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TOWARDS SUSTAINABLE FOOD SYSTEM

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Abstract. The paper addresses the terms "food safety", "food security" and "food system", from the position of commodity science (in Polish: towaroznawstwo) and economic sciences. The various descriptions of these items in literature are reviewed. Food safety has been described as opposite to food risk. Hence the authors discuss the differences in perception of food risk by customer, producer/supplier and official agencies. The objective safety of food risk (biological, chemical and physical) is measured by producers and official agencies but not by customers. Food security is a mix of availability, access, utilization and stability of supply over time. It is understood by a set of voluntary, obligatory and supplementary systems under inspection and control of official institutions on the local, regional or global level. Set of various expected and possible activities to ensure sustainable food system (SFS) in future has been proposed by the authors.

Key words: food security, quality, food system, sustainable food system

INTRODUCTION

Food is most necessary commodity for people and must be safe and secure. There is an increasing concern about the impact of food production systems on the quality of life and on the environment. The evidence of many health problems caused by unsafe food, agriculture/husbandry and the food production chain is well documented. Studies on food security on various levels are numerous and show divergences. The literature on most important food production aspects, food quality and quantity as well as on food losses is substantial and growing.

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Food safety and food security are now in the centre of interest of various scientific disciplines. This is in line with "the trend towards greater position of safety in other areas such as workplace safety and environmental protection" [Segerson 1999]. Both belongs to different scientific disciplines yet partly overlapps. The term "food safety" from the position of natural science, medical sciences, food technology, commodity science describe various aspects of health, probability of illness, poisoning or injury as a consequence of consuming a particular food [*Codex Alimentarius* 2003]. Food safety from the perspective of economy and social science describe security of production system, supply chain coordination, food availability, continuity and sufficiency for consumer and industry now and in the future. The issues connecting food safety and food security, as non-separable parts of system, will be discussed in this article. However, they belong to different scientific disciplines, dominated by competing stakeholders (e.g. governments, suppliers, institutions and politicians).

The aim of this paper is to deliver an analysis of place, significance, relations and differentiation between the terms "food safety" as a element of quality and "food security". The question arises if both are parts of the food system (local, regional or global). The additional question addressed in this paper is whether the food system is or could become sustainable in future or not?

FOOD SAFETY AND QUALITY

Food safety is an element of food quality [Świderski 1999, Grunert 2005]. The term "quality" has been defined by various authors in different ways. The most comprehensive definition states that quality means fulfilling the needs/requirements of a customer [Juran and Gryna 1974]. According to ISO 9000:2015 international standard "quality is a degree to which a set of inherent characteristics fulfills requirements". There is no doubt that quality is relative and does not exist on its own. Its perception is not constant over time or space because consumers change their needs, habits and preferences due to various circumstances.

Suppliers and producers of food describe the quality targets through market segmentation which can be driven by examining the consumer' structure of quality attributes according to their importance. Some attributes are very important (critical) in eyes of consumers and other not important for a given person or a segment of customers. This segmentation will lead to a definition of the "quality of type" which is generally described by documentation, formulas elaborated by producers or innovators, external or internal standards, specifications following the request of clients, results of scientific work, tradition etc. Quality of type formation strongly depends on the product concept [Zalewski 2008] and consumer expectations. In developed countries, the number of consumers seeking organic or high quality food depends on the actual level of information on the scientific results, the quality of raw foodstuffs, ingredients, additives, technology, processes packages and the storage/transportation technology. According to the report

of Fairtrade from 2013[1], the fair trade sector is growing dynamically and in 2013 hits 4.3 billion EUR in consumer sales worldwide.

A given quality of type serves as a standard to which actual production is compared, by measurement of various properties of raw materials used to production and processes execution. The growing significance of food quality during last decades has been observed and documented [Zalewski and Skawińska 2004]. The impact of science on quality issues has helped to shift the attention from control of processes to prevention and understanding of processes. People have accepted that it is better to build in the desired product quality at the initial stage of its life-cycle [Zalewski 2008, Roy 2012].

It refers to the decrease of various attributes of food quality mentioned in Figure 1, linked to the degradation of the product, at all stages of the food production chain from harvest to consumption. Food quality, as shown in Figure 1, is a result of various properties and functions of given food.

