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Cereals – Health or Disease

Zboża – zdrowie czy choroba

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Abstract
As a result of appropriate interference in the agro-ecosystems, a man can control their productivity and increase the amount of produced biomass, which can be utilized as food for humans, feed for animals, and raw material for many industries, including fuels. Such agriculture combines the laws of nature and human activity into a single coherent system. FAO has drawn attention to the idea of *food security* for a long time, because sufficient amount of healthy food is a prerequisite for life. The issue of genetically modified cereals not only to increase the yields, but also to stimulate the consumer's appetite, is still little discussed. Pervasive promotion of cereals praised as a healthy food set the trends and fashions in diet and surrendered them the agricultural markets and production fields. Growing the alternative crops, among others the amaranth, shows agriculture as an economic activity that combines natural laws with human interference into a single coherent system operating in accordance with the principles of sustainable development. In this way, resources of arable lands are exploited in a sustainable manner. Moreover, amaranth grains due to the high nutritional value, especially in view of special characteristics of protein, fat, and starch, are becoming more and more popular among producers, consumers, and the industry. Therefore, the aim of this study was to evaluate the usefulness of the forgotten plant species – amaranth (*Amaranthus cruentus L.*) to measure the impact of its raw materials and products on human health and in the context of wheat and its processed products dominance on agricultural markets.

Key words: food security vs. health, wheat vs. health, gluten vs. health, amaranth as eco-product of a future, sustainable development and management of a field production

Streszczenie
W wyniku odpowiedniej ingerencji w agroekosystemy człowiek steruje ich produktywnością i zwiększać ilość produkowanej biomasy, która może być spożytkowana jako pokarm dla człowieka, karma dla zwierząt i surowiec dla wielu gałęzi przemysłu, z paliwowym włącznie. Takie rolnictwo łączy prawa przyrody i działalność człowieka w jeden spójny układ. FAO od dawna zwraca uwagę na ideę *bezpieczeństwa żywnościowego*, gdyż dostateczna ilość zdrowego pożywienia jest warunkiem koniecznym do życia. Jednak publicznie nie mówi się na temat zbóż zmienionych genetycznie nie tylko w celu zwiększenia plonów, ale również pobudzenia apetytu konsumenta. Wszechobecna promocja zbóż zachwalanych jako zdrowa żywność ustaliła trendy i mody w diecie oraz podporządkowała im rynki rolne i pola produkcyjne. Uprawa roślin alternatywnych, m. in. szkarłatu ukazuje rolnictwo jako działalność gospodarczą, która łączy prawa przyrody z ingerencją człowieka w jeden spójny układ działający zgodnie z zasadą ekorozwoju. W ten sposób eksploatuje się zasoby gruntów ornych w zrównoważony sposób. Ponadto nasiona roślin amarantusa (*Amaranthus cruentus L.)*, z uwagi na wysoką wartość odżywczą, a zwłaszcza z uwagi na szczególne właściwości białka, tłuszczu i skrobi, cieszą się coraz większym zainteresowaniem wśród producentów, konsumentów i przedstawicieli przemysłu. Dlatego celem niniejszej pracy była ocena przydatności zapomnianej rośliny jaką jest amarantus pod kątem wpływu surowców i produktów uzyskanych z tej rośliny na zdrowie człowieka i w kontekście dominacji pszenicy i jej przetworów na rynkach rolnych.

Słowa kluczowe: bezpieczeństwo żywności a zdrowie, pszenica a zdrowie, gluten a zdrowie, amarnatus jako ekoprodukt przyszłości, zrównoważone zarządzanie jakością pół produkcyjnych

1. Introduction

As a result of appropriate interference in the agro-ecosystems, a man can control their productivity and increase the amount of produced biomass, which can be utilized as food for humans, feed for animals, and raw material for many industries, including fuels. Such agriculture combines the laws of nature and human activity into a single coherent system. The 21st century is the century of starch and plant-origin fats, and therefore perpetually renewable raw materials. These materials provide new and hitherto little-known products, that are environment friendly, on a large scale. The proper use of the goods given to us by nature leads to the production of economically useful biomass: grain yields, animal feed, and as a consequence – the food (Bender, Gilewska, 1996; Badora, 2012). Even 2,500 years ago, Hippocrates formulated the maxim, *Let food be the medicine and medicine be the food* (Rakiel-Czarnecka, 2010). At the beginning of this millennium, we are equipped in scientific evidences of the need to respect it. Thus, the amount, quality, and proper selection of food components are critical to the physical and mental condition, and hence the length of human life.

For decades, Europe enjoyed increasing a wealth and prosperity based on the intensive use of resources. But now, it is faced with a double challenge: (i) it is necessary to stimulate the economic growth, since it is required to provide new employment and prosperity for its citizens, (ii) on the other hand, it is to make the quality of this growth leads to the achievement of sustainable future (Flis, Konaszewska, 1986; Gawęcki, Mossor-Pietraszewska, 2006; Badora, 2012). The agriculture, that efficiently consumes natural resources, can contribute to the implementation of unusual plants in the crop structure, e.g. amaranth or millet as durable food resource resources with certain biological and consumption characteristics, that are useful from the point of view of the environment potential and population health (Coultate, 2007; Obiedziński, 2009; Rakiel-Czarnecka, 2010; Manahan, 2011; Lustig, 2013).

