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ASSESSMENT OF VARIABILITY OF CEREAL GRAIN QUALITY AS A COMPONENT OF FODDER MIXTURES

Dariusz Jaskulski[1], Iwona Jaskulska[1], Małgorzata Woźniak[2], Grzegorz Osiński[1]

[1] University of Technology and Life Sciences in Bydgoszcz
[2] Laboratorium Analiz Paszowych San-Vit S.J. in Janowiec Wlkp.

Abstract. On based on the results of analysis of 941 samples of barley, wheat and triticale grain harvested in 2006-2010, carried out in the laboratory of fodder raw materials San-Vit S.J. in Janowiec Wlkp. A variability of the content of total protein, raw fibre, phosphorus, calcium and chlorides in raw material for production of fodder mixtures was assessed. Relationships between the content of elements in cereal grain as well as between protein content and variability and total precipitations in the period of spring and summer growth were also determined. It was found that the protein content was the most stable element of grain quality. Its concentration in triticale grain was the highest, the less calcium it contained, whereas in wheat grain it increased with a growth in phosphorus content. In spite of a short time of the study, a tendency to increasing protein content in grain at lower precipitation in April and May and higher precipitation in June and July was observed.

Key words: barley, calcium, chlorides, phosphorus, raw fibre, total protein, triticale, wheat

INTRODUCTION

Fodder industry and standardized feeding of farm animals require raw materials with a definite and uniform quality [Jaśkiewicz and Sułek 2004]. The chemical composition of cereal grain is determined by the genotype of the species and cultivar, and formed be site and agricultural factors [Liszewski 2008, Noworolnik 2009]. Protein content depends mainly on the amount of nitrogen available in the soil and on its rate and the way of application during fertilization with this element [Müller 1998]. Its concentration in grain is also largely affected by interactive effect of cultivation technology and the course of the weather conditions, particularly thermal and precipitation [Oleksy et al. 2008]. The amount and proportions of mineral elements depend also on elements of crop production

Corresponding author – Address for correspondence: dr hab. inż. Dariusz Jaskulski, prof. nadzw. UTP, Department of Plant Production and Experimenting of University of Technology and Life Sciences in Bydgoszcz, Ks. A. Kordeckiego 20C, 85-225 Bydgoszcz, e-mail: darekjas@utp.edu.pl

technology: organic and mineral fertilization, tillage, cultivation, harvesting and storing and their cooperation with site factors [Gondek and Filipek-Mazur 2006, Korzeniowska and Stanisławska-Glubiak 2006, Brzozowska 2008, Kraska and Pałys 2009].

The analysis of fodder raw materials is the condition of making up the proper chemical composition of concentrate mixtures. The assessment of calcium and phosphorus content in fodder cereal grain allows the estimation of the appropriate proportion of those components in the technological process of fodder production for individual species and groups of farm animals. Knowledge of the amount of chlorides, in turn, is necessary to control the fodder salinity.

In view of the completely random supplies of grain from many farmers in the area where the feed processing plant is situated, it can be assumed that the production of its individual batches was carried out under changeable site and agricultural conditions. The sources of variability, although not recorded by the fodder producer, were probably for instance: the cultivar, soil conditions, the level of crop production intensity, as well as meteorological factors measured in the area of cereal growing. Under such conditions the chemical composition of grain could be subject to large changes, although to different extent in individual fodder cereal species.

The aim of this study was to estimate the variability in the content of total protein and raw fibre as well as some mineral elements in barley, wheat and triticale grain. The relationship between the content of individual elements in grain as well as that between the precipitation in the area of their cropping and protein content and its variability was also evaluated.

MATERIAL AND METHODS

Material for the study was samples of cereal grain coming mainly from the area adjacent to the feed processing plant in Janowiec Wlkp. (Kujawsko-Pomorskie voivodship), making up the raw material for industrial fodder production. In 2006-2010 in the laboratory of fodder raw materials San-Vit the quality assessment of 941 grain samples was carried out, including 248 of barley, 394 of wheat and 299 of triticale. The samples were collected from individual batches of delivered raw material in accordance with the standard PN-ISO 13690 [2000]. The content of total protein was determined in all the samples. In the first three years the content of raw fibre, phosphorus, calcium and chlorides was also analysed in 140 samples. Determinations were carried out with generally established methods: proteins – with the Kjeldahl method, in accordance with the standard PN-ISO 5983 [2000], fibre – with general method according to PN-ISO 5498 [1996], calcium – with the titration method according to PN-93/R-64750 [1993], phosphorus – with the spectrometric method according to PN-ISO 6491 [2000], chlorides – with the biamperometric titration method with silver nitrate according to the standard PN-81/R-64780 [1981]. Each determination was made in two replications. When the result of individual determination exceeded the limit of repetitiveness established in the method, the analysis was made again.

