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PRODUCTION AND SUPPLY OF CEREAL GRAINS IN POLAND AND THEIR IMPORTANCE AND USE IN POLISH ECONOMY

PRODUKCJA ORAZ PODAŻ ZIARNA ZBÓŻ W POLSCE ORAZ JEGO ZNACZENIE I WYKORZYSTANIE

Summary: *Cereals belong to the most important arable crops with 72% of arable land sown. This is due to the great importance of the grains obtained from them, which determines the food security of our country. Grain harvest is the basis for nourishing the country's population both directly through food use, as well as using it for animal feed. A new direction of grain management is the possibility of using surplus supply or grain that does not meet the quality requirements of food and feed processing for energy purposes.*

Keywords: *grain production, supply, food security*

Streszczenie: *Zboża należą do najważniejszych roślin uprawnych, których powierzchnia zasiewów gruntów ornych wynosi 72%. Wynika to z dużego znaczenia pozyskiwanego z nich ziarna, które stanowi o bezpieczeństwie żywnościowym naszego kraju. Zbiory ziarna stanowia podstawę wyżywienia ludności kraju zarówno bezpośrednio poprzez spożywcze wykorzystanie, jak również przeznaczanie go na paszę dla zwierząt. Nowym kierunkiem zagospodarowania ziarna jest możliwość wykorzystania nadwyżek podażowych lub ziarna niespełniającego wymogów jakościowych przetwórstwa spożywczego i paszowego na cele energetyczne.*

Słowa kluczowe: *produkcja ziarna, podaż, bezpieczeństwo żywnościowe*

Introduction

Cereal production in Poland is one of the most important areas of plant production. In the sowing structure, the cereals occupy 72% of the area (Fig. 1). It is due to their great importance in human nutrition, but also in the feeding of farm animals. For the latter, the cereals are the basic raw material for fodder production. A new direction of the use of grains which do not meet quality requirements for food or fodder production, is energy use. The supply of grains determines their price. Price fluctuations in the particular years are caused by unstable grain yields as a result of severe frosts, droughts and floods and flooding. A period of rapid price increases and decreases is usually followed by a period of searching for a new equilibrium level, characterized by short-term, quite violent price fluctuations. Low-cost cereal grains are important for reviving and improving the profitability of meat and milk production. Much will depend on the demand for these products, and thus on the general economic situation. Biofuels and bioenergy may begin to play a more and more important role in stabilizing the Polish cereal market, especially in the conditions of a systematic limitation of all forms of interventionism on the EU cereal market. In Poland the development of this direction of grain management is still at a very early stage

There are six main cereal species grown in Poland. These include wheat, rye, triticale, barley, oats, and maize. Their grains