Therefore, the aim of this study was to evaluate the usefulness of the forgotten plant species – amaranth (*Amaranthus cruentus L.*) to measure the impact of its raw materials and products on human health and in the context of wheat and its processed products dominance on agricultural markets.

2. 'Your health in your hands'

2. 1. Food and nutrition vs. health

According to the World Health Organization (WHO), health is a state of complete physical, mental, and social welfare, and not merely the absence of disease or infirmity. According to this organization, the human health is determined by three main factors: (i) a way of life – in about 50%, (ii) the environment – in about 20%, and (iii) genetic factors – in about 20%. The most important environmental factors that affect our health are: clean air and water, uncontaminated soils, and healthy food (Gawęcki, Mossor-Pietraszewska, 2006; Badora, 2012).

There is a close relationship between food, nutrition, and health. The focal position is occupied by two parameters that can be assessed and be consciously shaped: the health quality of food – including its widely understood safety, which is determined by the content of natural toxic and anti-nutritive substances and environmental pollutants, as well as nutritional value of food – informing about the content of components required for an organism, their relative proportions, and bioavailability. Both above parameters are related to one another. On the one hand, inadequate supply of nutrients increases the body's sensitivity to harmful substances and pathogens, while on the other hand, both acute and chronic poisoning make the nutrients utilization worse, which leads to malnutrition disturbances (Gawęcki, Moosor-Pietraszewska, 2006; Coultate, 2007; Manahan, 2011).

The natural environment (soil, water, air) is important both for health quality of food achieved over a given area (e.g. contamination with heavy metals, aluminum toxicity), and for its nutritional value (e.g. iodine, magnesium, and selenium contents) (Badora, 1999, 2011, 2012). Besides, the *march of chemistry* through the fields and tables is dangerous to the environment and the man himself, spreading allergies and cancer (Traczyk, 2002). Rational nutrition is therefore aimed at achieving a compromise between the comfort of a consumer and his health safety, as well as between the intensification of food production and the protection of the environment (Gawęcki, Moosor-Pietraszewska, 2006).

According to the *Gold Card of Proper Nutrition* (1998) developed by the Council for Promotion of Healthy Nutrition (in co-operation with Medical Societies, the National Institute of Cardiology, some foundations for health promotion, and in accordance with the *National Program for Cholesterol Prevention*), to be healthy, cereal products should be consumed every day in every meal. Other nutrition specialists also agree with this assumption (Rakiel-Czarnecka, 2010). Vice-President of the National Forum of Bakers and Confectioners at the Association of Food Engineers and Technicians promotes the idea that cereal products containing high levels of dietary fiber should be the basis of a daily diet. Consumption of cereal products should range from 5 to 11 servings a day, i.e. one serving of cereal prod-

ucts is equivalent to 1 slice of bread or ½ cup of cooked flakes, rice, pasta, or 30 g of *ready-to-eat* flakes.

For the first time, the public recommendations on an increased consumption of cereals were formulated in 1977 by a committee of the U.S. Senate. Following the adoption of the document *Dietary Goals for the United States* by the Senate, all government institutions, federal scientific and medical centers, as well as some universities, especially those interested in promoting *the fat and cholesterol hypothesis*, got automatically involved (Lustig, 2013). According to Davis (2013), involvement of academic centers has proved very effective, because it gave scientific and medical foundations to the political, economic, and ideological activities of the U.S. government. As a result, cereals could now be promoted under the guise of *health concerns*, namely the *war against fat and cholesterol*. In 1993, The World Bank sponsored a study on *Disease Control Priorities in Developing Countries* (Eades et al., 2002; Marcola, 2006; Berriedale-Johnson, 2012).

The effectiveness of all efforts to improve a human life is measured in arbitrary units called *Disability-Adjusted Life Years* (DALY), which take into account the age, at which health problems occur, as well as the degree of injury. With regard to health problems, rather permanent or temporary health disorder than premature death is taken into account when determining the DALY units (Musgrove, 1996; Świderski, 2003).

Food security means that it will not cause any harm to the health of the consumer, when it is prepared and/or consumed in accordance with its intended use. Safety food is such, that is not toxic and does not have infectious properties. However, food toxicity may be due to the presence of substances of different origins (Norvell et al., 2000; Borkowski et al., 2003; Babuchowski, 2005; Golia et al., 2008; Mościcki, Wójtowicz, 2009).

A definition of nutritional safety was developed during The World Food Summit in 1996; it says that: *The security of the food is referred to when all people at all times have access to sufficient, safe, and nutritious food to maintain a healthy and active life* (George, 2011). The term *food security* has been used during official meetings and in documents. In opinion of George (2011), it does not satisfy however, the majority of progressive forces, which include the international peasant organization *Via Campesina*, operating for over 20 years and promoting rather the notion of *food sovereignty* like most people struggling with hunger. They point out that the official definition of *food security* does not include anything about where food comes from, who, by what means, in what circumstances and in what farms it has been produced. According to the abovementioned organization, this definition either does not specify where, how, and by whom the agricultural products are processed and sold, at what costs and at what price. George (2011) summarizes that when saying *food security*, it is not said anything about who exactly controls the food production chain. However, *the food sovereignty* means the independence of a given community and focuses mainly on the direct control within this one of the most important areas of human life, i.e. food, nutrition, and health.