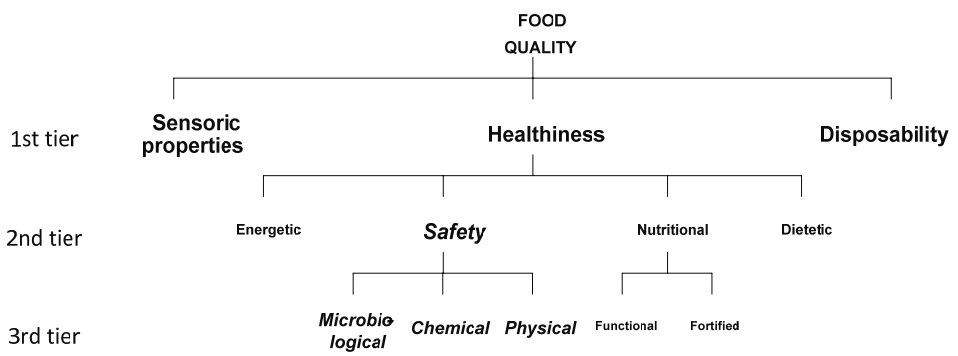

Fig. 1. Food quality as a function of basic attributes and values for consumers
Source: Own illustration after Świderski [1999].

Most consumers ranked the first tier of the food quality attributes in the order: taste, health, convenience [Grunert 2005]. Similar results can be found in numerous research with some regional differentiation for example in Europe [Grunert 2005], Việt Nam [Mubarik et al. 2006] or USA, Italy and Japan [Bertolini et al. 2003]. Japanese consumers were more directed towards food safety, e.g. irradiation, GMO free, genetically modified food. American and Italian consumers were likely to trust their governments about food quality and safety than Japanese consumers. For simplicity, sensory and disposability are not further developed in Figure 1.

In the second tier, only health attribute is shown as a construct of four values, namely safety, nutrition, energy and dietetics. The last two are less important for further discussion. In the third tier only safety and nutrition are described further.

Nutrition value is further split into functional and fortified. Following Ch. Hansen [Joppen 2006] "…all food is functional. That is why I prefer to work with functional food

[1]http://www.fairtrade.net/fileadmin/user_upload/content/2009/ resources/2013-14_AnnualReport_FairtradeIntl_web.pdf (access 20.12.2015).

that is already recognized as predominantly healthy (e.g. milk products due to hospitable environment), and good staple food consumed in significant amounts and with high frequency". Most food products on the market called functional are actually fortified with certain nutrients (e.g. minerals or vitamins). However, there are some reservations from public against such enhancements.

In literature, there are various definitions of food safety distinguished as broad and narrow ones. In the narrow sense, "it can be defined as the oposite of food risk, i.e. as the probability of not contracting a disease as a consequence of consuming certain food" [Grunert 2005]. P. Slovic [2002] have shown that perceived risk is both predictable and quantifiable and I. Shaw [2005] sets the risk of food in the broader context of a life's risk. A description of food safety as protection of food against chemical, biological and physical factors that can endanger human health has been used by *Codex Alimentarius* [2003], adopted by the HACCP principles (Hazard Analysis and Critical Control Point), the ISO-EN 22000 standard and many others.

Safety value for consumers is further split into three most important sources of health risk: microbiological (presence of pathogen microorganism), chemical (naturally occurring, additives allowed but exceeding certain concentration, residues of pesticides, herbicides, supporting chemicals, drugs, antibiotics, detergents, hydraulic liquids etc.) and physical (as appearance of external materials of various origin).

Unfortunately only few consumers are able to adequately evaluate quality attributes of food products and estimate eventual risk due to their consumption, as a first line of defense against health risk, quality loss or waste. The importance of the sensory attribute (e.g. taste, smell, appearance, texture, sound etc.) comes from experience, culinary heritage and sensory threshold of the individual food consumer. In many cases one is able recognize non-fresh foodstuffs by taste or smell. However professional knowledge of sensory analysis of food is restricted to a small population of people working in laboratories and applying a set of procedures based on generally accepted international standards.

Other food attributes such as influence on health and well being, easiness of preparation, chemical constitution or presence or absence of various substances, are difficult to examine and less important in the opinion of consumers. However, their role is growing due to better education and increasing awareness of food labeling, which decreases the information asymmetry in the food production chain between the producers and the customers. Some customers "seem to want information to help them achieve a balanced diet, to avoid certain allergens or ingredients that have proved not to agree with them, or to know the origin and environmental, ethical and technological conditions under which the food was processes" [Werbeke 2005]. This information can be used by consumers to choose between alternative products and to maximize their expectations. Such subjective quality is discussed lately in literature [Grunert 2005, Singham, et al. 2015].