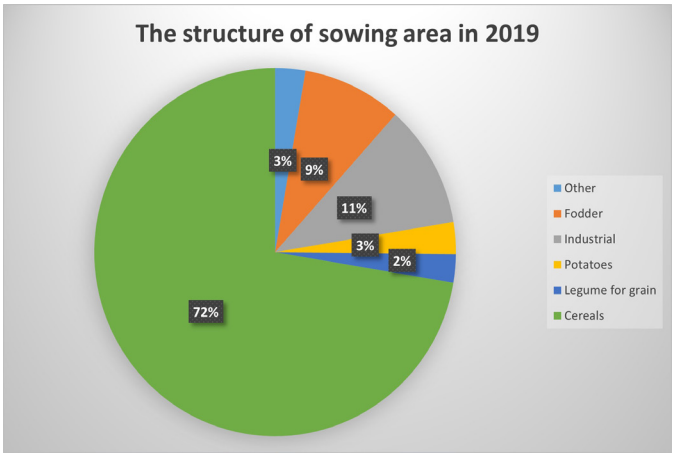
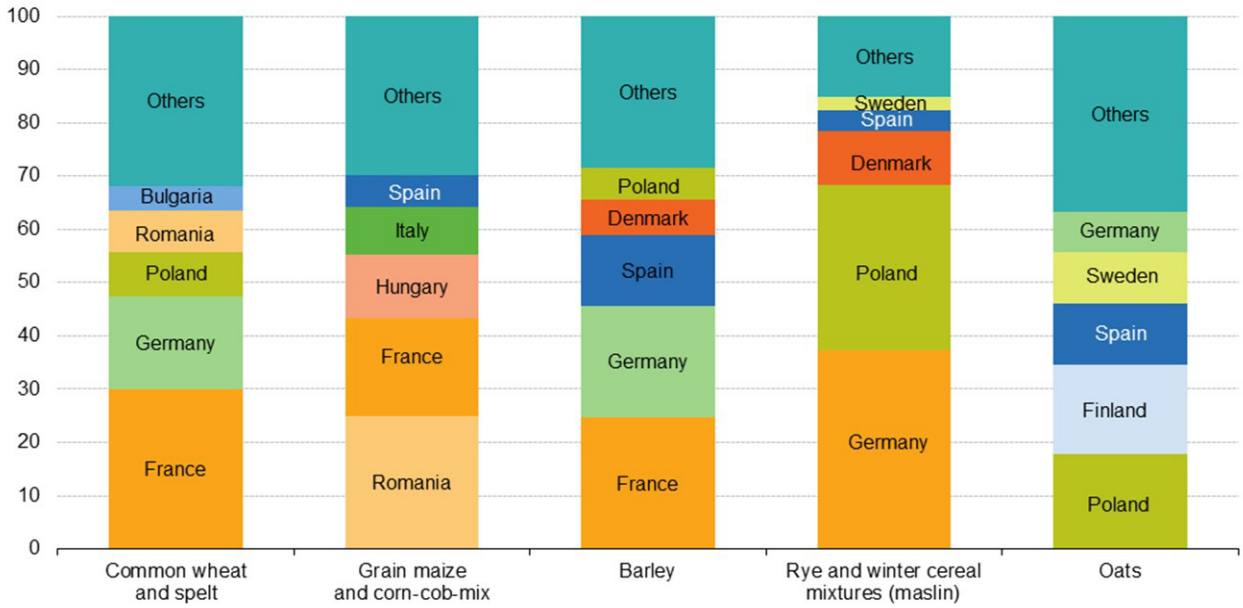


Fig. 1. Percentage of cereals in the sowing structure. Own elaboration based on CSO data [16]

are the basic raw material for food processing and fodder production. Production of grains of particular kinds of cereals depends on soil conditions. In Poland, wheat has the largest cultivation area and grain harvest scale. The grain harvest of this species in 2019 amounted to 11 million tonnes, which was 12% more than in 2018. The second cereal with the largest grain production scale is triticale, 4.5 million tonnes of which was harvested in Poland in 2019, 12% more than in 2018, the same as in the case of wheat. Slightly less, at 3.5 million tonnes of barley

Production of cereals by main producing Member States, 2019
(% share of EU-27 totals)



Source: Eurostat (online data code: apro_cpnh1)

eurostat

grains (10% more than the previous year), and 2.5 million tonnes of rye grains (13% more), were produced. Out of all cereals, Poland produces the least amount of oats, amounting to 1.2 million tonnes, which was more by 5% than a year before. Compared to other European Union countries, Poland is one of the leading grain producers. Production of oats in Poland, despite the fact that it is the smallest among major cereal species, places Poland in the first place in terms of grain production of this cereal in the European Union, with 19% share in the EU total oats production. Poland is second in terms of rye grain production with 30% share in the total grain production of this cereal, just after Germany. Poland ranks third as regards the production of wheat grains with 5% share in their EU total production. As far as the production of barley grains is concerned, Poland is on the fifth place in the European Union with a 4% share in its EU total production [1].