The basic statistics were made, the minimal and maximal values and arithmetic means were determined for each feature determining the grain quality of individual species throughout the period of the study. Standard deviations and variability coefficients were calculated. The variability of total protein content in the grain of each three cereal species was determined in all the years of the study. The variability of total

protein content in the grain of each of three cereal species was determined in all the years of the study. Coefficients of simple correlation between the content of elements in cereal grain and between protein content and variability and total precipitations during the spring-summer growth period were calculated. The total precipitations adopted (Table 1) were registered from April to July at the Research Station of the Faculty of Agriculture and Biotechnology in Mochełek near Bydgoszcz.

Table 1. Total precipitations in years of the study in Bydgoszcz area, mm
Tabela 1. Sumy opadów w latach badań w rejonie Bydgoszczy, mm

Month – Miesiąc	Year – Rok				
	2006	2007	2008	2009	2010
April – Kwiecień	77.0	17.6	38.7	0.4	33.8
May – Maj	59.9	73.1	11.5	85.3	92.6
June – Czerwiec	21.8	105.5	15.5	57.4	18.1
July – Lipiec	24.2	104.7	58.7	118	107.4
April – July Kwiecień – Lipiec	182.9	300.9	124.4	261.1	251.9

RESULTS

Variability in the content of organic elements in the grain of all the three species of fodder cereals, particularly total protein, was smaller than that of mineral elements. Calcium content ranged from 0.05% in all the cereals to 0.22% – in wheat and triticale as well as to 0.30% – in barley. The variability coefficient of this feature, the highest of all the grain element, was 42.9-46.8% , depending on the species (Table 2). The content of the other mineral elements of the grain, i.e. phosphorus and chlorides were characterized by a smaller variability. The concentration of phosphorus in barley grain was particularly stable and although its minimal and maximal contents differed twofold, the variability coefficient throughout the period of the study amounted to 14.2%.

The content of organic compounds analysed in the fodder cereal grain, particularly of total protein, was characterized by a relatively low variability. Its smallest content was observed in the grain of triticale, whereas the largest – in wheat. At the same time its concentration in wheat grain was the least diversified in the total amount of the analysed samples – with a variability coefficient of 13.5%. The variability of total protein content in the grain of the other species of fodder cereals was not much larger and amounted to 13.9% (barley) and 15.0% (triticale).

The content of total protein in the grain ranged from 7.48% in triticale in 2006 and 2009 to 16.65% in wheat in 2007 (Table 3). In the grain of barley and triticale the least changeable was its concentration in 2010, and in the grain of wheat in 2008. In those years the variability coefficient of total protein content in the grain was less than 10%. In wheat it amounted to 8.7%, and in barley and triticale 9.4% and 9.0%, respectively. The highest variability of protein content in the grain of fodder cereals occurred in 2007 – in wheat and triticale and in 2009 – in barley. However, the variability coefficient was not much higher and amounted to: 12.8, 14.1 and 16.1%, respectively.

Table 2. Variability in chemical composition of cereal grain
Tabela 2. Zmienność składu chemicznego ziarna zbóż