2. 2. Food enrichment

From an economic point of view, there are no substantial differences between enrichment, supplementation, and changes in dietary habits. Supplementation carries the risk of overdosing, since it is difficult to monitor. However, in an era when farmers grow most of their own food, enrichment is the need to purchase a new product, they had not purchased earlier and therefore enrichment is another form of diet change. The problem of enrichment is often exaggerated by many nutritionists, who fear that it cannot be maintained in the case of an economic downturn. However, the same nutritionists allege that managing of their crops by farmers is a process that affects the changes in a diet and is permanent. In both cases, people's opinions and requirements have to be changed, because economic restrictions affect the price the enriched foods and crops (Musgrove, 1996; Świderski, 2003).

The primary purpose of food enrichment is to increase the consumption of a nutrient or providing a nutrition information to the consumer so that he was aware of his choice. Food enrichment applies to relatively low processed food such as sugar, salt, rice, or flour, and also in relation to the water. These products are directly consumed. Speaking of food enrichment, it should be kept in mind the relationship of element deficiencies in the food with public health concern, which justifies and even requires strong government intervention. It also implies the need to enforce the form of management in order to all supplied food was a subject to enrichment, including penalties for manufacturers who do not adhere to this. Although enrichment does not require any changes to the diet, however, this food can be perceived by the public as different (worse) than traditional foods. It is therefore necessary to appease public opinion for this kind of food (Musgrove, 1996).

According to economic criteria, enriched food is a new quality of a product, not just the original article with higher price. The advantage of food enrichment is that this method can rapidly improve the health condition of a population. It should be noted that the problem of components deficiency in the soil environment can be solved by raising the awareness of the consequences associated and due to appropriate financing measures that allow the acquisition of enriched food. Therefore, the fundamental question refers not to whether people will eat more enriched sugar, flour, etc. because it is desirable for their health, but whether they will still prefer the food not

subjected to this process (Musgrove, 1996; Świderski, 2003).

2. 3. Management of a field production and food security

The concept of culture (fertility) of a soil means such soil condition, which provides growing plants enough nutrients, water, and air, and is the resultant of many natural and soil-forming factors dependent on the climate, bedrock, and vegetation. The highest cereal yields can be usually obtained on soils found in high culture (optimum content of available forms of plant nutrients, such as Mg, K, Ca, P, N, and humus), with regulated relations between water and air and with pH value close to neutral (pH = 5.6-7.2). Weaker yielding of cereal crops on acidic and very acidic soils reflects worse overall status of these soils culture (Noworolnik, 2006).

In case of countries like Poland the soil reaction has a significant impact on agricultural production. Light soils, strongly acidic (pH 4.5) cover more than 30% of the arable lands in Poland, and altogether with acidic soils (pH 4.5-5.5), they occupy about 60% of the area. The main drawbacks of these soils are deficits of water and many nutrients, especially magnesium, calcium, phosphorus, and potassium, as well as increased toxicity and uptake of polyvalent metals such as aluminum, manganese, cadmium, and many others, that may have toxic influences (Ślusarczyk, 1991; Badora, 1992, 2002, 2011; Norvell et al., 2000; Filipek et al., 2006).

Fertilization is a factor that particularly strong affects the yield and quality of cereals. This concept means providing plants with minerals, which are their food, through the soil or due to foliar application in the form of chemicals (fertilizers) and organic agents (natural and organic fertilizers). Fertilization is intended not only to obtain optimum cereal yields, but also improving the quality characteristics of grains within a specific range (Podolska et al., 2005; Filipek et al., 2006; Dietrych-Szóstak et al., 2008).

Soil abundance in macro- and micronutrients has an impact on the quality parameters of wheat grain. Among macroelements, the most important role in this respect is played by an adequate supply of nitrogen, which affects the increase in protein and gluten contents, sedimentation rate, and rheological properties of dough. Phosphorus and potassium along with microelements (copper, manganese, zinc) contribute to obtaining the grain with positive qualitative traits. The content of microelements in soils and their availability to plants depends on many factors (Ślusarczyk, 1991; Badora, 2002, 2011). In some parts of the country, their excessive levels can be met, which adversely affects the growth and yield of plants. Excessively high copper content in wheat grain will deteriorate the baking properties of flour, while the lack of this component leads to a reduction in growth and development of the main shoot and inhibition of the generative organs development, which greatly reduces the yield. Manganese deficit impairs metabolic functions of plants and reduces the sowing value of seeds. Feeding plants of winter and spring wheat with microelements has positive effects on grain quality features such as gluten content and sedimentation rate (Sobiech et al., 2003; Przybulewska, Stolarska, 2004; Kot, Zaręba, 2005).

The primary effect of the negative impact of acidic reaction consists in adverse changes in physical, chemical, and biological properties of soils, as well as poor growth and development of plants (lower yields). Secondary effect is mobilization of aluminum and heavy metal ions in amounts as larger as the soil is more acidic. In acidic soils with pH below 4.2, aluminosilicates are decomposed, whereas concentration of Al^{3+} and Mn^{2+} ions, that occupy space of Mg^{2+} and Ca^{2+} in the sorption complex and contribute to increased leaching of alkaline cations, is increased. These changes are a major cause of poor growth and development of crops (Badora, 1999; 2011, 2012). At first, high concentration of aluminum ions has a destructive effect on the root system, which makes nutrient uptake difficult and resulting in Mg and P deficiency symptoms in plants and their poorer growth. Aluminum ions also limit the growth of shoots leading to the decay of vertices and causing necrosis of leaves. Aluminum also forms the ion ratios in cereals, including enhancement of K+(Ca+Mg) ratio and affects the higher contents of Mn and Fe in the above-ground parts of plants. Ultimately, toxic aluminum reduces the quantity and quality of cereal crops (Badora, 1992, 1999, 2011; Szatnik-Kloc, 1999; Mizerski et al., 2002).

