

Bogdan Klepacki, Aleksandra Perkowska
Warsaw University of Life Sciences – SGGW

Specificity of the supply chain on the cereals market

Specyfika logistycznego łańcucha dostaw na przykładzie rynku zbóż

Abstract. The study presents the production of major agricultural products in Poland and in the world. The specificity of logistics in the field of plant production has been described in detail. The supply chain scheme in agribusiness was presented. The article presents trends on the global cereal production market and describes the market in Poland in detail. A graphic presentation of the flows of cereal products from primary producers to the consumer was prepared. The authors presented the trends of changes in the cereals sector and their products. Studies have shown that the logistics chain of cereals and their products is extensive. It covers many grain producers, agri-food processing units, agricultural trade, wholesale and retail food trade. The condition for the success of the cereal logistics chain is its efficient management, as well as the mutual trust of its participants and flexibility in adapting to new challenges.

Key words: logistics, agriculture, food industry, agricultural trade, supply chain, cereals

Synopsis. W opracowaniu przedstawiono produkcję ważniejszych artykułów rolnych w Polsce i na świecie. Szczegółowo opisana została specyfika logistyki w zakresie produkcji roślinnej. Zaprezentowano schemat łańcucha dostaw w agrobiznesie. Przedstawiono tendencje na światowym rynku produkcji zbóż, a także opisano szczegółowo rynek w Polsce. Opracowano graficzną prezentację przepływu przetworów zbożowych od wytwórców początkowych do konsumenta. Przedstawiono tendencje zmian w sektorze zbóż, a także ich przetworów. W badaniach stwierdzono, iż łańcuch logistyczny zbóż i jego przetworów jest rozbudowany. Obejmuje on wielu wytwórców zbóż, jednostek przetwórstwa rolno-spożywczego, handlu rolnego, hurtowego i detalicznego handlu żywnością. Warunkiem sukcesu łańcucha logistycznego zbóż jest sprawne zarządzanie nim, a także wzajemne zaufanie jego uczestników i elastyczność w dostosowaniu się do nowych wyzwań.

Słowa kluczowe: logistyka, rolnictwo, przemysł spożywczy, handel rolny, łańcuch dostaw, zboża

Introduction

Poland is a country with significant agricultural production potential, resulting from a relatively large, in relation to many other EU countries, areas of arable land and considerable resources of the labor force. The specific features of Poland's natural conditions and the entire complex of organizational and economic conditions [Krasowicz and Kuś 2010] determine the degree of utilization of this potential and its regional diversity. Production of cereal products in the world is important compared to other plant products however, it is produced in conditions of the dispersed economy, which causes the need to create effective supply chains. Recently, the concentration of cereal production has been noticed, but hundreds of thousands of farmers still deal with this activity. In the research of A. Madej [2018], an analysis of the spatial concentration of cereal cultivation for most crops, in 2016 compared to 2010, showed an increase in concentration index with varying levels of severity. This means that in the modern economy, the importance of organizing and managing cereal flows will continue to be very important.

The aim and methods

The main aim of the article was to analyze the market of plant products with particular emphasis on cereal products. The article also presents the author's pattern of the cereal sector supply chain. The research material was secondary data from publications of the Polish Central Statistical Office and the Institute of Agricultural and Food Economics – National Research Institute. Data analysis covers plant production with particular emphasis on cereal products, both in Poland and worldwide.

The study uses the method of literature review. The results of the data analysis were presented using a descriptive, tabular and graphic method.

Position of Poland in the global crop production

Plant production in the world is very diverse. The level of production of individual plants on a global scale is presented in Table 1.

On a global scale, the most important group of plants deciding about the possibility of feeding humanity are cereals (including corn and rice). Their total harvest in the world in the year 2017 is estimated at 2,892 billion tons. The basic cereal crop is corn, supplying 39.2% of the grain, the rice followed by wheat (by 26.7%). These three plants provide a total of 92.6% of the total grain of this group. Much smaller is the importance of barley and marginal millet, oats and rye.

