A C T A   A L I M E N T A R I A   P O L O N I C A
Vol. XV (XXXIX), No. 3 1989

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ATTEMPTS TO UTILIZE WILD OAT (*AWENA FATUA L.*) IN CEREAL PROCESSING
PART. I. PHYSICAL AND CHEMICAL PROPERTIES OF WILD OAT*)

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Key words: cereal processing, wild oat, physical and chemical properties.

Studies on the commdity and physical properties, and chemical composition of wild oat grain were conducted and they were compared with similar studies on the commercial oat grain, variety Rumak. It was stated that wild oat, owing to its favourable chemical composition and other properties may be utilized for food production purposes.

Wild oat, also called oat grass (*Avena fatua L.*) is one of the most troublesome cereal weeds. Large quantities of wild oat are harvested together with the grain of bread cereals. In Poland, the highest contamination of cereals with wild oat takes place in the eastern regions where about 1-2% of this weed are found in the cereal mass.

The studies of Canadian scientists [1, 3, 4, 5] revealed that the grain of wild oat is interesting due to the content of protein, vitamins and mineral components. Due to a high level of aminoacids and especially of lysine, the grain of wild oat may be utilized as a source of readily available dietetic protein, especially in food products destined for infants and small children [3].

The encouraging results of the Canadian studies have led to the performance of similar studies under Polish conditions.

The aim of the study is a characteristic of the wild oat, its selected physical and chemical properties and their comparison with the properties of grade oat of the Rumak variety.

*) The study has been subsidized by the Committee of Food Chemistry and Technology of the Polish Academy of Sciences.

EXPERIMENTAL MATERIAL

The experimental material used in the study was constituted by the following grain:

— wild oat (*Avena fatua L.*) obtained as a result of the cleaning of wheat grain at the Grain-Milling Industry, Mill in Białołęka;

— commercial oat (*Avena sativa*), variety Rumak, deriving from the 1985 harvest, obtained from the Poznań Plant Cultivation Centre.

METHODS OF WORK

From the mass of useful contaminations obtained as a result of cleaning wheat grain, the mixture of grains of various cereals and weeds was separated from which, by the method of manual picking, a pure fraction of wild oat was isolated. The grain of commercial and wild oat was dehulled in a laboratory huller OL 1 (made by PRM PZM at Szczytno).

The inner structure of grain of commercial oat and of wild was examined using a scanning microscope. The studies were conducted on longitudinal and transverse cross-sections. The obtained grain preparations were subjected to preliminary drying under vacuum and then to vacuum evaporation with carbon and silver (in a vacuum evaporator type JEE-4C of the Joel firm), at a pressure of 2.7 MPa. The parametres of observation were: electrons accelerating voltage in the microscope column — 25 000 V, electronic beam current absorbed in the sample — 1.5×10^{11} A.

The tested grain semples were subjected to routine evaluation and the following determinations were made: density of grain in a loose state, weight of 1000 grains, equalization — screening of the grain sample on a sieve with meshes 25 × 1.6 mm; the content of hull — by the method of manual separation of hull from grain, expressing the result in % d.m. after drying of samples at 130°C for 1 hour; hardness of the grain — by two methods: by measuring the resistance of a 50 g sample of grain during the milling in a Brabender mouthpiece to farinograph [2], and by crushing of individual grains perpendicularly to their longitudinal axis, in an Instron 1140 apparatus. In the second method, the hardness of grain was read out (maximum on curve) from the diagram in the force-deformation system, recorded during the measurements. Hardness was interpreted as the force, indispensable for breaking the grain in several places. The parameters of the measurement were: range of loads: 0-100 N, rate of deformation: 50 mm/min., feed rate of recording tape: 200 mm/min. Six individual measurements for each sample were made and the arithmetical mean was calculated.

The colour of grain was determined using a Momcolor 3098 apparatus; the x_1, x_2, Y and Z values were used to determine hue, saturation and brightness in the x and y arrangement, CIE system.