Value – Wartość	Element – Składnik				
	Total protein Białko ogólne	Raw fibre Włókno surowe	Calcium Wapń	Phosphorus Fosfor	Chlorides Chlorki
Barley – Jęczmień					
Minimum – Minimalna, %	8.83	3.29	0.05	0.20	0.10
Maximum – Maksymalna, %	14.67	6.80	0.30	0.40	0.34
Mean – Średnia, %	11.16	4.66	0.14	0.30	0.18
Standard deviation Odchylenie standardowe	1.55	0.78	0.06	0.04	0.05
Variability coefficient, % Współczynnik zmienności	13.9	16.8	42.9	14.2	25.9
Wheat – Pszenica					
Minimum – Minimalna, %	9.44	2.10	0.05	0.17	0.07
Maximum – Maksymalna, %	16.54	4.78	0.22	0.38	0.14
Mean – Średnia, %	12.12	2.71	0.11	0.26	0.10
Standard deviation Odchylenie standardowe	1.63	0.48	0.05	0.06	0.02
Variability coefficient, % Współczynnik zmienności	13.5	17.8	45.8	22.6	17.4
Triticale – Pszenżyto					
Minimum – Minimalna, %	8.05	2.02	0.05	0.11	0.05
Maximum – Maksymalna, %	13.55	5.36	0.22	0.37	0.13
Mean – Średnia, %	10.54	2.59	0.10	0.25	0.08
Standard deviation Odchylenie standardowe	1.58	0.54	0.05	0.06	0.02
Variability coefficient, % Współczynnik zmienności	15.0	21.0	46.8	23.1	24.9

Protein content in wheat grain was significantly positively correlated with the content of phosphorus. In the other fodder cereals the correlation coefficient was much smaller, although positive as well (Table 4). In contrast, the content of protein in triticale grain correlated negatively with the content of calcium. A similar relationship, although weak and insignificant, occurred in the other species. The chemical analyses revealed also a significant negative correlation between the content of calcium and raw fibre, a positive correlation between fibre and chloride in the grain of triticale, and non-significant in wheat.

Protein content in the grain of fodder cereals depended on the amount and distribution of precipitation in spring-summer months of their growth. A short, 5-year period of the study resulting in a small number of degrees of freedom in the calculation of simple correlation did not allow us to prove the significance of this relationship, but they indicate remarkable tendencies (Table 5). Lower precipitation totals in April and May, as well as their higher amount in June and July, favoured a high content of protein in the grain. The content of protein in triticale grain correlated most strongly with total precipitations in April, June and July, in barley in April and June, and wheat in June. Heavy precipitation in June increased the variability of protein content in the grain of wheat and triticale. Simple correlation coefficient, although they were non-significant, amounted to 0.65 and 0.80, respectively.

Table 3. Protein content in cereal grain and its variability in years
Tabela 3. Zawartość białka w ziarnie zbóż i jej zmienność w latach

Value – Wartość	Year – Rok				
	2006	2007	2008	2009	2010
Barley – Jęczmień					
Minimum – Minimalna, %	7.72	9.15	9.01	8.98	8.37
Maximum – Maksymalna, %	15.77	14.88	14.96	14.14	13.08
Mean – Średnia, %	10.67	11.74	11.81	11.45	10.78
Standard deviation Odchylenie standardowe	1.49	1.18	1.37	1.84	1.01
Variability coefficient, % Współczynnik zmienności	14.0	10.1	11.6	16.1	9.4
Wheat – Pszenica					
Minimum – Minimalna, %	8.84	9.12	9.42	9.88	8.62
Maximum – Maksymalna, %	15.37	16.65	15.25	13.73	14.88
Mean – Średnia, %	11.85	12.42	12.24	11.98	11.84
Standard deviation Odchylenie standardowe	1.43	1.59	1.06	1.15	1.07
Variability coefficient, % Współczynnik zmienności	12.0	12.8	8.7	9.6	9.1
Triticale – Pszenżyto					
Minimum – Minimalna, %	7.48	8.05	9.66	7.48	8.42
Maximum – Maksymalna, %	13.00	14.82	13.08	12.83	13.21
Mean – Średnia, %	10.15	11.71	11.23	10.88	10.96
Standard deviation Odchylenie standardowe	1.20	1.66	1.11	1.11	0.99
Variability coefficient, % Współczynnik zmienności	11.8	14.1	9.8	10.2	9.0

Table 4. Correlation coefficients between the content of elements of cereal grain
Tabela 4. Współczynniki korelacji pomiędzy zawartością składników ziarna zbóż

Element Składnik	Element – Składnik				
	Total protein (1) Białko ogólne	Raw fibre (2) Włókno surowe	Calcium (3) Wapń	Phosphorus (4) Fosfor	Chlorides (5) Chlorki
Barley – Jęczmień					
1	1.00	-0.13	-0.07	0.05	-0.05
2		1.00	0.06	0.07	0.01
3			1.00	-0.23	-0.01
4				1.00	0.13
5					1.00
Wheat – Pszenica					
1	1.00	-0.11	-0.05	0.47*	-0.10
2		1.00	-0.02	-0.15	0.20
3			1.00	0.15	0.00
4				1.00	-0.21
5					1.00
Triticale – Pszenżyto					
1	1.00	0.50	-0.27*	0.11	0.24
2		1.00	-0.35*	0.09	0.27*
3			1.00	-0.05	-0.33*
4				1.00	0.13
5					1.00