Considering the influence of environmental conditions on the quality of wheat grain, the health aspect of raw material cannot be overlooked, especially the content of heavy metals, including cadmium, even small amounts of which are harmful to the health of humans and animals and which has very high mobility within the environment. Cereals are the main source of cadmium for humans. It is estimated that in Poland, more than 40% of cadmium absorbed by ingestion, is derived from cereal grains and processed products (Kowalik, 2001; Babuchowski, 2005). Studies carried out by Szteke and Szymczyk (2005) and Mościcki and Wójtowicz (2009) revealed that within *Triticum* there is quite great differentiation in the quantity of cadmium uptaken from the soil. More cadmium is absorbed by durum rather than common wheat kernels (Norvell et al., 2000). Diverse cadmium levels are also found in grains depending on the cultivar (Badora, 1999; Sobiech et al., 2003; Grabiński, 2005).

Presence of heavy metals, such as Pb and Cd, in the soil, significantly affects the quality of grain yield, since exceeding the permissible content of these elements in the intervening purchase of cereals (greater than 0.2 mg kg^{-1}) disqualifies the grain for further processing and consumption, which can be associated with large economic losses. It is therefore nec-

essary to monitor the heavy metals content in soils. Most of agricultural soils in Poland have natural content of heavy metals (Terelak et al., 1995). Elevated heavy metals quantities found in soils are mainly a consequence of the industry impact. Therefore, crop production should be set up away from industrial centers and highways. Cadmium and lead are not necessary for the growth and development of plants. However, some plant species, such as wheat or rye, are characterized by a large accumulation capacity of these elements, particularly cadmium, under circumstances of the soil pollution. Because cadmium and lead are toxic elements for the human organisms, their content in grains is determined by Commission Regulation (EC) No 824/2000 of 19 April 2000.

Liming reduces the toxic effects of aluminum and heavy metals on plants. It is mainly used to increase the pH in order to create optimal conditions for growth, development, and yielding of crops. However, organic and natural fertilizers have a lesser impact on the quantity and quality of cereal yields than mineral fertilizers, because grains are sown for consumption purposes in the second year after application of manure or other organic fertilizers to the production field. This ensures a good supply of nutrients and prevents from the appearance of a number of cereal diseases (Rogalski, 1997; Kalinowska-Zdun et al., 1999; Rozbicki, 2002; Tyburcy, 2005).

To obtain good quality yields, it is essential to use herbicides as part of the agricultural technology. The use of herbicides is one of many factors determining the achievement of a well-developed and uniform grain, the characteristics of which indirectly determine its suitability for milling. On the other hand, although the herbicides are important yield-forming factor, there is a risk of adverse effects on the plant. Herbicides may disturb the biochemical processes in plants leading to unfavorable processes such as changes in the morphology of a plant, reduced yield, quality deterioration (Klimont, Osińska, 2004).

The presence of undesirable substances in plant material bears a risk to a consumer's health. Security of a crop production is therefore closely associated with the status of the natural environment. Some substances used a dozen or a few decades ago, have interacted with the environment and the trophic chain until now, being underwent to its continuous bioaccumulation. Enthusiastic use of DDT in the 40's of the 20th century revealed its insidious effect 20 years later. Birds became extinct, which found its reflection in the publication by Rachel Carson *Silent Spring* from 1962. It is an example of CTBs (Chemical Time Bombs), i.e. chain of events leading to a delayed and sudden negative effect within the environment (Stigliani and Anderborg, 1993). Remains of DDT and its conversion products (PCBs, aldrin, and deldrin) can be found even today in milk from lactating mothers.

The production fields in countries like Poland are characterized by the lack of so-called *elements of life* (Mg, Se). Deficiencies of magnesium and selenium in agricultural production area result in deficiencies of these elements in plant material. People need 200-375 mg of magnesium daily. Deficiencies of this element in a diet lead to the occurrence of restlessness, nervousness, drowsiness, sensitivity to stress, atherosclerosis, and cancer. Selenium is an element that is partially necessary for animal organisms, as well as man. A deficiency of selenium can lead to serious civilizational diseases. The presence of selenium in the human diet is essential, not only because its action to free radicals, but also due to the formation of simple and complex bindings with heavy metals occurring in the environment, in food, or living organism. In this way, metals are excluded from biochemical processes. Safe and sufficient selenium dose for adults is set up at the level of 50-200 micrograms per day (equivalent of a single brazil nut, Wąsowicz, Zachara, 1987; Badora, 2000; Wierzbicka et al., 2007). Selenium doses at the level of 1-5 mg kg^{-1} DM are toxic to humans and animals. Selenium deficiency can therefore not be so easily eliminated due to supplementation as it happens in the case of magnesium. Plants rich in selenium are: rapeseed, garlic, onion, mustard, peas, beans, and some cereals.