The production of particular cereals in Poland is determined by the demand for them on the market. It results from different allocation of particular species for consumption and fodder purposes. Wheat is considered to be a consumption cereal destined mainly for flour milling and bread baking. Rye is a dual-purpose cereal that is utilized for both human consumption and animal feed. Barley is a dual-purpose cereal used for beer production and animal feed. Oats is considered to be the main feed cereal and to a lesser extent, food cereal

Factors affecting cereal supply

The supply of grains of particular cereal species depends on many factors. These include climatic conditions, including frequent weather anomalies manifested by drought and excess precipitation, as well as periods of low temperatures in winter causing the freezing of winter forms of cereals. Genetic progress and breeding new varieties, which increase their yield, also have a significant impact. Genetic progress in breeding new varieties that yield higher can be noticed since the 1950s. Despite a systematic decrease in the acreage under cereal cultivation, grain yields per hectare and the overall supply of grains, have increased. Despite a decrease in the area of cultivation from the initial 9.5 million ha (100%) in 1950 to 7.4 million (78%), the supply of cereal grains increased in that period by 232%. [2]. The spread of progress in mineral fertilization and significant mechanization of agriculture are also important. Reduction of labour input is a significant incentive to grow cereals. The problem, however, is the changing climate and the occurrence of extreme weather phenomena which significantly reduce the grain yield, and thus its supply. Both heavy rains and droughts are unfavorable. Flooding of cereal crops, especially during the spring snowmelt, causes significant losses. Losses are also caused during the growing season, when excessive precipitation and low air temperatures cause lodging of cereals and increased pressure from fungal diseases. Droughts occurring more and more frequently in the recent years, causing water shortage, also cause significant losses in the cultivation of cereals. Water deficits causing a decrease in grain yields by at least 20%, are being recorded more and more often, both in the cultivation of cereals, and in particular of their spring forms [3]. New solutions to reduce the problem of yield losses, being associated with drought, include increasing water retention through its increased storage in water reservoirs and then irrigating crops during periods of lack of rainfall. Breeding grain varieties with higher

drought tolerance is also a potential solution. Maintaining the growth rate of food production proportional to the increase in the world's population, in a changing climate, is a great task and challenge, especially for cereal breeding. In Poland, the problem of drought affects mainly spring cereals, among which spring triticale has the highest resistance to adverse conditions caused by drought. Other cereal species are much more sensitive to drought periods, but among their varieties, we can distinguish those characterized by higher drought tolerance and those less resistant to drought stress. As one of the indicators of drought tolerance the date of earing is considered, because generally the varieties that earing earlier tolerate drought better, which usually occurs in June-July. Breeding advances aimed to increase yields, at the same time increase drought tolerance, with the benefit of a sufficient and stable supply of grains into the marketplace.

Supply of grains and their price in the era of globalization of trade in agricultural products depends also on harvest in other countries of the European Union and other countries in the world as well as on the stocks in storehouses. International situation related to world grain harvest has a direct influence on the Polish market, prices and supply of grains. This is particularly noticeable against the background of the 2020/2021 season. The mild winter at the turn of 2019 and 2020 had a positive effect on the overwintering of winter forms of cereals. At the same time, there was a short-lived precipitation deficit in April, followed by an offset in May. Cereal grain harvests were at a fairly good level, but already in the autumn of 2020, a systematic upward trend in cereal grain prices was noticed. This is caused by the increase of global grain consumption, which in the season 2020/2021 can amount to 2,76 billion tonnes, i.e. by almost 2% more than in the previous season. The increase in consumption influences the decrease in global grain stocks by 2.2%, mainly due to higher demand, but also due to lower crops compared to the forecast. It is predicted that in the 2020/21 season, about 465 million tons of cereals will be traded internationally, 5.7% more than in the previous season. As a result, a systematic trend of increasing selling prices for cereal grains can be seen on the global cereal markets. The FAO index of cereal prices on the global markets has risen sharply by 7.1% over the past months, primarily due to the high increase in corn prices by 11.2%, which are higher by as much as 42.3% compared to January 2020 prices. The main reason for this increase is the large purchases of maize, mainly U.S. by the Chinese feed industry, which has reduced the world supply of this important feed cereal. China's maize stocks will decrease significantly. This is accompanied by forecasts of a lower maize harvest in the USA, a decrease in global stocks of this cereal and a reduction of maize exports by the authorities in Argentina, one of the most important producers. Analysts of the global cereal market report a progressive increase of cereal prices on the global market. The reasons are smaller areas of grain sowing and lower yields in the 2019/2020 season, as well as recently introduced administrative restrictions on Russian grain exports. In recent months, cereal prices on the Paris MATIF exchange have increased by 7%. A similar price increase was recorded at the CBoT in Chicago. Grain prices in Ukraine have risen by up to 75-80% due to significantly lower yields; because of this, feed prices have risen by 45-50%. In this situation Canada and the EU countries are expecting significant benefits from cereal exports, although under the pressure of higher exports, we can expect an increase in prices on the domestic cereal markets, also in Poland, and thus an increase in feed prices.