The dimensions of the grain (lengt, width, thickness) were measured with the use of a micrometer screw, performing 12 measurements for each sample and calculating the arithmetical mean.

Determination of the content of total protein, cellulose, fat and water in the grain was made using an Infrapid 31.

In the examined samples, the content of amino acids was determined using a Beckman aminoacid analyzer. The results were expressed in g/16 g N.

The content of starch was determined by the polarimetric method of Lintner, the total content of reducing sugars — by the method of Bertrand and that of total ash — by incineration and calcination of the sample at 900-920°C for 1 hour. The level of ash insoluble in 10% HCl was also determined. The total acidity was determined by titration with NaOH solution in the presence of phenolphthalein.

The presence of macro — and microelements was determined by the method of atomic absorption spectrometry.

RESULTS AND DISCUSSION

EXTERNAL APPEARANCE AND INTERNAL STRUCTURE OF OAT GRAIN

There are distinct differences of colour between the grain of wild oat and commercial oat, differences in dimensions being also visible mostly in relation to the chaffed (screened) grain. The discussed differences are confirmed by the results of the measurements of characteristic dimensions of the grain of both oats and their colour. These results have been presented in Table 1. Both the size of the grain and its colour are properties which may affect the quality of products made from them.

Table 1. Comparison of the dimensions of the chaffed and dehulled oat grain

Examined grain	Dimension: (mm)		
	length	width	thickness
Wild oat:			
— chaffed	11.5±0.4	2.4±0.3	1.7±0.3
— dehulled	7.1±1.0	2.1±0.3	1.5±0.3
Commercial oat:			
— chaffed	12.0±0.9	2.5±0.7	3.3±0.4
— dehulled	7.1±1.4	2.5±0.7	2.0±0.5

The internal structure of the oat grain was studied using a scanning microscope. Fig. 1 shows transvers cross-sections of the examined grains, in a 30X magnification. Wild oat (Fig. 1a) is characterized by a relatively deep but simultaneously narrow groove (fissure). The surface of the fruit-and-seed cover is covered with thick and long hair.

Commercial oat of the Rumak variety (Fig. 1b) has a considerably shallower and wider groove. Its fruit-and-seed cover is thinner and is covered woth rare hair much shorter than in wild oat.