3. 'The catcher in cereals'

3. 1. Wheat vs. health

Due to the rapid expansion of agriculture, the modern world, in addition to corn and rice, *is governed by wheat* today. Wheat cultivations are donated by large financial sums, and wheat manufacturers are one of the most influential producer lobbies affecting the world of politics, economy, and science. In total, 2180-2200 million tons of cereals are harvested worldwide, of which about 650 million tons of wheat grains, giving it third place after rice and maize. In the structure of world's crops, wheat takes the first place with the surface of 220 million hectares. Cereals have become the fundamental diet of people and animals in the world, providing the organism 2/3 of the required protein amount. The share of global grain products consumption is 47%, including products of animal origin about 32% (Marcola, 2006; Davis, 2013).

Area under cereals in Poland is also large and currently amounts to 8.4 million hectares, while the harvest fluctuates around 26-27 million tons (Rozbicki, 2002; Szozda, 2009). During the past 2 decades, the area under cereal crops has increased even more, including wheat, triticale, and maize for grain, while area under rye, barley, oats, buckwheat and millet, as well as the area under legumes for grain, potatoes, industrial crops, fodder and vegetables significantly decreased (Hryncewicz, 1992; Stanko, 2005). In Poland, some positive changes in the consumption of basic foods can be observed, but consumption of cereal products remains at one of the highest levels in

Europe, especially in comparison with other European Union countries (Tyburcy, 2006).

According to Davis (2013), to make the production and distribution profitable, a demand is needed. According to this author, the real reasons, why the *whole grain cereals* were popularized by state-medical apparatus throughout the world as *healthy food* and became the basis of the food pyramid developed by the U.S. Department of Agriculture (USDA) in the early 80's, should be seen in this need. It must be remembered that the role of the USDA, like any other ministry of agriculture in the world, is primarily a promotion of local agriculture, of which cereals are the dominant part, therefore *healthy eating pyramid* is based mainly on cereal products. The result is the placement of the global wheat consumption at about 70 kg per person annually nowadays. Eades (et al., 2002) cites data by which the average American now eats about 360 loaves of wheat bread per year. Shop shelves are full of various products containing wheat. And it's not just a meal, flour, and its baked goods (bread, rolls, baguettes, etc.), a variety of pastries, cakes and cookies, but also a spectrum of cereal flakes. Today, wheat is used in many kinds of processed food, even sauces for meats. If we add the beer, it turns out that only a fraction of the space in grocery stores is occupied by grain-free foods. By doing shopping at a local store, or visiting a favorite restaurant – we are willy-nilly the catchers in cereals, often without even knowing it.

Nevertheless, it is estimated that the average person living in Poland eats even less than 150 grams of bread and about 40 grams of other cereal products a day, and if the consumption of bread and other cereal products will not increase, a growth in incidence of serious civilization diseases: obesity, cardiovascular disease, some cancers, and diabetes will be recorded in Poland (Rakiel-Czarnecka, 2010). According to the consumer's research conducted by the Institute of Fermentation and Microbiology, Faculty of Biotechnology and Food Sciences, Technical University of Lodz, factor influencing the eating habits of Poles is not the concern about health, but fashion and taste. Therefore, as a consequence, the consumption of many valuable products, including cereal ones, decreases even below the recommended minimum. The consumption structure is also unfavorable – people tend towards more processed foods. Eating different snacks and fast-foods *out on the town* becomes a fashion and lifestyle.

According to many researchers (Rozbicki, 2002; Borkowski et al., 2003; Świderski, 2003; Babuchowski, 2005; Świetlikowska eds., 2006; Tyburcy, 2006; Rakiel-Czarnecka, 2010; Badora eds., 2012) , cereal grains are *the sparks of life* important to human health and fertility. Cereal products, especially whole grain ones, are a good source of fiber and vitamins, particularly from the group B and a number of minerals, and first of all, they provide complex carbohydrates (starch). The plant-origin products also contain proteins, but with less balanced amino acid composition, and are a natural source of unsaturated fatty acids and lecithin. Index Nutritional Quality (INQ), taking into account the content of different nutrients and energy in a product, as compared to the human needs for a given nutrient and energy, is used to assess the suitability of the product for consumption. It indicates that cereals and their products are fairly well balanced, but it should be noted that the one-sided diet may provide some components in a deficient amounts, while other ones in some excess (Rakiel-Czarnecka, 2010).

Davis (2013) refutes myth promoted by the official dieticians that whole grain foods are healthy and should be the basis of an everyday diet. According to Davis (2013) and also to Marcola (2006), both medical practice as well as current scientific knowledge provides conclusive evidence that cereals, especially wheat, can be the source of many *incurable* chronic diseases for many people (e.g. hypertension, diabetes, heart disease, headache, joint pain, arthritis, allergies, etc.), for which *pharmaceutical* medicine is helpless. Davis (2013) and also Lustig (2013) show that a low-fat diet based on cereals driving people into the disease, and patients cannot be cured, instead it only increases their dependence on drugs. The author gathered knowledge about this subject not only from medical literature, but he also reached to agricultural genetics, that in the past 50 years turned traditional wheat into a hybrid product – profitable, robust, and efficient, but virtually with no relation to the original. Noble intentions were behind the biological and genetic modification of wheat, as fear of overpopulation and hunger in the world prevailed in the Western countries in the 60's. Therefore, the increased cultivation of cereals began to be presented as the only salvation for mankind, contrasting it to the *malicious* cattle husbandry and meat production. In an atmosphere of such hysteria, the U.S. government and other highly developed countries have begun to invest huge amounts in research aimed at improving crops and increase yields. And it worked – for example, the average yield per hectare is ten times higher today than it was 100 years ago. However, due to genetics and biotechnology, wheat has been modified to such extent that the new plant is still called *wheat* only for smoke screen.