At the same time, cereal prices are increasing successively at the global and national exchanges. The increased global demand for cereals is driving up prices on virtually all continents. Some analysts are even talking about a kind of panic among buyers (flour and fodder producers), who fear a further increase in cereal prices in the coming weeks or even months and are hastily concluding contracts for the purchase of cereals in the coming weeks. In order to prevent excessive export of cereals, the Russian authorities have introduced customs duties on wheat exports, announcing a further increase in March, and have also introduced prohibitive customs duties on cereal exports outside of the allocated quota. This also translates into the situation in Poland, where purchase prices for cereals, especially wheat, are rising. The price increase on the Polish cereal market is also fuelled by increasing exports. According to the Grain and Feed Chamber, the total export of cereals in Poland within five months (July-November 2020) increased by almost 58% to 3.68 million tonnes, including wheat export by 33% to 1.2 million tonnes, rye by 230% to 676 thousand tonnes, triticale by 131% to 582 thousand tonnes and barley by 246% to 235 thousand tonnes. The Grain and Feed Board expects that cereal exports in the first quarter of 2021 will also be high, amounting to more than 900 thousand tonnes for wheat, for example (they usually amounted to around 100 thousand tonnes/month). For a long time now, the supply of cereals to the north and west of Poland has been severely depleted due to the very large exports by sea and land to Germany. It would appear that there is also less and less grains in storage in the southeast of Poland, where it is difficult to find larger lots of grain, including wheat. Currently the largest amount of stored grains is still in storage in the center of the country, but even here the market supply of virtually all cereals is severely depleted.

Barley continues to be very difficult to buy and there are not many offers for triticale. There is very little supply of corn, the prices of which have reached the level of wheat. There are indications that there will be a shortage of maize on the Polish market until the new harvest, which will provide strong support to maize prices. The expected record exports of this cereal in the current season, trace imports from southern Europe, and practically no maize imports from Ukraine, will undoubtedly contribute to strong tensions in the balance of this cereal in the later part of the season.

Food use of cereal grains

Cereal grains have always been an important part of the human diet. It is through the use of wheat and the increasingly efficient cultivation and increase in grain yields that it has been possible to feed the ever-increasing world population. The best

example of this is the development of civilization in ancient Egypt, where in the valley of the Fertile Crescent, an efficient production of grain developed, and Egypt as one of the main suppliers of valuable grain developed economically and civilization. For centuries, cereal grains were considered a major trade commodity due to their important role in feeding the growing populations of European countries. Decreases in crop yields and grain shortages caused by unfavourable climatic conditions caused a significant part of the population to starve.

