhamnoides* L.), variety *Aromat*

required. Common sea-buckthorn (*Hippophae rhamnoides* L.) grows in various climatic conditions. It appears naturally in Europe, west Asia and southern Siberia. It is a species which typically occurs near rivers. Besides its marketing importance, sea-buckthorn is also a significant ornamental tree. Its roots are able to solidify soil threatened by erosion. The fruit is a tiny drupe, of round shape, and of orange up to reddish colour. The continuously growing requirements for a healthy diet, lead to the search for finding new resources of nutritionally valuable ingredients. There is a great demand for dietary supplements and bio preparations with healing or preventive effects against civilisation diseases.

Food companies, notably in western Europe, try to introduce new and fresh products to the market - something tasty and nutritious while technologically feasible. Many kinds of lesser known fruits fulfil these requirements, especially the common sea-buckthorn. It possesses unique new flavours and great potential for healthy materials. Sea-buckthorn berries are suitable only for processing. In the food industry, it is used to make jams, compotes, dried and candied fruits, juices and energy drinks. Its most promising use is as part of dairy and bakery products. New fruit will bring new stronger tastes, while increasing the substances that are healthy –



“Buchlovický” variety

which means significant enrichment of market supply. In recent years, the public have become more and more centred on healthy eating and focused on food supplements delivering vitamins, trace elements and polyphenolic substances with healing and preventive effects. Modern development of the new nutraceuticals is an effective and safe way to improve the general health of the population and the quality of life in general.

A typical example is the utilisation of biologically active substances from common sea-buckthorn berries. The isolation of substrates, consisting of the active substances from the common sea-buckthorn (especially biologically active substances contained in the sea-buckthorn oil) is the starting point for supplements selected for public health improvement. The fundamental importance of this plant seems to be the preparation of

substrates blocking intestinal and pancreatic lipase to restrain obesity. It is suitable for diabetics and for individuals with a high risk of cardiovascular diseases. Parapharmaceutical products, based on bioactive substances from the buckthorn seeds and pulp, have a high value either regarding reduction of the incidence of metabolic syndrome, or they also have good prerequisites to provoke antivirus effects. Considering the deteriorating health conditions of Europeans, it is necessary to correct some serious imbalances regarding healthy nutrition and life style. Experience of the industrially developed world has recently indicated fewer requirements for pharmaceutical products and a higher demand for a general improvement in the health of the population by using biologically active substances conceived into the form of pharmaceuticals, dietary supplements and dietetics. The great increase in cardiovascular

illnesses, obesity, diabetes and the complex metabolic syndrome, shows that in this field alone, some of the natural biologically active substances might prevent the threatening effects of civilisation – rationally and provably. Common sea-buckthorn is (regarding biomedicine) a very important source of bioactive substances that have not yet been fully researched, but can be very effectively used in the preparation of nutritional supplements and functional food and beverages.

Medically usable substances include not only the vitamins, minerals and bioflavonoids with antioxidant effects, but primarily the extraordinary lipid substances which have positive effects on the emergence and course of metabolic syndrome, obesity and diabetes.

It includes the following components with their favourable effects;

a) Ursolic acid, triterpene, oleanolic acid, sengenine. These substances block intestinal and pancreatic lipase by decreasing absorption of alimentation fats. The effect of lipase blockage is halting the development of metabolic syndrome, obesity and preventing fatty liver disease. These changes in metabolic syndrome development are also the basis for reducing risk of type 2 diabetes.

b) Sea-buckthorn oil contains a significant amount of alpha-linolenic acid, which is a precursor of biologically effective metabolites of polyene fatty acids omega-3 that positively affect the risk of cardiovascular diseases.

c) The combination of effects of polyunsaturated fatty acids omega-3 and polyphenols decreases thrombocyte aggregation and therefore suppresses excessive blood clotting and the emergence of thrombosis. Regarding this, the substances contained in the sea-buckthorn have similar healing effects to those of Aspirin. Using the substances isolated from the buckthorn is suitable even for people who are intolerant to antiplatelet treatment by salicylates.