Objective quality is a result of evaluation of numerous measurable characteristics and properties of a given food using scientific methods based on the highest scientific achievements and officially approved by independent organizations e.g. *Codex Alimentarius*, FAO, WTO. The execution of such measurement is in the hands of food control laboratories in the industry, supply chain, official control institutions or consumer organizations. The accuracy, precision, repeatability, performance etc. of their work is examined by laboratories of the highest expertise (e.g. reference laboratories or notified under EEC directive) [Caroli 2005].

FOOD SECURITY

In contrast, food security is understood as security of production, supply chain coordination, availability, continuity and sufficiency for the consumer and the industry and is more interesting for agricultural economists, politicians and the publics concerned about:

- product liability, terms of international trade, interactions between risk analysis and economic analysis [Unnevehr et al. 2003];
- food regulations and trade development towards an open global system [Pingali 2006, Żurek 2012];
- estimation of effects of agricultural policy on poverty in Europe and in developing countries [Schneider and Gugerty 2011];
- globalization of safety risk and failures [Unnevehr 2006, Maruchecka et al. 2011];
- or the geography and causes of food insecurity in developed, developing and undeveloped countries [FAO 2015 report], which were discussed in the literature.

According to the FAO definition, "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (http://www.fao.org/economic/ess/ess-fs/en/). Statistics Division developed a set of indicators which describe opposite – i.e. "food insecurity" – by measuring food availability, access, utilization and stability. S.L. Hendrics describes food insecurity as a continuous range of experiences between starvation and adequate quality and intake, divided into three stages: food insecure, insecure to vulnerable and food secure [Hendrics 2015]. More information about the construction of those indicators can be found in the report on food insecurity. At present "about 795 million people are undernourished globally, down 167 million over the last decade, and 216 million less than in 1990–1992. The decline is more pronounced in developing regions, despite significant population growth. In recent years, progress has been hindered by slower and less inclusive economic growth as well as political instability in some developing regions, such as Central Africa and Western Asia" [*Food insecurity*… 2015 and previous editions].

The priority of increasing food production was a key focus of agricultural research in the past (e.g. Green Revolution). According to Beintema and Elliot, "Agricultural research was indeed successful in the latter quarter of the 20th century in rapidly and significantly increasing production of staple grains (…) and total food calories". As consequence, investment in agricultural research and development declined until the next significant food price spike in 2007–2008 [Beintema et al. 2009, World Bank 2014]. In addition, de Carvalho [2015] quotes data on food supply per capita (kcal·capita^{-1}·day^{-1}) and total average growth rate in the period 1961–2007 concluding, that in many regions of the world, the growth rate is geometrical. Simulation results of macroeconomic data demonstrate that higher economic growth influences demand more than supply. Emerging economies tend to import food for improvement of their security while the other countries increase the export. In turn, faster economic growth leads to lower world prices, the magnitude of the effects decreases over time, and markets do not regain their baseline levels immediately. Due to such policy, the less developed countries are importing more and increasing their per capita food calorie intake. However, they simultaneously become movulnerable to disruptions and shocks on agricultural world markets [Kavallari et al. 2014]. Most

probably now "there is a need to focus relatively more on diet quality, which sits at the heart of food systems" [Herforth et al. 2015] and to interfere in food systems.

The current challenges for food security include the impact of climate changes and water shortage on food production. In a well documented research, D. Pimentel et al. concluded that the availability and quality of fresh water has become a major international problem [1997]. B. Campbell [2015] argues therefore in favor of a "Climate Smart Agriculture". This strategy incorporates the reduction of CO_2 emissions and considers the complexity and diversity of activities as well as a portfolio of options and input from new R&D. According to C. Hawkes [2015], the food system is driven by overconsumption of resources (energy, water) by the industry and people. She suggests four points of action:

- prevent the food industry from creating demand for too many of wrong food;
- intensify solutions that start with consumption problems in food system;
- improving food systems (FS) governance which will bring together production and consumption;
- disseminating a food system literacy to all people.