Poland is one of the major producers of plant products both in the European Union and in the world. Important information in this area is presented in Table 2.

In the European Union, Poland is a leading producer of rye, potatoes and sugar beet. It is similar in the case of world rankings, although apart from rye they are usually further places. For comparison, the second part of the table gives Poland's place in mining activities and selected industrial production. The data indicate that the places obtained by Polish agriculture are similar to the position of other branches of the national economy.

Table 1. World production of more important agricultural products

Tabela. 1. Światowa produkcja ważniejszych artykułów rolnych

Agricultural products	The level of production in (M t)		Change (%) 2017/2010
	2010	2017	
Grain	2381	2892	21
Maize	852	1135	33
Wheat	640	772	21
Rice	701	770	10
Barley	123	147	20
Millet	33	28	-15
Oats	20	26	30
Rye	12	14	17
Potatoes	333	388	17
Sweet potatoes	106	113	7
Sugar cane	1683	1842	9
Soybeans	265	353	33
Rape	59.8	76.2	27
Olives	20.4	20.9	2
Groundnuts in shell	43.5	47.1	8
Vegetables (excluding melons)	824	1094	33
Fruits (including melons)	756	866	15
Citrus fruits	129	147	14
Coffe	8.5	9.2	8
Tea	4.6	6.1	33
Cocoa beans	4.3	5.2	21
Cotton (lint)	23.8	26.2	10
Flax fibre and tow	0.6	0.8	33
Sisal	0.4	0.2	-50
Natural rubber	10.8	14.3	32

Source: [GUS 2019].

Table 2. Poland's share in selected production areas in Europe and the world
Tabela 2. Udział Polski w wybranych obszarach produkcji w Europie i na świecie

Specification	Share in % of the EU		Place in the EU		Share in % of the world		Place in the world	
	2010	2017	2010	2017	2010	2017	2010	2017
Total area	1.4	1.4	9	9	0.2	0.2	68	69
Population	5.2	5.1	8	8	0.6	0.5	68	69
Production of:								
wheat	4.7	4.3	6	6	1.5	1.5	15	16
rye	27.8	23.9	2	2	23.9	19.5	2	2
barley	4.6	4.3	7	8	2.8	2.6	11	11
maize	2.3	3.6	13	8	0.2	0.4	38	27
potatoes	7.9	7.5	4	4	2.5	2.4	7	8
sugar beets	6.6	7.6	5	4	4.4	5.2	7	6
raw sugar	7.4	7.8	4	5	1.0	1.0	20	16
Production of primary energy	2.7	2.7	8	6	0.5	0.5	36	34
Production of coal:								
hard	18.4	15.6	2	2	1.2	1.0	9	10
lignite	10.5	11.6	4	3	6.7	7.4	7	5
cement	5.9	6.1	6	4	0.5	0.4	26	26
crude steel	2.8	3.8	8	7	0.6	0.6	19	19
refined copper	15.3	15.6	3	3	2.9	2.5	9	10
electricity	3.2	3.4	8	7	0.7	0.7	23	24
gross domestic product	2.4	2.6	11	10	0.7	0.7	24	23

Source: [GUS 2019].

Trends in cereal production in the world and Poland

In world statistics, cereals are most often analyzed in two groups: wheat and feed grains. Wheat is grown on the largest scale in the Commonwealth of Independent States, the Americas, the European Union and East Asia. In the last two decades, the area's tendency has increased (in the harvest years from 2000/2001 to 2014/2015 by 3.9%), with the highest dynamics in South Asia (by 14.9%) and Oceania (11.2%). A decrease (20.5%) was recorded in South America and North America (by 5.3%). The area of fodder cereal

cultivation increased by 8.4% over the period considered, the fastest in East Asia (by 40.9%) and South America (by 27,%). The decrease was mainly recorded in South Asia (by 11.3%) and the European Union (7.7%).