Sea buck-thorn contains a significant amount of biologically active substances such as ascorbic acid, phenolic substances, tocopherols, tocotrienols, and carotenoids. Consumption of these fruits provably increases the proportion of HDL cholesterol, while decreasing the propensity of LDL cholesterol to oxidize. The flavonoid extract has antithrombotic effects proven *in vivo*. In the *in vitro* conditions, there also appeared cytoprotective effects that are probably present thanks to its antioxidant activity. All these findings confirm the common sea-buckthorn is a promising and functional foodstuff.

The Value of Medicinal, Aromatic and Culinary Plants (MAPs) for Nutrition

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Medicinal, aromatic and culinary plants (MAPs) represent an extraordinarily large and taxonomically diverse group of plant species. It is stated that 50-80 thousand species of flowering plants are used worldwide as a source of natural healing substances. Since ancient times, people have been interested in medicinal plants, and their healing effects were recognized first through a trial and error method by shamans and spiritual leaders. Plants were used for pain relief, prevention and curing of various illnesses,

and improvement of quality of life. However nowadays, even in highly developed countries, traditional treatment by plants also plays an important role in a therapeutic process as an alternative to classical medicine. In recent years, the demand for plant-based natural products has been rising, especially thanks to a growing popularity and promotion via media of a healthy lifestyle. The most traditional way of using MAPs in a healthy diet is consumption of various medicinal teas and mixtures and spices and herbal additives improving



Field collection of MAPs genetic resources

taste, smell, nutritious value and also the digestibility of meals. A number of species is also used for the production of dietary supplements with herbal extracts that have become quite popular. Specific secondary metabolites, produced by MAPs, represent globally an important source of structurally diverse biologically active substances (alkaloids, flavonoids, phytoncides, glycosides, bitters, coumarins, resins, saponins, essential oils, tannins etc.), used in the food industry, pharmacy, medicine, and other domains. In a number of secondary metabolites produced by MAPs, important curative effects have been discovered, which can be studied in plant species maintained in the gene banks. At the Department of Genetic Resources of Vegetables, Medicinal and Special Plants, at the Crop Research Institute in Olomouc, a large collection of MAPs of the Central European region is maintained. It is one of the most important European collections thanks to a wide extent of species particularly the genera represented (i.e. 956 accessions of 70 genera registered in the National information system EVIGEZ and another 1,246 accessions within the working collection). The most numerous are species of the families Apiaceae, Lamiaceae and Asteraceae (see the pie chart). The great amount and variability of the maintained accessions represent an important source of diversity regarding the content substances and therefore it has a wide potential for practical use. The most promising genetic resources of MAPs with important healing effects can be mentioned e.g.: oregano (*Origanum*), especially for anti-inflammatory, antispasmodic, choleric, diaphoretic, expectorant, and sedative activities; plantain (*Plantago*), which has anticancer, anti-inflammatory, astringent, diuretic, expectorant, and hepatoprotective activities; marigold (*Calendula*), which has analgesic, antibacterial, anti-inflammatory, antiviral, carminative, diaphoretic, and emmenagogue effects; sage (*Salvia*), which has especially antibacterial, anti-inflammatory,

antioxidant, antiperspirant, antisialagogue, antiviral, astringent, choleric, diaphoretic, estrogenic, hypotensive, and vermifuge effects; St. John's wort (*Hypericum*) with esp. analgesic, antibacterial, antidepressive, anti-inflammatory, antiviral, astringent, sedative, tonic, tranquillizer, and vermifuge activities; and other genera with a high number of accessions maintained (see the pie chart).