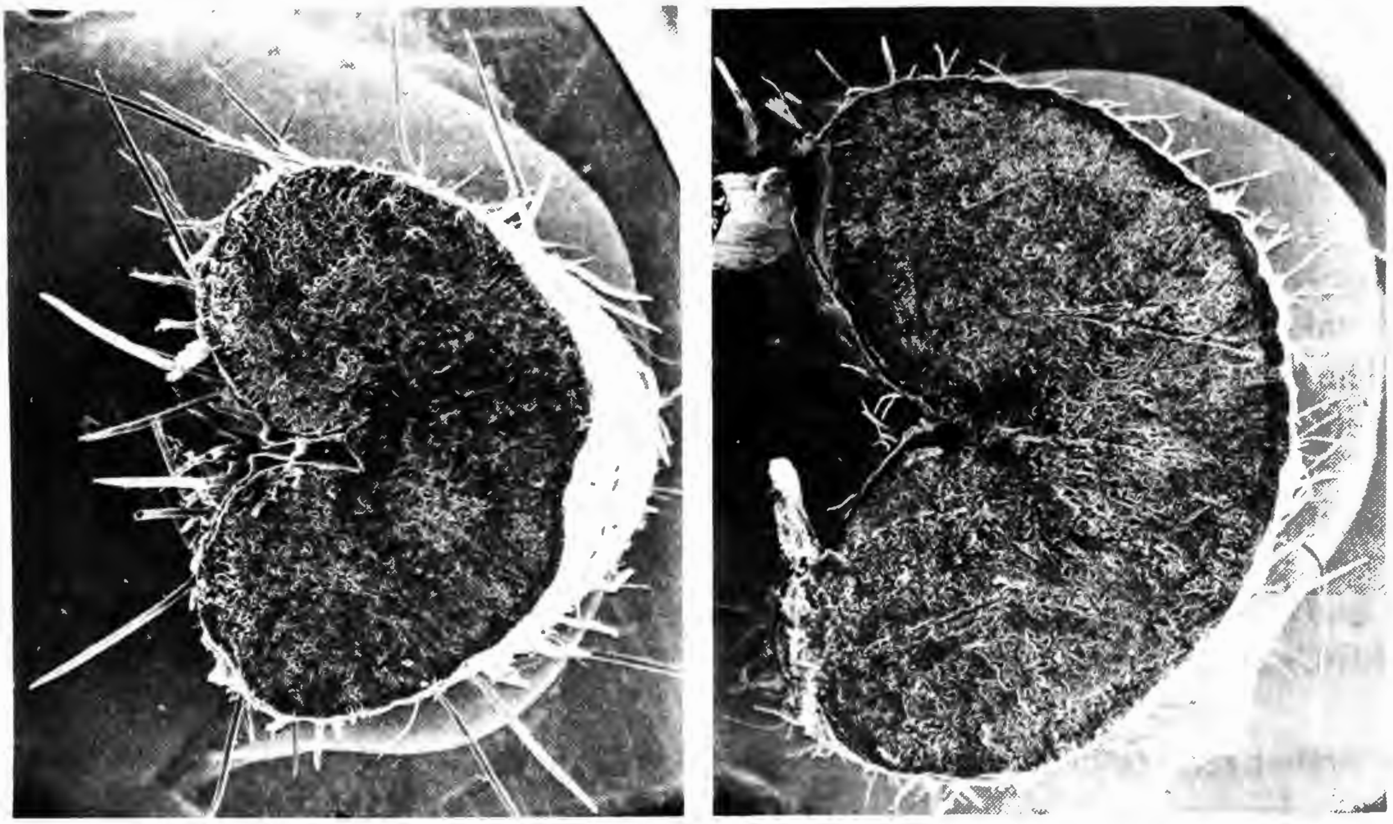

Fig. 1. Transverse cross-section of oat grain (scanning microscope, magnification 30x; a — wild oat, b — commercial oat

Fig. 2 shows fragments of the fruit-and-seed cover together with the aleuronic layer and adjacent endosperm. The aleuronic layer of wild oat (Fig. 2a) is composed of rectangular, non-uniform cells almost completely filled with, most propably protein. No free space was found in aleuronic cells, a frequent property