A similar reasoning is used by Ingram et al. [2013], who states that "from the perspective of the food system activities, the need to take into account optimal allocation of natural resources to increase the efficiency with which inputs are used is emerging as a critical area for further research (…) Key elements of the food security outcomes (including nutrition, food safety and affordability) also emerged as priorities". Concerns about the future impact of climate change on the food led to a number of significant estimations on the future of food systems [OECD 2008, e.g. Godfrey et al. 2010] which explored priority areas for action, to ensure the world could feed its predicted population in 2050. The report states "For wheat, rice and maize in tropical and temperate regions, climate change without adaptation is projected to negatively impact production. (…) Climate change is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions, intensifying competition for water among sectors" [*Climate Change* 2014].

ARE FOOD SYSTEMS SUSTAINABLE?

The definitions of food systems (FS) in literature are numerous [e.g. Ericksen et al. 2010, Ingram et al. 2013]. In our opinion one very compact and complete definition states: "a food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes" [*Food Losses*… 2014]. In other words FS includes all steps from agricultural raw production (including crops and animals) up to the food eaten by consumers and includes all losses occurring between the very source up to the consumers' table. At each stage along the processing chain some losses occur. For example "food waste refers to food appropriate for human consumption being discarded or left to spoil at consumer level – regardless of the cause", while "food loss and waste refers to a decrease, at all stages of the food chain from harvest to consumption in mass, of food that was originally intended for human consumption, regardless of the cause" [*Food Losses*… 2014].

Numerous available data suggests that the necessity to reduce the amount of food losses and waste in all links of the food production chain is evident. For example Figure 2 shows that the total food loss per capita by consumers, in production and in retail, is almost 300 kg per annum in highly developed and approximately half this value in underdeveloped countries. The difference between consumer food waste in Europe and North America is approximately 100 kg per person higher than in Sub-Saharan and South-East Asia countries [FAO 2011]. There are also dramatic differences between losses in various groups of foodstuffs in particular regions due to climate and technology used (Fig. 3).

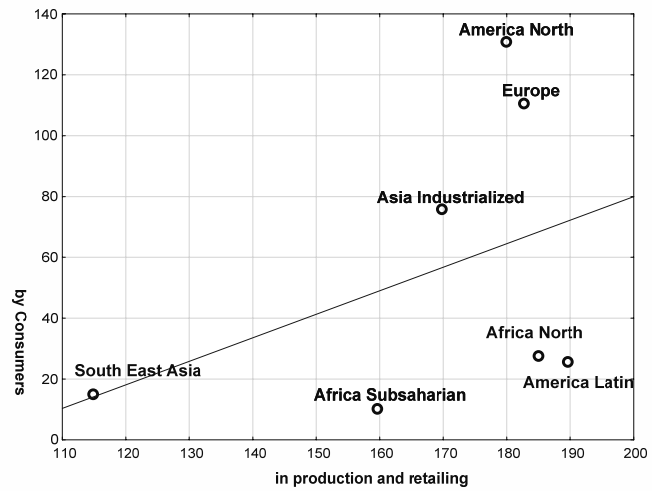

Fig. 2. Annual food losses and waste per capita in different regions at consumption and pre-consumption stages

Source: Own drawing using data from FAO [2011].

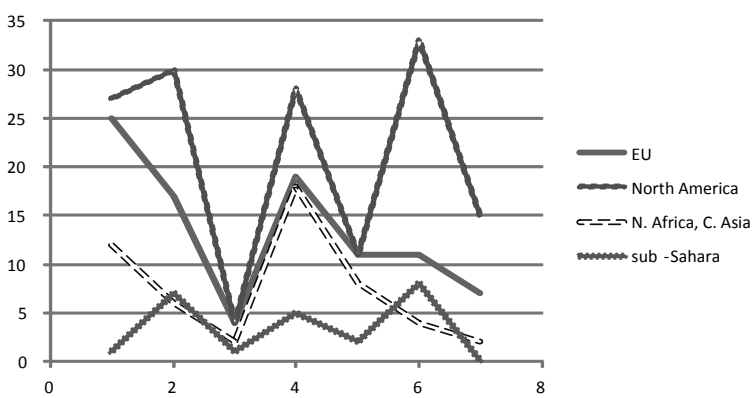

Fig. 3. Weight percentages of food losses and waste (as a percentage of input entering each step): 1 – cereals, 2 – roots and tuber, 3 – oilseeds, 4 – fruits and vegetables, 5 – meat, 6 – fish and sea food, 7 – milk

Source: Own drawing from data FAO [2011].