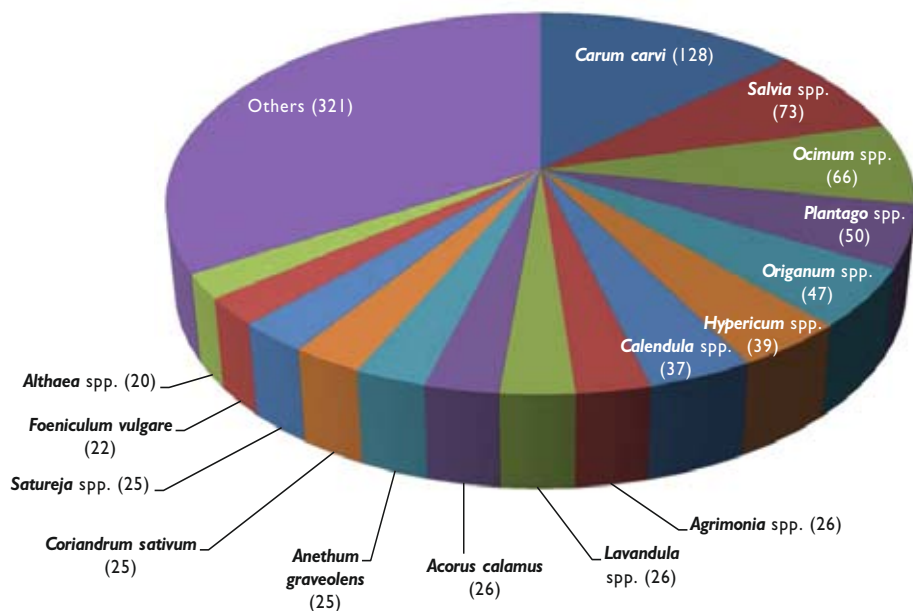


Golden root (*Rhodiola rosea*)

Regarding minority and lesser known species, of importance are, for example, golden root (*Rhodiola*) and maral root (*Leuzea*) that belong to the so called natural adaptogens, i.e. plants that increase adaptation of an organism to stress. Species non-native to the Czech Republic that are of interest are: leopard flower/blackberry lily (*Belamcanda chinensis*) whose leaves, when chewed, release phlegm and therefore can be used for the treatment of angina, bronchi or throat inflammation and lung diseases; anise hyssop (*Agastache foeniculum*) that supports perspiration, reduces fever, and has positive effects on digestion; Moldavian dragonhead (*Dracocephalum moldavica*) that is used to alleviate psychical problems to suppress

uneasiness and stress, but also for headache and toothache, to improve digestion, and for its antispasmodic effects. Among the species used not only as medicinal plants but also as spices and herbs for seasoning meals, the most numerous represented genetic resources in the collection include basil (*Ocimum*), cumin (*Carum*), coriander (*Coriandrum*), fennel (*Foeniculum*), oregano (*Origanum*), less numerous also marjoram (*Majorana*) and thyme (*Thymus*). Plants appropriate for food production supplements are represented by e.g. coneflower (*Echinacea*; boosting immunity), stevia (*Stevia*; natural sweetener for diabetics), milk thistle (*Silybum*; against liver diseases), St. John's wort (*Hypericum*; treating depression, calming down the nervous system), fenugreek (*Trigonella*; hypoglycaemic effects), hemp (*Cannabis*; applicable during chemotherapy, significantly buffering the side effects of drugs used for the treatment of HIV/AIDS), etc.

Current research of MAPs is focused on qualitative and quantitative analyses of content substances. The object of this study is the analysis of essential oil and its main components for example in lavender, cumin, fennel, mint, thyme, oregano, or milk thistle. Hemp (*Cannabis sativa* L.) contains a range of substances with unique pharmacologic effects, such as cannabinoids, fatty acids and essential oil. Currently, the most promising seems to be especially research of cannabinoids (e.g. for treatment of neurodegenerative diseases or cancer growth or for influencing the immunity response of an organism). However, earlier research has not provided enough data for clinical use. A newly created collection of hemp for medicinal purposes (currently containing only the technical varieties) will enable us to make a comprehensive assessment of the content substances, something which has not been achieved as yet in the Czech Republic.