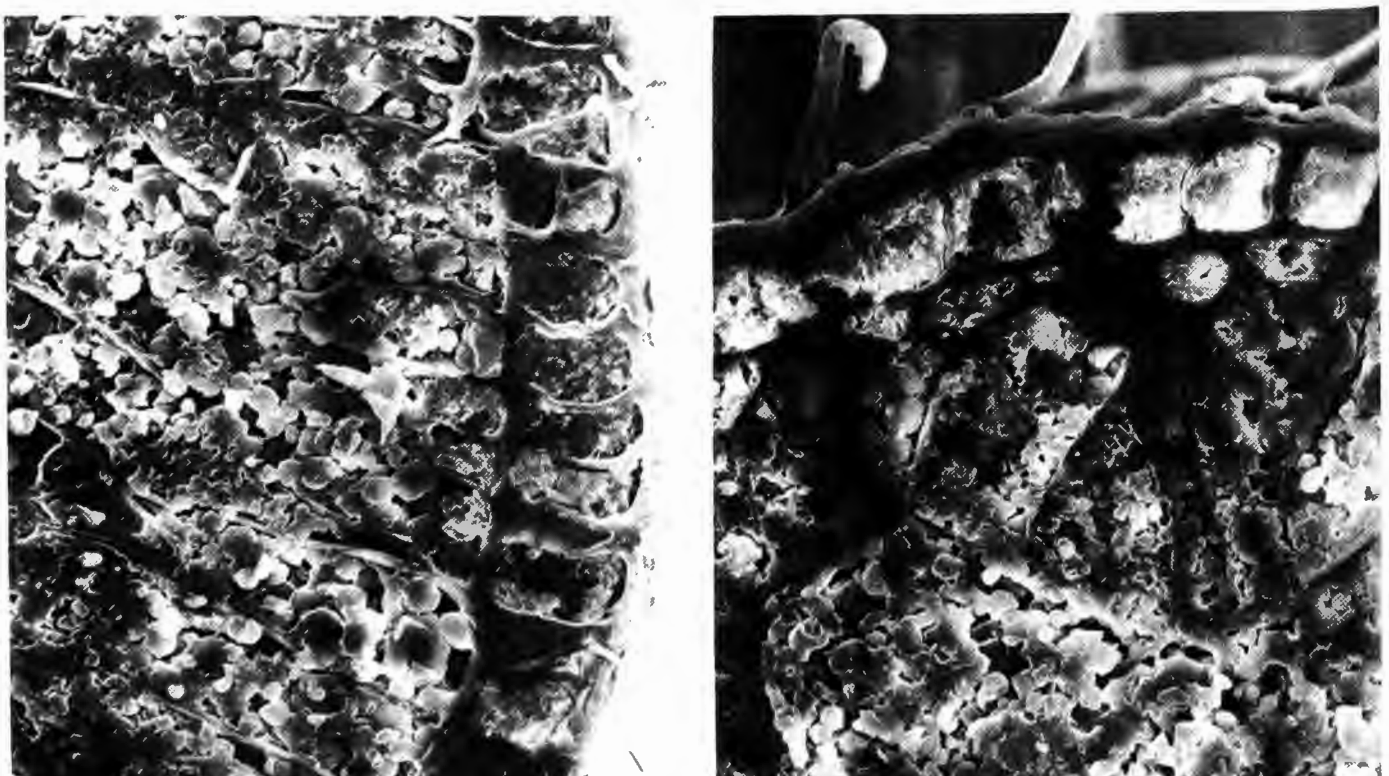

Fig. 2. Section of fruit-and-seed cover with a fragment of grain endosperm (magn. 400x); a — wild oat, b — commercial oat