Area crops are not the best measure of the importance of individual cereals, more accurate is the level of collections, which are presented in Table 3.

Table 3. Wheat and feed cereal harvest by region of the world

Tabela 3. Zbiory pszenicy i zbóż paszowych według rejonów świata

Region	Harvest in years (million t)			
	2000/01–2002/03	2003/04–2007/08	2008/9–2011/12	2012/13–2014/15
Wheat				
EU	125.5	131.8	141.6	147.5
East Asia	93.7	103.0	116.3	126.1
South Asia	95.7	98.4	110.9	125.9
CIS	77.8	88.3	106.4	103.0
North America	80.0	82.3	90.3	91.1
Near East	37.0	42.3	36.8	38.6
Africa	17.4	21.7	23.3	25.8
Oceania	21.0	18.2	25.5	25.1
South America	21.4	23.8	24.2	20.7
others	3.7	4.0	3.8	4.1
Feed cereals				
North America	313.6	366.0	383.7	404.7
East Asia	125.1	153.3	183.3	225.2
EU	145.1	149.3	153.8	156.2
South America	70.8	85.1	103.2	133.1
Africa	81.3	94.0	108.2	115.4
CIS	56.9	58.1	68.2	83.3
South Asia	36.9	42.1	47.2	50.5
Southeast Asia	18.6	23.9	27.0	31.0
Near East	17.0	19.4	18.8	20.3
Oceania	11.6	11.6	12.4	12.7
others	11.4	14.3	13.4	13.4

Source: [Szajner 2015].

The European Union is the largest producer of cereals, especially wheat, in the world scale, however, the volume of harvest increased much faster in Africa (by 48.4%), East Asia (by 34.6%) and South (by 31.6%) and Commonwealth of Independent States (32.4%). These regions increased the global harvest by 23.6%. Wheat production decreased only in South America (-3.3%). On the other hand, feed grain production grew the fastest in South America (88.1%), East Asia (80%) and Southeast Asia (66.6%). The European Union's advantage over other producers is decreasing. With an increase in EU production by 17.6%, China recorded a 34.8% index, and India 31.1%. The CIS and the USA are also important wheat producers, but the largest increase among the ten largest wheat producers was recorded in Ukraine (by 61.2%).

The largest producers of feed cereals are the United States, China and the European Union. However, the most harvests increased in Ukraine (by 128.8%), Brazil (96.6%), Argentina (82.1%) and in China (81.3%), with a global increase of 40.2%.

In Poland, the area of cereal sowing has been steadily decreasing since 1990, from over 14 to 11 million ha, and has stabilized in recent years. The scale of storage and marketing of cereals measured by their inventory, harvest, import and export are presented in Figure 2. During the research period in Poland, cereal harvests increased by 7.1%, although the directions and pace of change varied. Corn harvest increased the most – which is becoming an increasingly important product of Polish agriculture (over 2.5 times).

Cereals are mainly used for feed (over 60.9%) and then for human consumption (below 20%). In the analyzed years, the use of cereals for industrial processing increased (2.3 times), especially for the production of bioethanol (5.4 times).