According to studies performed by Marcola (2006) and by Davis (2013), foods made of wheat raise blood sugar more than any other food, including white sugar. Therefore, to stop eating wheat lowers blood sugar and reduces obesity, as well as joint pain, arthritis, chronic rashes disappear, and asthma receded enough that some patients of Davis (2013) could set aside their inhalers; chronic infections paranasal sinuses, leg swelling, migraines and headaches also disappeared; symptoms of gastroesophageal reflux disease and irritable bowel syndrome went down to relieve as well.

According to Davis (2013), we are faced to a long and difficult battle, which will take place in the so-called *public sphere*. Today, wheat meets about 20% of all calories consumed by people. Its cultivation, collection, fertilization, protection, processing, and distribution requires extensive infrastructure. For this reason, presenting wheat as a cause of civilization diseases is a potential threat to the professional situation of hundreds of thousands, even millions of people, who are part of the infrastructure. There is no doubt that the dogma that *fats are unhealthy, while cereals are healthy* will be held for a long time among doctors. It should be noted, however, that so-called *wheat* is no longer a wheat, but completely changed product of genetic research. Having such knowledge, it is understood that many common diseases can be explained by the consumption of that modern *wheat* and its impact on the human body. According to Marcola (2006) and Davis (2013), two slices of whole-grain wheat bread increase the blood sugar concentration more than white sugar, more than many chocolate bars, and even though nutritionists still recommend increased consumption of whole-grain breads. The more wheat you eat, the higher and more frequent increases of blood sugar levels. This leads to larger and more frequent secretions of insulin into the blood, which in time causes insulin resistance. And this state leads directly to diabetes.

Thus, increased consumption of wheat, that is recommended, is not a good response to the epidemic of diabetes, which, according to Marcola (2006) and Davis (2013), will soon affect half of Americans, and 346 million people worldwide. There is no doubt that wheat in the early stages of agriculture, was used in order to survive periods when hunted or gathered food lacked. As noted by Lustig (2013), wheat as a caloric filler that allows for surviving without hunting, is convenient food. However, from the very beginning its consumption has had negative health effects. Even early cultivars such as einkorn wheat and emmer wheat were not healthy for humans. There are reports from year 100 on the prevalence of celiac disease. However, just genetic changes made in the last 40-50 years, coupled with the global consumption recommendations of increasing amounts of wheat, has led to today's tragic situations. These circumstances have changed wheat – in opinion of Davis (2013) and Lustig (2013) – from unhealthy ingredient of our diet into a dietary scourge of a mankind.

3. 2. Gluten vs. health

There is one component of wheat, which is responsible for all negative health effects associated with the consumption of this cereal. Gliadin directly induces inflammation, but also stimulates the appetite. Gluten is responsible for the occurrence of inflammation in the intestines and central nervous system. Lectins make the intestines become more permeable to foreign proteins that cause diseases associated with inflammation or an autoimmune reaction (e.g., rheumatoid arthritis and systemic lupus erythematosus). Amylopectin A is responsible for the formation of abdominal obesity, i.e. *wheat belly*, which is a cause of inflammation, insulin resistance, diabetes, arthritis, and heart disease (Berriedale-Johnson, 2012; Davis, 2013). Considering gluten, the structure of the amino acids may be different, but all the variants have the same characteristics desired by bakers and consumers – the viscoelasticity. This trait makes possible to mold the dough by tossing into the air, to mold pieces of pizza, to give the dough any shape – from pita to ciabatta. New cultivars being a result of genetics work are the worst and most harmful type of gluten. Changes made to the set of genes *D* (*genome*), that are characteristic for today's semi-dwarf wheat, most likely led to a fourfold increase in the incidence of celiac disease. Only in the last 20 years, the incidence of this disease has doubled. Less harmful gluten was present in old wheat cultivars such as einkorn and emmer wheat – less harmful, but not harmless (Marcola, 2006; Berriedale-Johnson, 2012; Davis, 2013).

According to Davis (2013), gluten is harmful to humans in any form, so it should be completely eliminated from a diet. Geneticists are nowadays working on modifying the wheat in such a way to be less harmful (Marciniak-Łukasiak, Skrzypacz, 2008). One area of the research concerns the attempts to remove all the harmful sequences of gluten. Thus, regardless of what bakers or geneticists do to change wheat, it remains substantially the same food with all unfavorable properties: stimulates appetite, negatively affects the brain functioning, triggers inflammation, initiates autoimmune processes, and causes obesity (Marcola, 2006; Darewicz, Dziuba, 2007; Davis, 2013). It should be noted that amaranth or buckwheat grains are essentially pure carbohydrates and unlike wheat, they do not invoke any immunological and neurological effects, nor stimulate the appetite. However, like oat, they raise the blood sugar levels and produce all the effects associated (increased insulin resistance and glycation in the eye, cartilage, arteries, and LDL glycation). For this reason, Davis (2013) recommends that these grains are consumed in small amounts, i.e. less than half cup after cooking, and only as a part of a low-carbohydrate diet (e.g. an average of 40-50 grams daily).