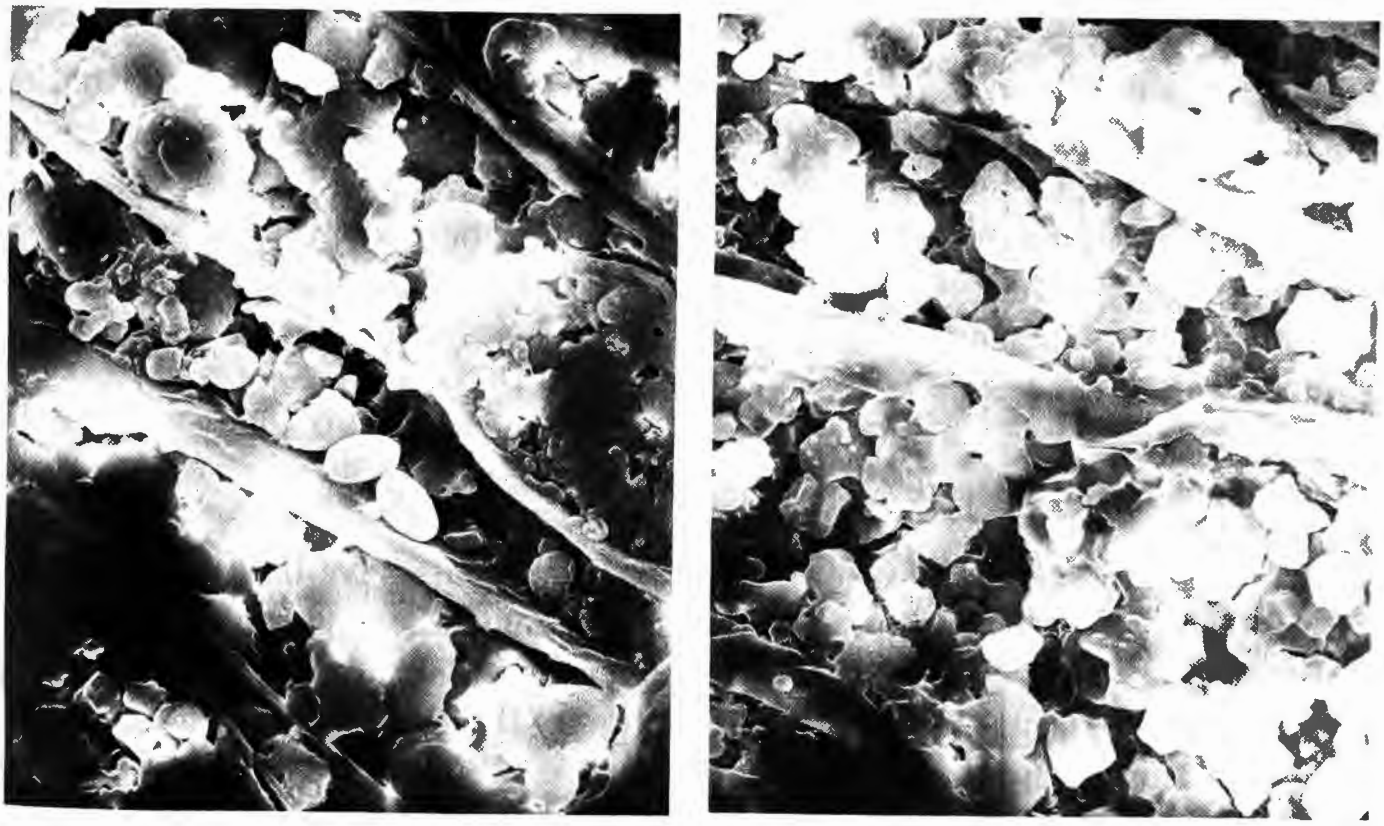

Fig. 3. Structure of grain endosperm (magn. 1000x); a — wild oat, b — commercial oat

of other cereals. The structure of the aleuronic layer of commercial oat (Fig. 2b) is similar but it is thinner and its cells have a square cross-section.

The structure of the endosperm visible in Fig. 2 and in Fig. 3, in a much greater magnification, shows that the endosperm of wild oat is looser in comparison with that of commercial oat, variety Rumak. The visible starch grains of wild oat have an oval shape and are larger than the grains of commercial oat. The latter, which are slightly smaller, do not have a regular shape.

Fig. 4. Structure of grain endosperm (magn. 3000x); a — wild oat, b — commercial oat

It may be explained by a greater, closer packing of endosperm of commercial oat what causes that starch grains do not have a regular shape. A similar phenomenon is met with e.g. grains of hard wheat, in contrast to soft wheat. In the endosperm of both oats, the grains of starch are separated with bands which are probably constituted by so-called fibrous protein, appearing in cereal grains. The above properties are especially well visible in Fig. 4 at a 3000 x magnification. We cal also see protein membranes around the starch grains in wild oat as well as in commercial oat.

THE COMMODITY QUALITIES OF THE GRAIN OF WILD AND COMMERCIAL OATS

The commodity qualities of the two examined oats have been presented in Tables 2 and 3. Table 2 shows the results for the chaffed (screened) grain and Table 3 gives the results for the hulled grain. All examined samples were characterized by a high degree of equalization of the grain, being the amount of grain remaining on the screen with meshes sized 25 × 1.6 mm, expressed in percent. Commercial oat was always superior to wild oat in terms of grain equalization, regardless of the form of grain i.e. chaffed or dehulled. After dehulling, in both oats, the degree of grain equalization was decreased especially in wild oat in which — after dehulling — the degree of equalization dropped by almost one third. The above results are evidence of the considerably thicker hull in wild oats and consequently of its higher percentage share in the mass of the whole grain. It was confirmed by further results, e.g. by the content of hull in the grain. Measurments demonstrated that the hull in the grain of wild oat constituted 33.2% of d.m. of the whole grain while in the commercial oat it was only 26.1% of d.m.