Structure of the collection of MAPs genetic resources (number of accessions in brackets)

Oilseed Flax for a Rational and Healthy Diet

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Common flax (*Linum usitatissimum* L.) includes two basic commercial types – fibre flax and linseed. Due to the economic reforms in the nineties in the Czech Republic, cultivation basically finished and hence the breeding of fibre flax. On the other hand, the cultivation of linseed (focused on seed production), has been developing quite successfully since 2010. The emphasis on seed production is not only on the pressing of edible oil (so called low-linolenic types), and the production of technical oil and paintwork materials (classic species), but also particularly for using the seeds in bakery products and rational nutrition products (classic species). By-products (stem, short fibre, tow, shives) are used in the paper industry and are a significant component of composite, isolation and ameliorative materials that are utilised in the automotive, aviation and construction industries. Besides such versatile uses, there are even more possibilities of usage, some of which have not been explored yet. There are many opportunities to process linseed into edible oils, forage, or food supplements using its high nutrition potential. This field of research has been very attractive recently even abroad, especially in the context of the recently growing endeavours to eat and live healthily.

The uniqueness of linseed oil for human health and rational nutrition is based on Omega-3 polyunsaturated fatty acids (PUFA MK) that are present in the seeds. Omega-3 PUFA MK,

in particular linolenic acid, eicosapentaenoic acid and even docosahexaenoic acid, have numerous positive effects on human health. Consumption of Omega-3 fatty acids lowers risk of heart diseases, inhibits breast and prostate cancer development, it postpones



Linseed oil products

the loss of immunological functions and moreover these fatty acids are necessary for normal development of brain and sight in a foetus (Castro-Gonzalez 2002, Lewis et al., 2000). According to WHO (2003), the acids mentioned above lower the risk of cardiovascular diseases.

The human organism is not able to synthesize these fatty acids, therefore they must be delivered through food or food supplements, either via seeds or in the form of oil. Otherwise, it can also be supplied via salt water fish, which can synthesize the fatty acids. Consumption of Omega – 3 PUFA MK is (considering local dietary habits) quite

low in the Czech Republic. According to the recommendation of WHO, the daily intake should be 6–10% of the total daily energy intake.



Examples of products

In recent years, research has started to focus on the eventual substitution of fish meat (both salt water and freshwater fish), with other living organisms (hens, lambs, goats), that are fed with linseed oil or fodder supplements with linseed additions with required qualitative parameters regarding the content of Omega-3 PUFA MK and other substances

contained in flax seed (cyanogenic glycosides, lignans). Regarding the latter substances, the lignans are of crucial significance because they are beneficial for an organism and have antioxidant effects (Touré and Xu, 2010). On the other hand, the cyanogenic glycosides are unwanted (e.g. linamarin). It has been proven that it has cytotoxic effects when feeding (e.g. on pancreas cells, which can distort various metabolic processes in an animal organism) (Soto-Blanco and Gorniak, 2010). With new breeding, a genotype has been gained with a completely unique composition of fatty acids that had not previously existed either in the home collection or in any European or overseas collections. In 2011 it was registered as a new linseed variety called RACIOL (Tejková, Bjelková, Pavelek, 2011). This variety was awarded “The Golden Cob” at the Czech national agricultural fair “Země Živitelka” in 2013. Regarding the average content of alpha-linoleic acid, the oil has a higher durability, so it is suitable for the food industry and rational nutrition. The grain is appropriate for bakery products as a surface dusting or mixed in the dough etc.



Demonstration of flax genetic resources vegetation

The Use of Unusual Bean Plants in a Healthy Diet

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The *Fabaceae* genus, as already mentioned in earlier chapters, contains very valuable substances for the human diet. These plants are especially beneficial for people with some dietary restrictions, such as individuals suffering from celiac disease, vegetarians or vegans. The majority of us are familiar with peas, lentils or beans, so let us introduce some less commonly known species of this genus that are quite promising regarding healthy nourishment.