Currently, however, due to the increasing number of people with gluten intolerance, the consumption of cereal products, including bread, is decreasing. In Poland in 2018/2019, the balance consumption of cereal products in flour equivalent was 101 kg per capita, compared to 121 kg in 2001 and 119-120 kg in the mid-1990s. According to the Institute of Agricultural and Food Economics - National Research Institute, consumption of cereal products in flour equivalent in the 2019/2020 season may reach 100 kg per capita. There is a systematic decline in the consumption of bread and cereal products [4]. Consumption of more expensive grain assortments is increasing, as is consumer interest in health-promoting and convenience products. Increasingly, alternatives to cultivation are being sought for pseudo-cereal species with health-promoting effects such as amaranth or quinoa. Cereal grains are used depending on the species. Wheat is the most commonly used for food purposes, and to a much lesser extent, rye. Wheat grains are the most expensive among all grains grown in Poland, therefore it is very popular among growers. It is the main cereal used for food purposes, especially for baking and confectionery, as well as flour production. Rye grains are an important processing raw material, whose considerable supply on the market influences their use mainly for the production of flour and bread baking, but also processing into cereal flakes. The products made of rye grains bring to the human diet many valuable nutrients with a pro-health effect. This is confirmed by the results of scientific research [4, 5]. These are: dietary fiber, minerals, antioxidants, vitamins, phytoestrogens and polyphenols [6]. Rye bread is the most frequently consumed product, which is also the source of these valuable substances [7]. Rye grains contain biologically valuable protein, which includes essential amino acids, mainly lysine. Rye flour, similarly to rye grains, is characterized by a high nutritive value, which depends on the fineness and purification of grains from the fruit and seed coat. Wholemeal rye flour is a source of fiber, outperforming wheat flour in this respect. It is characterized by a higher content of fructo-seed coat and aleurone layer, and also contains more protein, vitamins (especially of the B group), and minerals (iron, phosphorus, and magnesium). Fiber is also considered an important component of the diet. Its content in rye grains depends on the cultivation method [8]. The fiber fraction is dominated by pentosans (arabinoxylans) and betaglucans, which have beneficial effects in human nutrition, as opposed to use in animal nutrition. Rye with high arabinoxylan content and the flour produced from it, contain significant amounts of tocopherols (vitamin E derivatives). Wholemeal rye flour is used for baking wholemeal bread, which contains an increased content of health-promoting substances [9]. Another important criterion for consumers when choosing food products is their calorific value, which is the lowest for rye compared to other cereals. Moreover, the acid fermentation process of rye dough releases more calcium than wheat dough [10]. Rye bread retains its freshness and consumability much longer [11].

Besides the strictly food use, rye grains can be used in the distillery industry. Currently, more than 70% of the spirit produced by domestic distilleries is obtained from rye [12]. Rye grains are characterized by a high carbohydrate content, 60% of which is starch. This makes it possible to achieve high productivity and efficiency in the alcohol production process [13]. Spirits produced on the basis of rye grains are characterized by very good quality, as these grains contain a small amount of undesirable compounds, such as aldehydes (0.07g/dm^3 on average). The final quality of the product, however, depends on the quality of the grains. If the grains are of poor quality, overgrown or infected with moulds, the obtained crude spirit will contain excessive amounts of aldehydes and organic acids [14]. Other cereals, such as barley and oats, are less important for consumption. Oats is used for the production of flakes. A new direction for the use of oat grains is for brewing purposes, to produce beer with health-promoting properties. This is not a new direction of potential processing of oat grain, as it has been practiced by European breweries for many centuries, but nowadays it is somewhat forgotten [15]. Barley in food processing is mainly used for beer production.

Use for fodder

Cereal grains are the basic raw material for the production of feed used in the feeding of various livestock. They constitute from 60 to 80% of the raw material composition of mixed feeds, which depends on the current price and quality. Such a large percentage in the feed is due to the high content of nutrients, especially starch, which is a very good source of energy. Furthermore, cereal grains also contain a certain amount of protein. Apart from the desired nutrients, cereals also contain substances that impair the nutritional value of feeds by reducing the digestibility of nutrients and their absorption in the digestive tract of monogastric animals. Therefore, when formulating compound feeds, the basic criteria for selecting a particular cereal grain include the balance between nutritional value and price. Due to the large percentage of cereals in mixtures, their price is closely related to the final price of feed. According to the CSO data [16], in 2019, the total feed production amounted to 10 499 thousand. A major share, 63%, were feed mixes for poultry, 23% for pigs and 11% for cattle, 3% were mixes for horses, and 1.7 mixes for other animals [16].