* simple correlation coefficient significant – współczynnik korelacji prostej istotny

Table 5. Correlation coefficients between total precipitations and protein content in cereal grain and its variability
Tabela 5. Współczynniki korelacji pomiędzy sumami opadów a zawartością białka w ziarnie zbóż i jej zmiennością

Fodder cereal – Zboże paszowe	Total precipitation – Suma opadów				
	April kwiecień	May maj	June czerwiec	July lipiec	April – July kwiecień – lipiec
Zawartość białka – Protein content – Zawartość białka					
Barley – Jęczmień	-0.60	-0.46	0.51	0.31	0.00
Wheat – Pszenica	-0.39	-0.41	0.67	0.19	0.13
Triticale – Pszenżyto	-0.66	-0.08	0.63	0.60	0.38
Variability coefficient of protein content – Współczynnik zmienności zawartości białka					
Barley – Jęczmień	-0.07	0.02	-0.06	-0.15	-0.14
Wheat – Pszenica	0.23	0.21	0.65	-0.21	0.43
Triticale – Pszenżyto	0.02	0.05	0.80	-0.09	0.42

DISCUSSION

The obtained results of analyses of nearly 1000 samples of grain coming from numerous plantations of fodder cereals grown on many farms and in several years indicate the scale of diversity of its chemical composition. Although the lack of precise information concerning the cultivars, soil conditions and crop production technique does not allow the assessment of the effect of individual factors on the content of studied organic and mineral elements, it shows explicitly a difference in variability of their contents in the grain of individual species and variability of individual elements in the given species resulting from the effect of the complex of genetic, site and agricultural factors. The significant effect of plantation location on the mineral composition of wheat grain is confirmed by the results of the study by Sabo and Ugarčić-Hardi [2002]. The grain of several cultivars of winter wheat, derived from plantations located in two places, differed in the content of: N, P, K, Mg, Zn, Cu and Mn.

The diversity of the yield and chemical composition of cereal grain in many places within a single productive field indicates a significant impact of changeable soil conditions, and the effect of the weather conditions in successive years [Pecio and Kubsik 2006]. Although the content of organic and mineral elements in grain is genetically determined depending on the species and cultivar of the cereal plant, the modifying effect of the site and crop production technique is very strong. Bertholdsson [1999] observed that the variability in protein content in barley grain depends in nearly 90% on the environmental conditions and in about 7% – on the genetic factor. In the present study, the fodder grain derived from different locations and farms, and with so large number of its batches it can be assume that it was produced under highly diversified conditions. Different variability of the content of individual elements in the grain of the given species is an important conclusion with applicative character. Thus the concentration of an element with a relative small variability cannot be to a large extent modified by cultivation practices. Apart from protein and fibre, in the presented study, such an element was phosphorus. A large stability of phosphorus content in the grain of cereals grown under changeable soil and agricultural conditions is also reported by Sager and Hoesch [2005]. The authors at the same time point out the importance of

results obtained in studies carried out under production conditions, as the results of pot experiments are often different from them.

In the present study, in spite of the short observation period – five years – an attempt was made to assess the effect of precipitation during the months of spring-summer growth on protein content in cereal grain, and mainly its variability in individual species. The results of many studies show a higher protein content in grain of cereals grown under conditions of water deficit [Wyszyński et al. 2002, Podolska et al. 2006]. This is explained by a larger concentration of this element at a small grain yield at that time. Such relationships were confirmed by Noworolnik [2010] in the model experiment with the effect of nitrogen and changeable substrate humidity. Irrespective whether water deficit occurred from the stage of tillering or flowering to maturity, protein content in the barley grain was larger than at the optimal humidity – 60% FWC. A remarkable tendency towards an increase of protein content in grain at low precipitation at the initial period of spring growth of fodder cereals and at high precipitation in June and July was observed. A similar conclusion results from the study by Stankiewicz [2004]. The author observed a larger content of total protein in the spring triticale grain in the year with a high precipitation in July, which he relates to a better plumpness of grain, a higher total protein yield and its larger concentration in grain. The high precipitation in June, in turn, increased the variability of protein content in the wheat and triticale grain in the present study, which could have been a result of interactive effect of water conditions and other site factors and elements of crop production technology on individual plantations.