Chickpea

(*Cicer arietinum* L.)

The chick pea is an unusual minority bean plant originating from India. It is cultivated mainly in the Mediterranean area, over the Far and Near East, up to India and also along the Nile River and in North America.

Regarding the volume of production - it is the fourth most important legume in the world (after soya, peas and beans).



Chickpea Irenka - *Cicer arietinum*

In the Czech territory, historically chickpeas were grown mainly in the area of the Moravia-Slovakian borderland, especially in the White Carpathians and also in South Moravia where it is still cultivated occasionally in gardens. It is grown especially as a pulse for its seeds. However we can consume directly the whole unripe pods or young shoots, too. There are two main chickpea types – “desi” and “kabuli”. The desi type has smaller, dark seeds and red-purple blooms. It is commonly grown in India. Kabuli has light, bigger seeds and white flowers and is cultivated in the Mediterranean. Considering the nutrition values and organoleptic characteristics, chickpeas belong among the highest quality pulses for the human diet. There is a high content of carbohydrates (starch) and proteins. Lightly coloured varieties have a high content of sulphur amino acids. There are also many essential amino acids – linoleic and linolenic acid. Anti-nutritional components (enzyme inhibitors, phenolic substances) which occur, are removed by cooking or soaking. Food utilisation is based on the whole cooked or roasted grains or flour. Sprouted seeds or young plants are suitable for salads. The famous falafel is made of chickpeas (fried spicy pulse balls). It is frequently used in the Near East and Far East cuisines (Arabian hummus, tamiya and koschari; Indian dhall etc.). In the Genebank, there is currently quite a large collection of 68 materials. Within the research project called “Minority crops for specific usage in the food industry” different types

of chickpeas were assessed considering their quality and output aspects. The only variety which is Czech is called “Irenka” and it gained a good assessment.

Grass pea

(*Lathyrus sativus* L. - blue sweet pea, chickling vetch, Indian pea, white vetch)

Another unusual minority pulse is commonly grown for human nourishment and as fodder to feed cattle in Asia and eastern Africa. In the Czech territory, the grass pea was grown historically especially in the Moravia-Slovakian borderland, in the White Carpathians, where it is still sporadically cultivated in gardens. It is a very important crop for areas that often suffer from drought or famine. Grass pea is a valuable source of proteins for the human diet.

However, the seeds contain a neurotoxin called ODAP (Oxalyldiaminopropionic acid) which causes a neurodegenerative disease called neurolathyrism, when it is eaten long term as a primary source of protein. If the grass pea is consumed moderately within a balanced diet, there is no need for concern. Typical usage for the human diet is in the form of whole grains - boiled or roasted, occasionally flour.

Within the project under discussion, various genotypes of grass pea were evaluated regarding the aspects of quality, output and also the content of ODAP. New recipes for baking bread were tested. Part of the cereal flour was replaced by grass pea flour. However it turned out bean flour is more suitable for this purpose. There are six materials in the Genebank collection. Based on the assessment of the various grass pea genotypes, suitable plants were selected and subsequently bred into the first registered Czech variety called “Radim”.

Lablab bean

(*Lablab purpureus* L. - hyacinth bean, dolichos bean, Egyptian kidney bean)

Lablab is a climbing plant similar to a bean coming from eastern Africa. It is grown in tropical and sub-tropical areas all around the world as a pulse, vegetable, fodder, or as a green fertiliser. Ripe seeds contain poison, cyanogenic glycosides, so they are not edible until they have been heat treated. Green pods are consumed as a vegetable, like common beans. In Chinese medicine the lablab seeds are used to treat diarrhoea, inappetence or emesis. This bean is a valuable source of protein for humans.