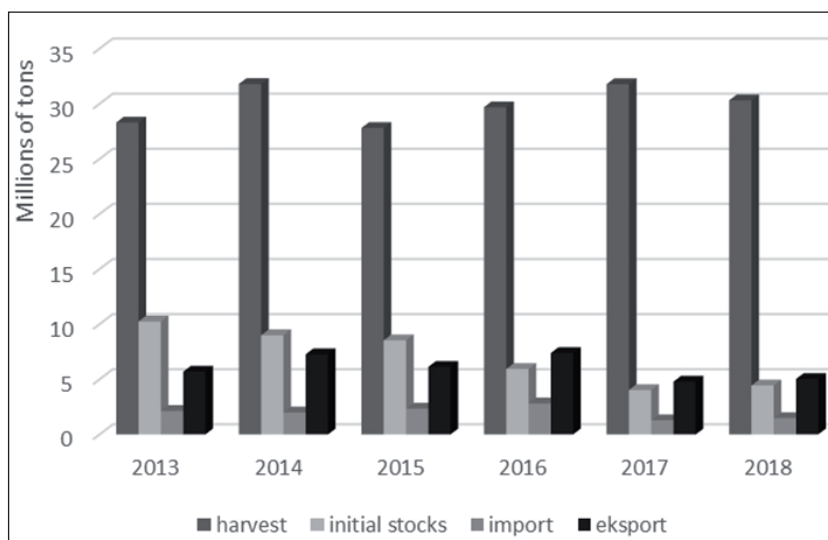


Figure 1. The level of grain mass in Poland in 2013–2018 (M t)

Rysunek 1. Poziom masy towarowej zbóż w Polsce w latach 2013–2018 (mln t)

Source: own study based on [IERiGŻ-PIB 2018].

The specificity of logistics in the field of plant production

The role of logistics in agribusiness is particularly important due to the specificity of the sector, which manifests itself in many aspects [Klepacki 2016]. There is an imbalance of supply and demand for agricultural products at different times of the year, especially in the cereals, oil and fruit and vegetable sectors. Most plant products are obtained once a year and in a certain season, while the demand for agricultural raw materials and food products is quite even. There is therefore a need to store these raw materials, while storage involves costs. In agriculture and agri-food processing, specific warehouses are needed, because products stored incorrectly lose their value (deteriorate). Often, such warehouses are specialized and their construction is expensive, but they must provide stored products with the right conditions in terms of temperature, humidity and even air movement. Many plant materials have low transport and storage susceptibility, some contain a lot of water (e.g. green fodder, silage, roots, tubers, fruit and vegetables – even 80–90%), they are not concentrated and require food processing, e.g. for drought, jams or bread. Agricultural products without processing are often economically and physically sensitive to transport. Economic sensitivity is due to the high water content, and physical sensitivity due to the delicacy of products, especially fruits such as raspberries and strawberries. Incorrectly transported, they change their characteristics and lose value for the individual customer. They can also undergo adverse processes such as fermentation, decay or drying. Some agricultural products require specialized means of transport, e.g. For the transport of flour, cereal, rice – bulk transport. The farm is of a spatial nature. Plant production takes place in fields located at a considerable distance from the economic center and other fields. This means that a large mass must be transported to and from the fields of the production means (fertilizer, seed, pesticides, water), and agricultural products (grain and straw cereals, potato tubers, roots beet, vegetables, fruit etc.). In agriculture, not very large, dispersed farms still dominate, which means they need to consolidate small batches of goods into larger units for trade, processing or export. This means the need for many intermediate links in the supply of raw materials and food products from the farmer to the final consumer. Both the level of technical sophistication and the level of producers' knowledge vary. Not all manufacturers appreciate and implement modern technological requirements. They are often very attached to traditional production methods, while the contemporary audience put specific demands on product quality, as well as their uniformity.

Typical supply chain in agribusiness

Logistics supply chain is the next stages of the entire process flow of goods and services from producer to consumer [Bechtel and Jayanth 1997]. Such a chain can be of different lengths and depths. It starts with producers of primary raw materials for the entire production (e.g. oil, coal, etc.), or a specific link in the chain. Regardless of their length, all operations and processes must be organizationally and financially coordinated. International institution – The Council of Supply Chain Management Professionals (CSCMP) provide the concept of logistics management as “that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the

point of consumption in order to meet customers' requirements" [CSCMP 2019]. Mentzer et al. define the supply chain as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" [Mentzer et al. 2001].