CONCLUSIONS

Assuming diversified site and agricultural conditions of fodder cereal grain production on the basis of a large number of batches of analysed grain coming from many farms and examined in the period of five years, it may be concluded that they diversified to a larger degree the content of mineral than organic components. Protein content was the most stable element of grain quality, irrespective of the cereal plant species, and of mineral compounds – the content of phosphorus. The concentration of calcium underwent the largest changes. Along with an increase in calcium content in triticale grain there was a decrease in the concentration of total protein, raw fibre and chlorides. The larger phosphorus content in fodder wheat grain was accompanied by a higher protein concentration; whereas no significant relationships were found between contents of components in barley grain. In spite of a short period of the study, there was a visible tendency indicating an increase in protein content in fodder cereal grain in conditions of lower precipitation in April and May and higher total precipitations in June and July.

REFERENCES

Bertholdsson N.O., 1999. Characterization of malting barley cultivars with more or less stable protein content under varying environmental conditions. Eur. J. Agron. 10, 1-8.

Brzozowska I., 2008. Macroelement content in winter wheat grain as affected by cultivation and nitrogen application methods. Acta Agrophys. 11(1), 23-32.

Gondek K., Filipek-Mazur B., 2006. Akumulacja mikroelementów w biomasie owsa oraz ich dostępność w glebie nawożonej kompostem z odpadów roślinnych [Accumulation of microelements in barley biomass and their availability in soil fertilized with compost from plant wastes]. Acta Agrophys. 8(3), 579-590 [in Polish].

Jaśkiewicz B., Sułek A., 2004. Główne kierunki zmian w produkcji i wykorzystaniu zbóż [Major trends of changes in cereal production and utilization]. Pam. Puł. 135, 67-80 [in Polish].

Korzeniowska J., Stanisławska-Glubiak E., 2006. Reakcja owsa na różne metody nawożenia P, K, Mg w tradycyjnym i zerowym systemie uprawy roli [Response of barley to different methods of P,K,Mg fertilization in traditional and zero tillage system]. Biul. IHAR 239, 7-17 [in Polish].

Kraska P., Pałys E., 2009. Plonowanie i skład chemiczny ziarna pszenicy ozimej uprawianej w monokulturze w warunkach stosowania zróżnicowanych dawek herbicydów [Yielding and chemical composition of grain of winter wheat grown in monoculture in conditions of applying varied herbicide doses]. Prog. Plant Protection/Post. Ochr. Roślin 49(1), 440-444 [in Polish].

Liszewski M., 2008. Reakcja dwóch form jęczmienia jarego pastewnego na zróżnicowane technologie uprawy [Response of two forms of fodder spring barley to different cultivation technologies]. Zesz. Nauk. UP we Wrocławiu, Rozprawy 565 [in Polish].

Müller S., 1998. N uptake, yield and quality of malting barley in relation to inorganic soil nitrogen and N fertilization. Landwirtschaftliche forschung 41(1-2), 99-108.

Noworolnik K., 2009. Wpływ wybranych cech jakości gleby na plonowanie pszenżyta ozimego i żyta ozimego [Effect of selected features of soil quality on yielding of winter triticale and winter rye]. Acta Agrophys. 14(1), 155-166 [in Polish].

Noworolnik K., 2010. Plonowanie i jakość ziarna owsa w zależności od wilgotności podłoża i dawki azotu [Barley grain yielding and quality as affected by substrate humidity and nitrogen rate]. Żywność. Nauka. Technologia. Jakość 3(70), 190-196 [in Polish].

Oleksy A., Szmigiel A., Kołodziejczyk M., 2008. Wpływ intensywności uprawy na zawartość i plon białka odmian pszenicy ozimej [Effect of cultivation intensity on protein concentrations and its yield of the winter wheat cultivars]. Acta Sci. Pol., Agricultura 7(1), 47-56 [in Polish].