Similar data on food waste in EU was presented lately [Masar 2015]. He suggested that approximately 30% of edible and healthy food is wasted in the EU – i.e. approximately over 89 million t of food annually or 180 kg of food per capita per annum. Also in Poland food waste is high as indicated in reports published in 2012 and 2013 [Raport Federacji 2013].

It is expected that a sustainable food system will, at last in part, help to decrease the problem. The term sustainability has been proposed, discussed and introduced into science and praxis in the 1970. The number of definitions of sustainability found in literature is vast. In the particular case of the food system, sustainability "ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised" [Esnouf et al. 2013, Garnett 2014] and can be visualized by the double-pyramid model (Fig. 4) of drivers and security measures.

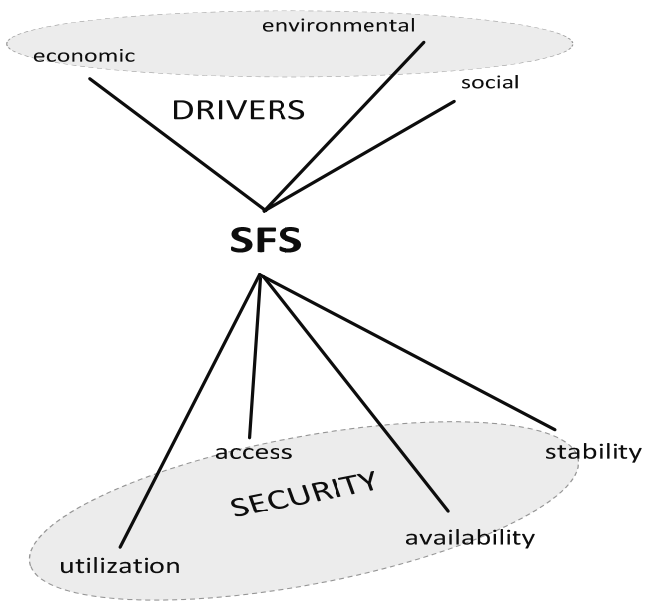

Fig. 4. Sustainable food system (SFS)
Source: Own drawing.

Among security measures one can mention availability, access, utilization and stability of supply over time. The discussion on those measures is out of scope of this paper, although all of them are strongly linked to food quality and finally to its safety. However, the components in SFS are of economic, social and environmental nature, as discussed above. Unfortunately, their directions frequently are opposite.

The expected by the authors activities of all participants and players in food system, that can help to build SFS in the future, are listed in Figure 5.