In a typical logistics chain, there are many processes related to production, inventory, demand management, order processing and purchasing. In the course of implementing the logistics chain, it is important to obtaining raw materials (e.g. extraction), a supply of raw materials and semi-finished products, production as well as distribution of finished products to the customer. The logistics chain is a network extending between the supply and sales market, producers, suppliers, commercial units, logistic units and final recipients. It covers the flow of goods, information and financial resources [Szymańska et. al. 2018].

The basic organizational principles that exist in logistics chains generally also apply to food flows. Organizational scheme common to almost all logistic chains in agribusiness is shown in Figure 2.

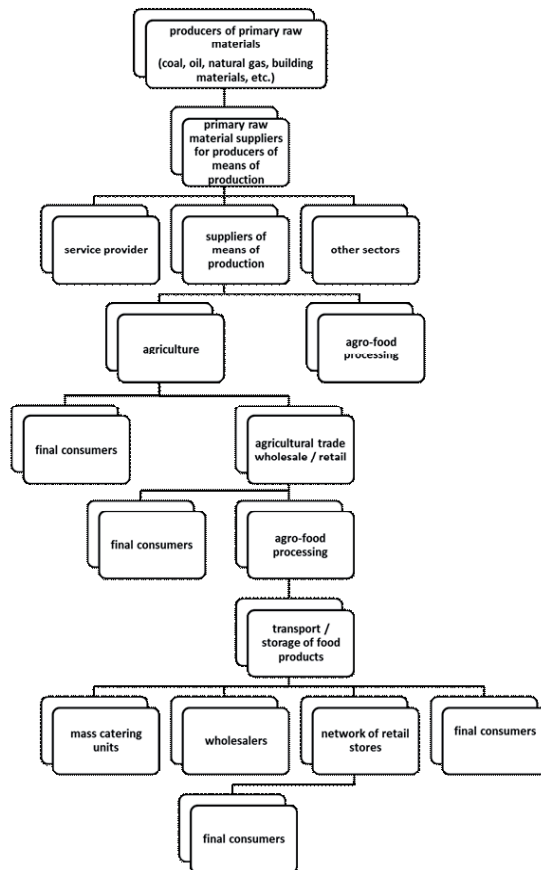


Figure 2. Generalized scheme of food supply chains
Rysunek 2. Ogólny schemat łańcuchów dostaw żywności

Source: [Klepacki and Perkowska 2018].

Logistics supply chain of the cereal sector

Food products can be obtained directly from cereals as a raw material, or indirectly. Direct use takes place with only a slight grain processing, e.g. in the form of milling, resulting in middling serving as an animal feed. This situation is common in meat and milk producers, who use their own feed grain cereals. The situation is similar in the production of e.g. cereal or oat flakes. Increasingly, cereal grain is “processed” several times in various production and commercial units. This means that the movement and processing must take place inefficient links of many networks of connections [Klepacki 2000]. The main cereal supply chain processes and their links are presented in Figure 3.