PN-ISO 5498, 1996. Oznaczanie zawartości włókna surowego. Metoda ogólna [Determination of raw fibre content. The general method] [in Polish].

PN-ISO 5983, 2000. Oznaczanie zawartości azotu i obliczanie zawartości białka ogólnego. Metoda Kjeldahla [Determination of nitrogen content and calculation of total protein content. The Kjeldahl method] [in Polish].

PN-ISO 6491, 2000. Oznaczanie zawartości fosforu. Metoda spektrometryczna [Determination of phosphorus content. The spectrometric method] [in Polish].

PN-ISO 13690, 2000. Ziarno zbóż, roślin strączkowych i przetwory zbożowe [Grain of cereals, legumes and cereal products] [in Polish].

PN-81/R-64780, 1981. Oznaczanie zawartości chlorków rozpuszczalnych w wodzie [Determination of content of chlorides soluble in water] [in Polish].

PN-93/R-64750,1993. Oznaczanie zawartości wapnia. Metoda miareczkowa [Determination of calcium content. The titration method] [in Polish].

Pecio A, Kubsik K., 2006. Zróżnicowanie plonu i zawartości białka w ziarnie jęczmienia jarego w obrębie pola produkcyjnego [Diversity of yield and protein content in spring barley grain within the production field]. Pam. Puł. 142, 349-362 [in Polish].

Podolska G., Sułek A., Konopka I., Dziuba J., 2006. Wpływ stresu suszy na plonowanie i zawartość związków alergizujących w ziarniakach pszenicy jarej odmiany Nawra [Effect of drought stress on yielding and content of alergizing compounds in kernels of the Nawra spring wheat]. Rocz. AR Poznań CCCLXXX, Rolnictwo 66, 297-304 [in Polish].

Sabo M., Ugarčić-Hardi Ž., 2002. Concentration of macro- and microelements in grain of some new winter wheat genotypes (*Triticum aestivum* L.). Acta Alimentaria 31(3), 235-242.

Sager M., Hoesch J., 2005. Macro- and microelement levels in cereals grown in lower Austria. J. Cent. Eur. Agric. 6(4), 461-472.

Stankiewicz C., 2004. Plon i zawartość białka ogółem oraz skrobi w ziarnie pszenżyta jarego odmiany Wanad w zależności od gęstości wysiewu, herbicydów i bronowania [Effect of sowing density, herbicides and harrowing application on yield and content of total protein and starch in Wanad spring triticale kernels]. Acta Sci. Pol., Agricultura 3(2), 77-88 [in Polish].

Wyszyński Z., Gozdowski D., Łoboda T., Pietkiewicz S., Wołejko E., 2002. Reakcja jęczmienia jarego browarnego w latach o zróżnicowanych opadach przy różnym nawożeniu azotem [Response of malting spring barley in years with varied precipitation at different nitrogen fertilization]. Zesz. Probl. Post. Nauk Rol. 481, 349-355 [in Polish].

OCENA ZMIENNOŚCI JAKOŚCI ZIARNA ZBÓŻ JAKO KOMPONENTA MIESZANEK PASZOWYCH

Streszczenie. Na podstawie wyników analizy 941 próbek ziarna jęczmienia, pszenicy i pszenżyta zbieranego w latach 2006-2010, przeprowadzonej w laboratorium surowców paszowych San-Vit S.J. w Janowcu Wlkp., oceniono zmienność zawartości białka ogólnego, włókna surowego, fosforu, wapnia i chlorków w surowcu do produkcji mieszanek paszowych. Określono także zależności pomiędzy zawartością składników w ziarnie zbóż oraz pomiędzy zawartością białka i jej zmiennością a sumami opadów w okresie wiosenno-letniej wegetacji. Stwierdzono, że najbardziej stabilnym elementem jakości ziarna była zawartość białka. Jego koncentracja w ziarnie pszenżyta była tym większa, im mniej zawierało ono wapnia, natomiast w ziarnie pszenicy wzrastała wraz ze wzrostem zawartości fosforu. Mimo krótkiego okresu badań stwierdzono tendencję zwiększania się zawartości białka w ziarnie przy mniejszej ilości opadów w kwietniu i maju oraz większej w czerwcu i lipcu.

Słowa kluczowe: białko ogólne, chlorki, fosfor, jęczmień, pszenica, pszenżyto, wapń, włókno surowe

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