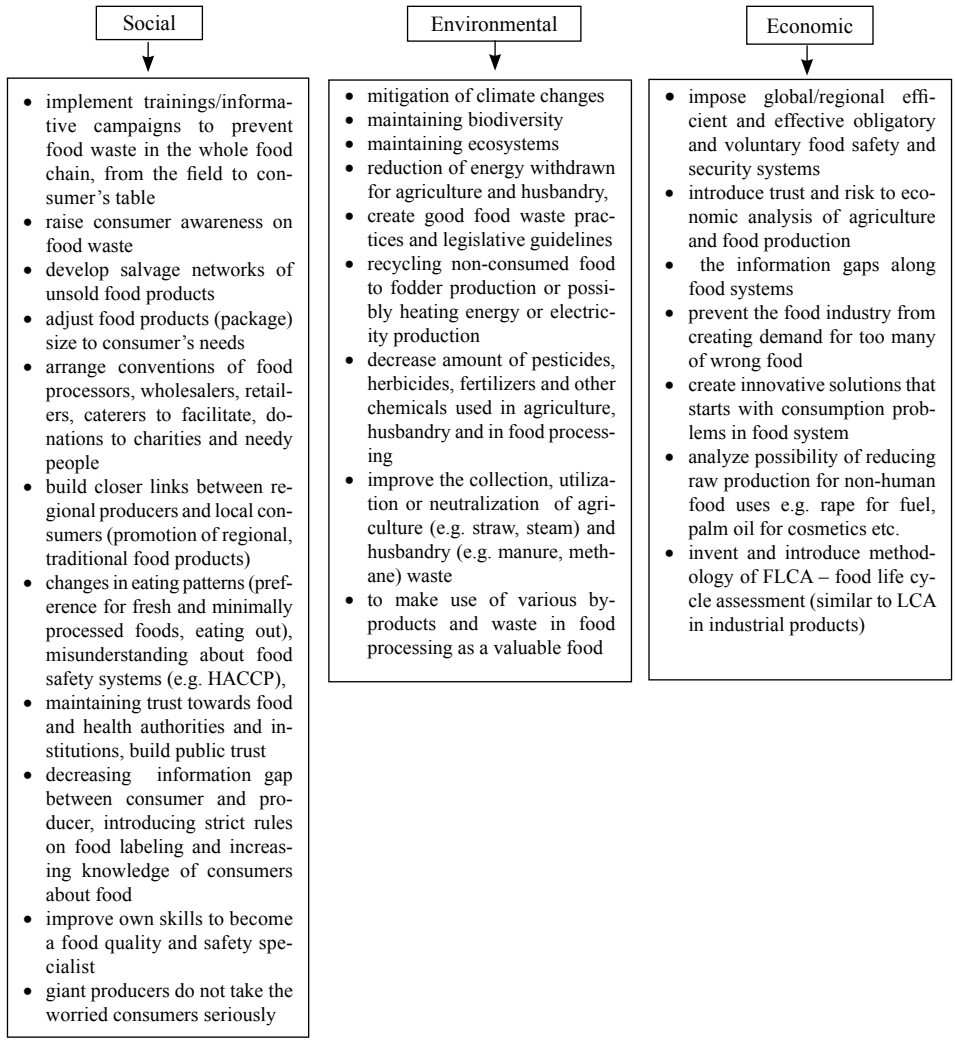

Fig. 5. Expected and possible activities to ensure sustainable food system in future
Source: Own knowledge.

CONCLUSIONS

The authors analyzed the terms of food safety and food security from perspectives of economy and natural science. Food is a necessary everyday commodity and its parameters are evaluated from the position of both the customer (subjective quality, narrow sense of safety) and the producer/supplier (objective quality, broad sense of safety). Food safety policy has been describeded as a construct of voluntary, obligatory and supplementary systems acting along food value chain and being under the impact of official food control.

The food safety policy system is very flexible and can be shaped by the actual needs and requirements. The role of official control authorities which could mould the shape of the system in a given country will be very important.

Food security has been described as combination of security of production and supply chain coordination, availability, continuity and sufficiency for consumer and the industry. Various available data, strongly suggest reducing the amount of food losses and waste in various links of food production chain. In addition construction of sustainable food systems on local, regional or global level is strongly recommended.

We conclude that food security, food safety and a sustainable food system all belongs to so-called wicked problems [Dentoni et al. 2012]. All of them are composed of many independent and dependent variables being in a certain state of equilibrium. The task for the future is to try to modify and improve the relations between them at the most desirable level.

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W KIERUNKU ZRÓWNOWAŻONEGO SYSTEMU ŻYWNOŚCIOWEGO

Streszczenie. W publikacji dokonano, na podstawie analizy literatury, porównania kategorii „bezpieczeństwa zdrowotnego" z punktu widzenia nauk przyrodniczych i „bezpieczeństwa ekonomicznego żywności" oraz z perspektywy konsumenta i producenta. Bezpieczeństwo zdrowotne i jakość żywności są funkcją jej różnorodnych właściwości (mikrobiologicznych, chemicznych i fizycznych), które wpływają na ryzyko jej spożycia. Przedyskutowano różnice jego oceny przez konsumentów, producentów i nadzór nad rynkiem. Bezpieczeństwo ekonomiczne dla konsumenta i producenta określono jako mix składający się z dostępności, stabilności i korzyści w dłuższym okresie. Oba rodzaje bezpieczeństwa tworzą system żywnościowy w skali regionu, kraju, a nawet świata. Przedstawiono wpływ niektórych czynników zaburzających jego stabilność (straty i marnotrawstwo żywności w łańcuchu „od pola do stołu", zmiany klimatyczne i deficyt wody). Ich ograniczenie może doprowadzić w przyszłości do zrównoważonego systemu żywności. Przedstawiono zbiór oczekiwanych i możliwych działań zmierzających do zrównoważenia systemu w przyszłości.

Słowa kluczowe: bezpieczeństwo żywnościowe, jakość, system żywnościowy, zrównoważony system żywnościowy

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