3. 3. Amaranth (Amaranthus cruentus L.) – eco-product of a future

Due to the Polish climate, major cereals in the country are: rye, wheat, oats, and barley, less popular – buckwheat, and almost forgotten and cultivated by amateurs – millet. The result of narrowing the crop species consists, among others, in depletion of food in terms of the number of plant-origin product lines as well as the size and share in an everyday diet, and thus promoting the development of various diseases due to faulty nutrition. Therefore, long ago forgotten

crops or such, that have not been used for nutritional purposes in our civilization, attracted more interests in the last few years. These plants provide opportunities for new choice during the food production, that is why they are called alternative crops (Gajewska, et al., 2002; Piecyk et al., 2009; Dudziak et al., 2010; Czaplicki et al., 2011; Dudziak et al., 2010).

Amaranth is a plant that can be counted among alternative, somewhat forgotten crops. It has relatively low soil and climatic requirements. It is resistant to cold weather and frosts, although it grows best in warm and dry climates (Niekrasz, 2011; Radziewicz, 2011; Piesiewicz, 2012). Amaranth is a good forecrop on all crops, because it leaves de-weeded position with large amounts of post-harvest residues. Now, cultivations of selected in Poland *Rawa* cultivar are spread, which is characterized by yellow or magenta inflorescences. Amaranth does not require sophisticated soil types, it is drought resistant, and does not require high doses of fertilizers or pesticides (Prokopowicz, 2001; Rywotycki, 2005; Januszewska-Jóźwiak, 2009). Amaranth plants are best suited for light to medium soils with stable pH, but also grow well on slightly acidic soils. The plant is a C_4 cycle (like millet, maize and sorghum) (Świetlikowska, 2006). This type plants produce higher yields than type C_3 plants, like four basic cereals. Moreover, the extraordinary property of amaranth consists in that it binds atmospheric CO_2 with quite great intensity, thus alleviating the effects of global warming (Januszewska-Jóźwiak, 2009; Piesiewicz, 2012).

Polish amaranth plantations appeared early in Lublin region; achieved crop yield reaches 3-3.5 t/ha and green mass yield reaches up to 100 t/ha (Świetlikowska, 2006; Piesiewicz, 2012). The interests in the cultivation of this plant are due to the fact that the seeds of amaranth possess valuable properties: high content of protein abundant in lysine and sulfur amino acids, lack of gluten, presence of tocotrienols, which have assigned the role of cholesterol synthesis inhibitors, especially related to LDL (low density lipoproteins, popularly known as the *bad* cholesterol), high fat content relative to other traditional cereals abundant in essential fatty acids are essential fatty acids (from 65 to 76%), presence of valuable oil component called squalene (5-8% of oil) used in the cosmetics and electronic industry, extremely small size of starch granules (1-3 microns in diameter) present in an amounts from 48 to 60%, which may be used as a carrier in the food, pharmaceutical, and cosmetic industries. An additional advantage of all possible amaranth forms can be the possibility to use the green mass of plants as feed for animals. The leafy type of amaranth can also be used as a vegetable to all sorts of salads (Kłoczko, 2008; Dudziak et al., 2010; Borowy, Kubiak, 2012).

Amaranth contains about 2.5 times more protein than rice, about 40% more than barley, wheat and corn, and about 25% more than rye and oats, and biological value of amaranth protein is high, because there are present exogenous essential amino acids that are not synthesized by human organism. The content of lysine, which is a limiting amino acid (the smallest amount in relation to the egg protein) in cereal crops is twice as high as in wheat and three times higher than in rice and sorghum ranging from 0.701 to 0.908 g/100 g grain. The crop also contains high levels of sulfur amino acids: methionine, cystine and cysteine: 0.591-0.752 g/100g of seeds. Compared to other cereals, amaranth contains twice more sulfur amino acids than maize and rice and about 1.5 times more than wheat. Amaranth protein biological value with respect to the FAO standard for chicken proteins within 100-point scale is at a level of 75-80, whereas for other plants, the value is lower: 44 for maize, 60 for wheat, 64 for soybean (Darewicz, Dziuba, 2007; Marciniak-Łukasiak, Skrzypacz, 2008; Januszewska-Jóźwiak, 2009).

A combination of amaranth with traditional cereal flour can play an important role in human nutrition. The addition of amaranth flour into other cereals improves the quality of the mixture. Available data indicate an increase in protein quality by 62% for wheat flour, by 40% for corn flour, and by 25% for rice at the proportion of amaranth to other cereal flour of 30:70. The amaranth flour can be a natural bread improver. Even small addition not only improves the nutritional value of bread, but also successfully replaces synthetic improvers. This flour improves the rheological properties of dough, making them more flexible and plump, increases the bread volume, and shortens fermentation time (Borowy, Kubiak, 2012). Amaranth is also a valuable component of special bakery products intended, among others, for vegetarians, allergies, celiac disease or atherosclerotic disorders suffering patients, convalescents, and athletes.