Lablab bean - *Lablab purpureus*

In the Czech Republic, the lablab is not an ancient forgotten plant, but rather a novelty, enhancing the spectrum of cultivated crops. Nowadays the lablab is dedicated to leisure gardeners and small-scale farmers. There are currently no materials of lablab beans in the genebank.

Several materials were gained for the working collection. As plant selections and breeding proceeded, we registered the first Czech lablab cultivar called “Robin”.

Now we have also been testing the second genotype which is distinguished by purple anthocyanin colouring of the whole plant and it is earlier than the previous variety.

Liquorice

(*Glycyrrhiza glabra* L. - licorice)

Liquorice significantly differs from the above mentioned species. Instead of seeds, we use its roots and rhizomes. Liquorice is not valuable as a source of protein but because of carbohydrates and healing substances as will be explained below in the text. It is a medically important plant, particularly in oriental medicine. Liquorice comes from south-eastern Europe. This old cultural plant was rarely grown in Bohemia and abundantly in Moravia from the 16th century.

It was cultivated extensively until the second part of the 19th century, especially around the town of Hustopeče (villages of Pouzdřany, Popice, Starovice), around the town of Mikulov (villages Věstonice and Strachotín) and the town of Bzenec.

In southern Moravia, we can still find some wild liquorice plants, namely around Hustopeče and Pouzdřany. Liquorice was already highly appreciated in the first Chinese atlas of medical plants, that was written, according to legends, by the mythical emperor and wise man Cheng-Nung around 3000 BC.

Liquorice is used for confectionary and also it is added into liquors and non-alcoholic beverages. Liquorice candy is the concentrated and processed extract from liquorice root. It is also mixed into beer as a foaming ingredient. It is used for adjusting the taste of tobacco. The root waste is utilised for the production of paper or as part of noise and heat insulation. Last but not least, it is a valued honey plant. The exterior parts of the plant can be used as fodder for cattle.

Liquorice is widely used in the pharmaceutical and food industries. Nowadays it is not cultivated in the Czech Republic, so current consumption must be covered by imports.

However, it is a shame, because a sufficient amount of planting material is available from the extensive vegetation that still grows between vineyards and terraces surrounding Hustopeče and Pouzdřany. The question is whether it is economically attractive to grow liquorice. Introducing this plant into local production, would mean at least a desirable improvement in the bio-diversification of agricultural land and the notion that we maintain the traditional crop that was cultivated by our ancestors hundreds of years ago.



Liquorice - *Glycyrrhiza glabra*

The genepool of the genus *Glycyrrhiza* is kept in vegetative form in the area of the Faculty of Horticulture of Mendel University in Lednice. Thanks to its cooperation with the Research Institute of Fodder Crops in Troubsko, the contemporary genepool was evaluated (especially the *Glycyrrhiza glabra* L., *G. echinata* L., *G. pallidiflora* Maxim.).

EVIGEZ, the Czech national genebank information system, currently contains seventeen generatively kept items from the genus, including six items of the species *G. glabra*. Now, there is no variety of liquorice available in the Czech Republic.

Hops (*Humulus lupulus* L.)

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Hops are almost always connected with beer production. Beer and hops are usually associated with health. It is not surprising because beer has very suitable so called osmolality therefore it is actually an isotonic beverage. It has roughly the same osmotic pressure as blood and it provides “fast calories”, which is good to replenish energy after sports activity. Beer makes the metabolism efficient. Included substances are utilised quickly and easily without side effects.