The size of the grain has a direct influence on the weight 1000 graints and an indirect one on its density in a loose state. The weight of 1000 grains depends also on other factors, including the humidity of the grain, thickness of the hull and structure of endosperm. The obtained weights of 1000 grains are a confirmation of this statement.

The density of the grain in a loose state was more equalized than other examined properties. For the chaffed grain, it was: 50.1 kg/hl for the commercial oat and 48.1 kg/hl for the wild oat while for the dehulled oat, it amounted to 74.4 and 70.4 kg/hl, respectively. Higher results for the commercial oat are evidence of better equalization and better filling of endosperm what was confirmend by microscopic studies.

Within the framework of the performed evaluation of commodity qualities, measurements of the hardness of grain were conducted, using Brabender farinograph mouthpiece and Instron 1140. The measurements revealed that in each case, using both methods of measurement, the commercial oat was characterized by a harder grain. The results confirm earlier observations concerning inner structure, chemical composition etc. Smaller hardness of the

Table 2. Commodity qualities and physical properties of the chaffed oat grain

Specification	Grain of wild oat	Grain of commercial oat
Humidity (%)	14.1	13.4
Equalization (%)*	96.8	100.0
Density of grain in a loose state (kg/hl)	48.5	50.1
Weight of 1000 grains (g)	28.5	22.6
Content of hull (% d.m.)		
Content of usable contaimina-	33.2	26.1
tions (%)	0.0	2.0
non-usable contaiminations (%)	0.0	2.1
Characteristics of colour hue (= λ)	575	580
saturation	0.24	0.80
brightness	11.9	28.7

*) amount of grain (%) retained on a screen with meshes 25 × 1.6 mm

Table 3. The commodity qualities and physical properties of the dehulled oat grain

Specification	Grain of wild oat	Grain of commercial oat
Humidity (%)	12.6	12.0
Equalization (%)*)	60.3	95.9
Density of grain in a loose state (kg/hl)	70.4	74.4
Weight of 1000 grains (g)	15.8	24.3
Hardness of grain		
— Brabender mouthpiece to farinograph (B. U.)	250	300
— Instron 1140 (N)	30.0	51.7
Work used for disintegration of grain (J/1000 g)	2600.0	2400.0
Characteristics of colour hue (= λ)	581	579
saturation	0.35	0.39
brightness	25.8	26.7

*) amount of grain (%) retained on a screen with meshes 25 × 1.6 mm

grain of wild oat may be evidence of its behaviour during processing. Such grain may require a lower energy input e.g. during flaking but may also have an unfavourable influence on the quality of flakes, and first of all, on their structure and amount of flour in the flakes.

CHEMICAL COMPOSITION OF THE GRAIN OF WILD AND COMMERCIAL OAT

Table 4 shows the chemical composition of the chaffed grain of wild oat and commercial oat, variety Rumak. The conducted tests revealed, first of all, that the grain of wild oat is a rich source of protein. Its content amounted to 15.7% in the chaffed grain and 17.8% in dehulled grain, in terms of dry mass of the grain and it was by 2.7-3.3% higher than in the grain of the Rumak variety commercial oat. It was simultaneously stated that protein of the wild oat is a good source of amino acids (see Table 5). In wild oat, the content of all amino acids was higher than in the commercial oat what is especially clear when calculating their amount in relation to the weight of the whole grain. Aminoacid composition together with

Table 4. Chemical composition of the chaffed grain of oat

Examined grain	Humidity (%)	Protein, total (% d.m.)	Starch (% d.m.)	Ash, total (% d.m.)	Ash insoluble in 10% HCl (% d.m.)	Fat (% d.m.)	Cellulose (% d.m.)	Acidity °
Wild oat	14.1	15.7	48.3	3.9	0.4	5.2	17.9	6.7
Commercial oat	13.4	13.0	55.8	3.1	0.3	5.7	15.0	7.3