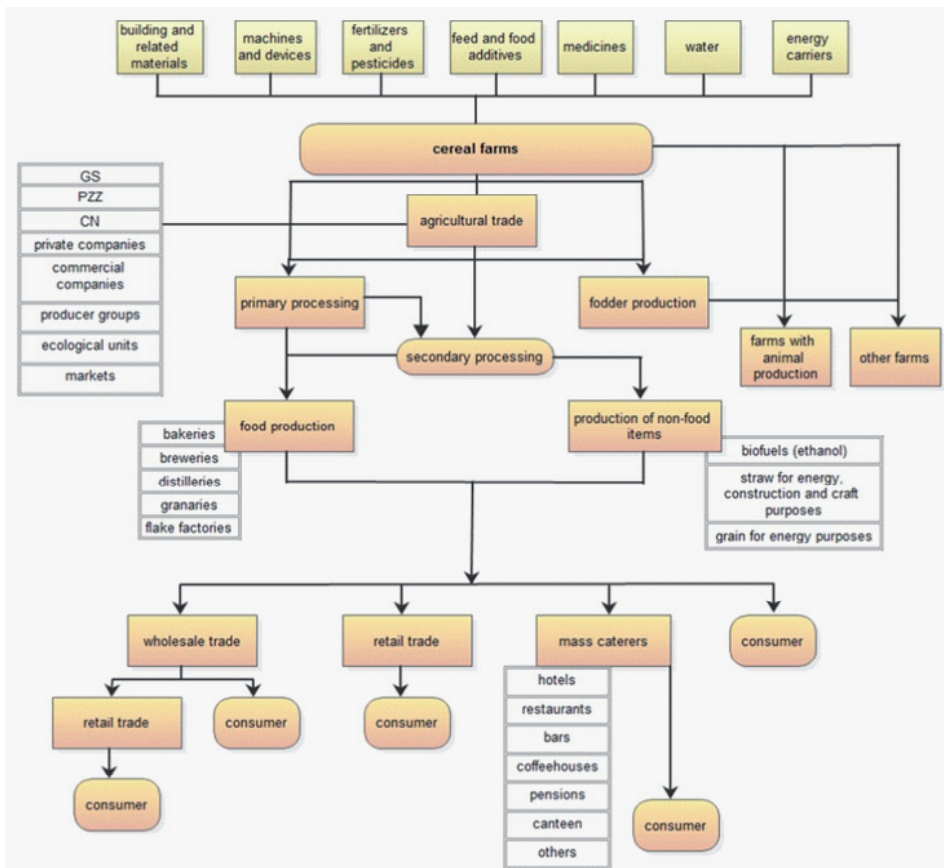


Figure 3. Supply chain pattern cereals sector

Rysunek 3. Schemat łańcucha dostaw sektora zbożowego

Source: [Klepacki and Perkowska 2018].

The cereal supply chain begins with producers and suppliers of inputs¹, such as: agricultural machinery and tools, building materials, energy carriers, fertilizers, plant protection products, feed, medicines, seed and germs, etc. The “roots” of the supply chain can therefore be sought in mines, machinery and chemical factories, but also on other farms. This indirectly indicates how large the recipient/buyer of industrial and own production is the agricultural sector.

Agricultural production takes place in a large number of relatively small farms, so it is very dispersed and requires a good system of connections between producers and recipients of grain as well as good organization of transport and storage. In agriculture, the number of cereal producers has decreased. This is due to the decreasing number of farms in total from 2.86 million in 2000 [GUS 2008] to 1.41 million in 2017 [GUS 2018] – over 50%.

Cereal grain flows for processing take place in many channels. The simplest relationship is: producer – processor. In the case of cereals, they are a farm – cereal industry plants, e.g. mills, feed processing plants, etc. However, this type of supply mainly concerns producers of large grain batches or producer groups. Many farmers produce smaller quantities of cereals and use the services of intermediaries, such as commercial companies and private entities.

Conclusions

1. The cereal sector is one of the most important in global and Polish agribusiness. The functioning of the sector is an important factor in the economic situation of many entities in agriculture and beyond.
2. The logistics chain of cereals and their products is very extensive. It includes over one million cereal producers, tens of thousands of agri-food processing units, agricultural trade, wholesale and retail food trade. It must be flexible and adapt to new challenges related to technological and organizational progress as well as changes taking place in the agribusiness environment and among clients.
3. The condition of supply chain success in distributed raw material production is the efficiency of managing individual entities. Equally important are solidarity and mutual trust of producers, traders, processors and consumers. It is important to recognize that every actor in the supply chain benefits in a similar way.

¹ In the presentation of logistic chains of agricultural raw materials and their products, the authors usually omit the link of producers and suppliers of raw materials and means of production for agriculture. However, we consider this to be the wrong approach. Modern agriculture depends on the quantity, quality and timeliness of their deliveries as well as industrial or commercial enterprises.