This makes it easily digested. Beer contains significant amounts of potassium ions, magnesium ions, phosphor ions and ions of other trace elements, so it can be labelled as an ionic drink. In one litre of beer there are plenty of vitamins that are present in relatively high doses of the recommended daily intake, e.g.:

- Vitamin B1 – *thiamine* (3% of the RDI) – it eliminates carbohydrates in tissues, supplies the body with energy and it is also useful for growth, digestion and neural activity.
- Vitamin B2 – *riboflavin* (20% RDI) – is a prosthetic group of oxidation reduction enzymes, important for an organism.
- Vitamin B3 – *Niacin* (Nicotinic acid, 45% RDI) – significantly contributes to cell nutrition. It acts during energy release from fats and carbohydrates and during body energy accumulation. It is part of two coenzymes and it helps to synthesize body fat and cholesterol.
- Vitamin B6 – *Pyridoxine* (31% RDI) – plays an important role during metabolism and absorption of proteins. It regulates fats and carbohydrates and supports the correct function of the neural system and creation of red blood cells.



Hop cone

- Folic acid (53% RDI) – is a basic vitamin, that supports blood cell creation, amino acid metabolism and restoration of all the cells in the body.

The hop plant itself, also has healing properties and belongs among the group of crops that might be directly consumed. Spring hop shoots were used in the past in the preparation of spring salads. These lightly yellow shoots, sometimes called “hop asparagus”, are collected from below the soil in order to keep them brittle. Nowadays this ingredient is sought for special salads specifically in France and Belgium. Hop works as a sedative, disinfectant and supports digestion. It is also used against insomnia, nervous excitement, uneasiness, flatulence or problems related to the menopause. Hops, as herbal antibiotics, can be used externally as well, e.g. as a gargle or to treat furuncles

or wounds that are slow to heal by having a bath or using a poultice. Usually, a macerate or an infusion is prepared from seed cones, its maximum dose is 15 grams a day during up to 3 months. Nowadays there is a great demand from the pharmaceutical industry for the substances contained in the cones. These are especially prenylated flavonoids, because it has been revealed, they dispose of significant antioxidant, anti-inflammatory, antiviral, and anti-carcinogenic effects. These substances were also proven to have an activating effect on quinone reductase.



Hop shoots (asparagus)

The mentioned enzyme, protects cells against toxic xenobiotics by reducing quinone to hydroquinone, which breaks down more readily in the of a mammal. In the substances of desmethylxanthohumol (DMX), isoxanthohumol and 8-prenylnaringenin, inhibitive effects were detected on cytochrome P540 enzymes that activate the action of various carcinogens. Bone resorption is significantly inhibited by some hop substances,

mainly by xanthohumol and humulone. In other substances that are present, there were found inhibitive effects on enzymes that activate the operation of various carcinogens. Bone resorption is also significantly inhibited by some other substances contained in the hop cones. These days, the mentioned compounds are considered as promising therapeutic substances against osteoporosis. Antioxidant properties of the flavonoids mentioned above were discovered during inhibition of oxidation of low density lipoproteins, which (the process) lowers the risk of emergence of cardiovascular diseases.

Some substances contained in hops have been proven to have a cytotoxic effect on human cancer cells in a few organs, at a concentration of 0.1 to 100 μm . The testing of positive characteristics of xanthohumol and other relative substances still proceeds, both in *in vitro* and *in vivo* conditions. Considering the given facts, it can be expected, that more and more hops will be used in pharmaceuticals.

Because of this, the breeding of hops is focused on increasing the amount of these substances important for the pharmaceutical industry. Currently there are five varieties of hop and five newly bred varieties present in the collection of hop genetic resources. The new additions were gained within the project called “Development of hop genotypes for biomedical and pharmaceutical purposes”.

Table 1: Genotypes of hop with the highest content of DMX

Item number	Genotype indication	Country of origin	Alpha acid (%)	Beta acid (%)	DMX (%)
328	Vital	CZ	12–16	6–10	0.25–0.40
126	Record	Belgium	5–7	6–9	0.14–0.21
206	Sládek ¹⁾	CZ	5–8	4–7	0.14–0.20
254	Magnum	Germany	11–15	6–8	0.12–0.20
306	Columbus	USA	11–16	4–6	0.11–0.19
299	Agnus	CZ	9–12	5–7	0.11–0.18

¹⁾ Brewer

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