Table 5. The content of amino acids in the examined oats

Amino acids	Wild oat		Commercial oat	
	in g/16 g N	in % of grain weight	in g/16 g N	in % of grain weight
Treonine	3.33	1.1042	3.48	0.0884
Valine	5.25	0.1643	5.31	0.1349
Isoleucine	3.83	0.1199	3.90	0.0991
Leucine	7.29	0.2282	7.35	0.1867
Thyrosine	3.61	0.1130	3.72	0.0945
Phenylalanine	5.49	0.1718	5.35	0.1359
Lysine	3.92	0.1227	4.20	0.1067
Cysteine	2.73	0.0854	3.23	0.0820
Methionine	1.63	0.0510	1.84	0.0467
Tryptophan	1.36	0.0426	1.41	0.0358
Aspartic acid	7.80	0.2441	8.15	0.2045
Serine	4.50	0.1409	4.90	0.1245
Glutamic acid	24.08	0.7537	24.08	0.6116
Proline	5.13	0.1606	5.44	0.1382
Glycine	4.61	0.1443	5.16	0.1311
Alanine	4.41	0.1380	4.84	0.1229
Histidine	2.36	0.0739	2.29	0.0582
Arginine	7.42	0.2322	7.54	0.1915
Nitrogen content, total in % d m.	3.13		2.54	

the high content of total protein causes that wild oat may be a valuable raw material for the food industry.

As seen from the presented composition of amino acids (Table 5), glutaminic acid occupied a top place on the list followed by aspartic acid, arginine and leucine, both in commercial oat and in wild oat. The content of lysine in the commercial oat as well as in wild oat was 4.20 and 3.92 g/16 g nitrogen, respectively, or 0.1067% and 0,1227% in relation to the weight of the whole grain.

According to expectations, the oat grain had a high centent of fat. A higher content was found in the commercial oat (5.7% d.m.) than in wild oat (5.2% d.m.). The content of fact had a direct influence on the acidity of oat which amounted to 7.3° for commercial oat and it was by 0.6° higher than in wild oat.

Likewise, according to expectations, it was stated that both examined oat had a high content of cellulose, amounting to 15.0% d.m. in the commercial oat and 17.9% d.m. in the wild oat. In the latter oat the higher level of cellulose was accompanied by a higher content of and ash.

Table 6. The content of major macroelements in dehulled oat grain

The examined grain	Total nitrogen %	Potassium %	Phosphorus %	Sulphur %
Wild oat	3.13	0.29	0.57	0.36
Commercial oat	2.54	0.31	0.45	0.48

Table 7. The content of microelements in dehulled oat grain

The examined microelements (ppm) / The examined grain	Wild oat	Commercial oat
Magnesium (Mg)	425.0	375.0
Calcium (Ca)	287.5	243.7
Sodium (Na)	90.6	90.6
Manganese (Mn)	42.5	47.5
Zinc (Zn)	35.4	38.4
Copper (Cu)	6.1	4.6
Iron (Fe)	64.4	46.2
Nickel (Ni)	0.4	0.1
Lead (Pb)	traces 0.1—0.3	
Cadmium (Cd)	traces 0.02 0.04	
Cobalt (Co)	not found	
Chromium (Cr)	not found	

In both examined oats, there were certain differences in the content of macro and microelements. The results are listed in Tables 6 and 7. Among macroelements, noteworthy is the high content of nitrogen in the dehulled grain of wild oat, being by almost one fourth higher than in the grain of the Rumak variety commercial oat. As to microelements the level of magnesium and calcium is higher in the grain of wild oat than in commercial oat (by 13 and 18%, respectively).

The stated chemical composition, and especially the level of total protein and its amino acid composition is evidence of the high nutritive value of the grain of wild oat, a potential raw material for cereal processing.

CONCLUSIONS

The conducted studies lead to the following conclusions:

1. The grain of the wild oat, both chaffed and dehulled, is generally smaller and the greatest differences with commercial oat, appear in relation to the thickness and length of the chaffed grain.

2. There are differences between the wild oat and the Rumak variety commercial oat in the internal structure of the grain. The differences refer to the size of the particular elements, i.e. aleuronic layer, size and distribution of starch grains and distribution of proteins. These differences may be explained by the way of packing inside the grains, grain hardness and also, they may be a consequence of variety properties.