The fat content in amaranth grain ranges from 4.8 to 8.1% depending on the species (Darewicz, Dziuba, 2007; Marciniak-Łukasiak, Skrzypacz, 2008; Czaplicki et al., 2011), which is the highest content in the cereal group. The main components of amaranth fat are essential fatty acids, among which linoleic acid (62%), linolenic acid (1.1%), and arachidonic acid (0.7%) make up the highest proportions, as well as monounsaturated oleic acid (20.4%). These acids are very important from nutritional and health points of view. A major advantage of the lipid fraction of amaranth is a high content of valuable squalene (over 6%). Squalene is a regulator of cholesterol synthesis and enhances the immune system through a beneficial effect on the lymph nodes, adrenal glands, and bone marrow. This triterpenic hydrocarbon ($C_{30}H_{50}$) has up to 6 double bonds, due to which it exhibits excellent antioxidant properties (Kłoczko, 2008). Squalene is a natural component of lipids protecting against harmful UV rays and other

aggressive external factors, as well as it helps to remove any kind of non-polar xenobiotics (substances harmful to human health and introduced into the environment and into the organism as a result of industrial activity) from the organism. Xenobiotics are readily dissolved in non-polar squalene and are eliminated from the organism altogether (Kłoczko, 2008; Piesiewicz, 2012).

Although amaranth, like other cereals, is a crop with high carbohydrate content (60% DM), it also has a low content of mono and disaccharides (2-3%). The rest is made up by pentosans (3-4%) and starch (55-65%), which is 2-5 times more readily digested and absorbed than the same complex carbohydrate contained in millet (Januszewska-Jóźwiak, 2009). Fact that amaranth contains more calcium and iron than conventional corn is worth mentioning. Grains of this plant contain extremely much calcium: 217-303 mg/kg. However, the level of vitamins in this alternative crop is similar as in conventional cereals.

The anti-nutritional compounds contained in grains and roots of amaranth include: oxalates, phytates, phenolic compounds, saponins, alkaloids, tannins, and hemagglutinins. In particular, it is important to get rid of the saponins from raw amaranth, since these compounds are harmful to human health (causing damage to red blood cells – i.e. hemolysis). It turns out that technological processes and cooking eliminate almost completely the content of these adverse substances (Januszewska-Jóźwiak, 2009; Piecyk et al., 2009). It should be noted that amaranth grains contain less antinutrients than soybean and rye (Borowy, Kubiak, 2012).

Due to its chemical composition and the pro-health impact, processed products made from amaranth apply to preventive diets reducing the risk of atherosclerosis and heart disease, anti-aging diets, because squalene delays the organism's aging processes, gluten-free diets, the high protein diets (e.g. for pregnant women), diets for persons with skeletal system disorders, because amaranth contains a lot of calcium and tocotrienols (antiinflammatory agent), vegetarian diets, as it contains high concentration of lysine, as well as iron, calcium, and vitamins, including A, E, C, for which 90% of the requirement is covered by about 100 g of amaranth grains (Niekrasz, 2011; Piesiewicz, 2012). Amaranth and its products therefore, meet all the criteria of a healthy and functional food.

4. Summary

FAO has drawn attention to the idea of *food security* for a long time, because sufficient amount of healthy food is a prerequisite for life. The longer the chain of access to some vital ingredients, the more likely that one of its elements will be the weakest link. Nutrition is an extremely important issue that raises a lot of emotions. Nutritionists and other *experts* on nutrition have been heavily indoctrinated by a positive influence of *healthy whole-grain food* on human. The issue of genetically modified cereals not only to increase the yields, but also to stimulate the consumer's appetite, is still little discussed. At the same time, the anti-fat phobia, that has prevailed for over 40 years, discourages to consume foods such as eggs, beef, and pork, because of saturated fats contained. However, saturated fat was never a problem. The carbohydrates in combination with saturated fats cause a sharp increase in blood LDL (bad cholesterol). Carbohydrates rather than saturated fats has always been larger problem.

Pervasive promotion of cereals praised as a healthy food set the trends and fashions in diet and surrendered them the agricultural markets and production fields. Sometimes it seems that we will extinct as a species without a few slices of bread a day, with no cereals and without oatmeal. The truth is that while the development of agriculture and the cultivation of cereals have enabled a rapid population growth and the formation of modern societies based on specialization and division of labor, in terms of health it proved to be a disaster for us, related to the one-sidedness and genetic hybridization of crops aimed at providing food quality and safety. In addition, high consumption of cereal products amounting to about 120 kg/person annually is the cause of their deficit, which leads to the need of its supplementing through imports. The import can be reduced by means of spreading the amaranth cultivation. This crop can be grown on soils not suitable for other cereals. Moreover, amaranth grains due to the high nutritional value, especially in view of special characteristics of protein, fat, and starch, are becoming more and more popular among producers, consumers, and the industry.

As a consequence of deliberate intervention in agroecosystems, a man can control their productivity and increase the amount of produced biomass, which can be utilized as food for humans, feed for animals, and raw material for many industry branches. Growing the alternative crops, among others the amaranth, shows agriculture as an economic activity that combines natural laws with human interference into a single coherent system operating in accordance with the principle of sustainable development. In this way, resources of arable lands are exploited in a sustainable manner, because the soil is a non-renewable treasure of the nations and the most precious resource. Renaissance of the agriculture and sustainable development between countries should therefore be based on a gradual introduction of a variety of plants species, competing with imperialism of herbaceous and cereal crops not only in Poland, but also in other countries. From alternative plants new, healthier. and less processed goods are made. Such approach to the agricultural future promotes not only the safety, but also the nutritional sovereignty of so-

cieties. Beside it is necessary to stimulate the economic growth, since it is required to provide new employment and prosperity for its citizens and to make the quality of this growth, which leads to the achievement of sustainable future agriculture.

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