References

- Bechtel Ch., Jayanth J., 1997: Supply Chain Management: A Strategic Perspective, *International Journal of Logistics Management* 8, 1, 15–34.
- Council of Supply Chain Management Professionals (ed.), n.d. CSCMP Supply Chain Management Definitions, [electronic source] <http://cscmp.org/aboutcscmp/definitions.asp> [access: 18.12.2019].
- GUS, 2008: *Statistical Yearbook of Agriculture and Rural Areas 2007*, Warszawa.
- GUS, 2018: *Rocznik Statystyczny Rolnictwa 2017*, Warszawa.
- GUS, 2019: *Mały Rocznik Statystyczny Polski [Concise Statistical Yearbook of Poland 2018]*, Warszawa.
- IERiGŻ-PIB, 2018: Rynek zbóż, stan i perspektywy. Analizy rynkowe [Cereal market, state and outlook. Market analysis], Warszawa.
- Klepacki B., 2000: Oil-seeds Market. The Strategic Options for Polish Agro-food Sector in Light of Economic Analyses, Warsaw Agricultural University, Research and Implementation Centre, Warsaw.
- Klepacki B., 2016: Miejsce i znaczenie logistyki w agrobiznesie [Place and importance of logistics in agribusiness], *Zeszyty Naukowe SGGW w Warszawie. Ekonomika i Organizacja Logistyki* 1, 7–18.
- Klepacki B., Jarzębowski S., 2000: Łańcuchy dostaw w gospodarce żywnościowej [Supply chains in the food economy], *Zeszyty Naukowe SGGW w Warszawie. Ekonomika i Organizacja Logistyki* 103, 107–117.
- Klepacki B., Perkowska A., 2018: Organization of Food Supply Chains in Dispersed Production on the Example of the Grain Sector in Poland, *CLC Praha*.
- Krasowicz S., Kuś J., 2010: Kierunki zmian w produkcji rolniczej w Polsce do roku 2020 – próba prognozy [General Directions of the Agricultural Production in Poland until the Year 2020 : a Prognosis], *Zagadnienia Ekonomiki Rolnej* 3, 5–18.
- Madej A., 2018: Procesy koncentracji w produkcji zbóż w Polsce, *Polish Journal of Agronomy* 35, 23–31. DOI: 10.26114/pja.iung.370.2018.35.03
- Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D., Zacharia, Z.G., 2001. Defining supply chain management, *Journal of Business Logistics* 22, 1–25, [in:]: Gold S., Seuring S., 2011: Supply chain and logistics issues of bio-energy production, *Journal of Cleaner Production* 19, 1, 32–42.
- Szajner P. (ed.), 2015: Sytuacja na światowym rynku zbóż, roślin oleistych, cukru i biopaliw oraz jej wpływ na krajowe rynki produktów roślinnych i możliwości ich rozwoju [Situation on the global market for cereals, oilseeds, sugar and biofuels and its impact on domestic markets for plant products and development opportunities], IERiGŻ-PIB, Warszawa.
- Szymańska E.J., Bórawski P., Żuchowski I., 2018: Łańcuchy dostaw na wybranych rynkach rolnych w Polsce [Supply chains on selected agricultural markets in Poland], Wydawnictwo SGGW, Warszawa.

Correspondence addresses:

prof. Bogdan Klepacki PhD, Eng, h.c. multi

(<https://orcid.org/0000-0003-3483-7530>)

Warsaw University of Life Sciences in Warsaw – SGGW

Institute of Economics and Finance

Department of Logistics

Nowoursynowska St. 166, 02-787 Warsaw, Poland

e-mail: bogdan_klepacki @sggw.pl

Aleksandra Perkowska, MSc

(<https://orcid.org/0000-0002-7059-0689>)

Warsaw University of Life Sciences in Warsaw – SGGW

Institute of Economics and Finance

Department of Logistics

Nowoursynowska St. 166, 02-787 Warsaw, Poland

e-mail: aleksandra_perkowska @sggw.pl