3. Wild oat is a rich source of total protein. Its content amounts to 15.7% d.m. in the chaffed grain and 17.8% d.m. in dehulled grain which is by 2.7 and 3.3% more than in commercial oat. Wild oat is also a richer source of amino acids, including lysine (limitating amino acid) the level of which, calculated in relation to the weight of the whole grain, is by about 15% higher than that in the commercial oat, variety Rumak.

4. The content of starch in wild oat is by 5-8% lower in the average than that in the commercial oat while the content of total ash and of cellulose is higher. The content of fat in both oats was similar.

5. The grain of wild oat was characterized by a higher total (general) acidity what may point to its increased lipolytic activity.

6. On the basis of the conducted studies, it may be stated that wild oat may be utilized as raw material in cereal processing. Therefore, it is purposeful to perform technological trials aimned at its practical utilization.

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Manuscript received: December 1987
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PRÓBY WYKORZYSTANIA DZIKIEGO OWSA (*AVENA FATUA L.*) W PRZETWÓRSTWIE ZBOŻOWYM. I. CHARAKTERYSTYKA CECH FIZYCZNYCH I CHEMICZNYCH KRAJOWEGO DZIKIEGO OWSA

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Streszczenie

Prace naukowców kanadyjskich [1, 3, 4, 5] dotyczące możliwości wykorzystania ziarna dzikiego owsa (*Avena fatua L.*) w przetwórstwie zbożowym skłoniły do przeprowadzenia podobnych badań w warunkach krajowych. Przeprowadzone prace miały na celu określenie składu chemicznego i cech towaroznawczych ziarna dzikiego owsa pod kątem jego ewentualnego wykorzystania w przetwórstwie. Uzyskane wyniki oceny porównano z analogicznymi badaniami owsa handlowego odmiany Rumak. Ziarno dzikiego owsa uzyskano w wyniku wydzielenia go z zanieczyszczeń użytecznych otrzymywanych podczas czyszczenia pszenicy przed przemiałem. W tab. 1 zebrano wyniki podstawowych wymiarów ziarna, tj. długości, szerokości i grubości. Badanie struktury wewnętrznej ziarna wykonano przy użyciu mikroskopu skaningowego, a niektóre otrzymane zdjęcia przedstawiono na fot. 1-4.

Przeprowadzona ocena towaroznawcza obu badanych owsów, zarówno ziarna oplewionego (tabl. 2), jak i obłuszczonego (tabl. 3) wykazała, że są różnice między owsem dzikim i handlowym, przede wszystkim w wielkości ziarna, co z kolei rzutuje na masę 1000 ziarn, czy gęstość ziarna w stanie zsypnym. Ziarno owsa dzikiego zawiera znacznie więcej łuski niż ziarno owsa handlowego. W owsie dzikim stanowi ona przeszło 1/3 masy całego ziarna. Analiza chemiczna (tabl. 4) wykazała przede wszystkim, że dziki owies zawiera w swoim składzie dużą ilość białka ogółem, 15,7% sm w ziarnie oplewionym i 17,8% sm w ziarnie obłuszczonym i przewyższa pod tym względem owies handlowy odmiany Rumak odpowiednio o 2,7 i 3,3%. Białko owsa dzikiego zawiera także korzystny skład aminokwasowy (tabl. 5). Ponadto stwierdzono, że oplewione ziarno dzikiego owsa zawiera, w porównaniu z ziarnem oplewionego owsa handlowego, mniej skrobi i tłuszczu, natomiast więcej popiołu i błonnika. Z oznaczonych makro- i mikroelementów (tabl. 6 i 7) zwraca uwagę przede wszystkim zawartość azotu ogółem (o 1/4 wyższa w owsie dzikim niż handlowym) oraz magnezu i wapnia, wyższa odpowiednio o ok. 13 i 18%.

Na podstawie przeprowadzonych badań można stwierdzić, że dziki owies może być potencjalnym surowcem dla przetwórstwa zbożowego.