The supply of particular grain species is reflected in their price, which has a direct influence on the economics of animal production, ultimately translating into profitability of breeding particular livestock species and the price of products obtained from them. Grains of different cereal species have different nutritional value, which depends on the starch and protein content, as well as the content of components with antinutritional effect. Ultimately, when selecting a particular cereal species for

a compound feed formulation, the feed companies try to achieve the right balance between the market price of the grains and their feed value. Ultimately, these requirements are most often met by triticale, which has a good composition as a feed cereal and is basically only used in animal feed; hence, its price is usually at an optimum level. Other important fodder cereals are barley and oats, which are also readily used for fodder production. The least useful cereal in terms of feed value, but at the same time with the lowest price, is rye.

Grain use for energy

European Union policy imposes on the member states the obligation to use raw materials from renewable sources for energy purposes. In Polish climatic and economic conditions, raw materials of plant origin are becoming more and more important. A new trend currently observed is the use of cereal grain for energy purposes — the production of bioethanol. The expected increase in demand for biofuels will be a factor of further increase in processing of cereals for industrial purposes. Processing of cereals for this purpose may increase from approx. 5-6% to over 10% of the total resources of cereals in Poland [17]. In this context, the rye grains which does not meet quality requirements for milling, baking and fodder processing can be used for energy purposes. This applies to low quality grains, largely infected by fungal diseases and contaminated with mycotoxins. However, these grains are a valuable feedstock for bioethanol production [18]. It is extracted from agricultural renewable feedstocks and then used as a fuel additive. The production of bioethanol from grains entails the benefit of obtaining waste products that can be reused. The bioethanol production process generates by-products - dried distillers grains (DDGS) — that are increasingly used as substitutes for post-extraction soybean meal. Hybrid varieties of winter rye that provide significant amounts of both fresh and dry biomass can be used for biogas production [19]. Biogas from rye is rather not competitive to biogas from winter rapeseed due to higher energy efficiency of the latter cereal — about 43.1 GJ - ha-1 [20].

Straw can be used for energy purposes only when agricultural demand is met, for animal production (fodder and bedding), and for fertilizer purposes to maintain a balanced balance of organic matter in the soil. Dried straw is more valuable from the point of view of energy use. It contains less moisture and chlorine compounds, which adversely affect the durability of the equipment used to burn it. Moreover, the calorific value of dry straw is several MJ higher than that of fresh straw and amounts to approx 14-15 MJ/kg. Dried straw is collected from the field by means of balers with various degrees of crushing. It can be incinerated in batch or automatic boilers.

Oat grains that do not meet quality requirements can also be used for energy purposes. This makes economic sense, especially if the grains are produced on one's own farm using low-input technologies. It also gives environmental benefits as it reduces the consumption of fossil raw materials and reduces the emission of harmful gases and dusts into the atmosphere [21]. Oats has a higher calorific value compared to rye and triticale, which confirms the appropriateness of its use for energy purposes [22]. Compared to hard coal, it has half the energy efficiency. However, its advantage is a smaller amount of ash produced after combustion (2.2%), which can be used as a fertilizer [23].

Other grains are not used for energy production because of their better nutritional and fodder value, and thus higher price, but the exception is contamination of their grains with mycotoxins or other substances that preclude their food or fodder use. Using them for energy production is then justified as an efficient way to utilize the grains.

Summary and conclusions

Cereals are a group of crops of the greatest importance, which is shown by their significant percentage in the sowing structure in Poland. The main direction of grain use is for food and fodder, as well as an alternative use of the excess grains or the grains not meeting quality standards, which is for energy purposes. Climate change, which has a negative impact on grain yields, can result in a lower supply of grain, whose prices can fluctuate wildly. The challenge is, therefore, to breed new, more drought-resistant varieties of cereals in a targeted manner, and to breed varieties that yield more stably under rainfall deficit conditions. Since grain yields of the biggest world grain producers are very important in the era of the global market, it is necessary to create strategic reserves in warehouses in order to ensure the stability of supply and prices in the internal market to maintain the country's food security.

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