

# SHORT COMMUNICATION

## FEEDING QUALITY OF WHEAT FROM CONVENTIONAL AND ECOLOGICAL FARMING\*

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The feeding quality of diets with wheat varieties, cultivated ecologically (according to the principles of IFOAM – Basic Standards, and the Law of Organic Farming No. 368/1992 Coll. and 242/2000 Coll. of the Ministry of Agriculture of the Czech Republic) and with varieties cultivated intensively with higher rate of fertilization, seed treatment, use of herbicides, fungicides and growth regulators was studied in three-year feeding experiments performed with model animals – rats. The differences among varieties were showed in feeding value tested in polysynthetic diets in which the studied wheat varieties were the only source of nitrogen (in the amount equivalent to 10% of N x 6.25). The varieties of excellent baking quality had significantly worst values of feed conversion, daily weight gain, uptake of lysine and PER values. On the contrary, some non-food (non-baking) varieties showed better results in feeding. Moreover, generally better feeding values of diets, where wheat varieties originated from ecological farming, were recorded. Wheat varieties from ecological farming had higher share of soluble fractions of proteins (albumins and globulins) and hence also higher content of essential amino acids is presupposed. Better results of the feeding trial can be seen in it. The convincing preference of experimental rats in consumption of diets with ecologically cultivated wheat could be explained by better palatability but rather with an ability of animals to perceive also trace amounts of pesticide residues.

ecological farming; wheat, varieties; feeding quality

### INTRODUCTION

In recent years a fast development of ecological farming, particularly in the countries of the European Union, was recorded. There is a growing demand for pork and poultry from ecological farming and ecological production of feed is needed for it. Cereals are the main source of energy in monogastric animals. Not many information exist on the feed quality from ecological farming. Some literary data report on lower mortality of young animals during feeding of rabbits by ecological feed (Gottschewski, 1975) and similar experience was found with chicks. We still have devoted material composition of winter wheat varieties in relationship to baking quality and spring barley from malting from ecological and conventional (intensive) farming. We found lower content of crude proteins and changes in the composition of protein fractions (Petr et al., 1998, 2002, 2003). In this work we tested the feeding quality of wheat cultivated ecologically and intensively.

### MATERIAL AND METHOD

A nutritional value of selected wheat varieties was tested in growth experiments with model animals (laboratory rats). Several tests were conducted for this pur-

pose. Different diets were composed with respect to different contents of nutrients (particularly of crude protein) in used varieties to obtain the same level of crude protein content (10%), energy and use indicators. The feed and water were administered ad libitum.

In 1997 it was the test carried out with five varieties of feed wheat (Siria, with protein content 12.5%, Šárka (12.0%), Samara (11.1%), Ritmo (11.6%) and Estica (11.4%) where varietal differences in feed value were investigated. In further experiment the nutritional value of two wheat varieties (Ritmo and Siria), cultivated conventionally with a high intensity (fertilizer: 60 kg P<sub>2</sub>O<sub>5</sub>, 60 kg K<sub>2</sub>O and 90–110 kg N, herbicide Glean 25 g per ha, fungicide Tango (0.6 litre per ha, and plant regulator Chlormequat-CCC 1 kg active substance per ha). Ecology farming at the Experimental Station of the Czech University of Agriculture in Uhřetěves, certified for ecology experiments was according to the principles for ecology farming (without use of fertilizers and pesticides) set by the Decree of the Ministry of Agriculture of the Czech Republic No. 242/2000, and instructions issued by international organisation for ecology agriculture IFOAM (the International Federation of Organic Agriculture Movement) was tested. Both systems were situated in the same fertile sugar-beet growing region.

Males of laboratory rats of the strain Wistar from the SPF (specific pathogen free) rearing were used in the

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experiment. Their starting weight ranged between 50 and 60 grams. After 7-day acclimatisation the experiment lasted 20 days.

Different polysynthetic diets were composed in such a way that a sole source of nitrogen (in amount equivalent to 10% N x 6.25) were studied wheat varieties. In addition, diets contained identical amount of mineral-vitamin concentrate for laboratory rats and soybean oil. The wheat starch was used to completing the diets to 100%. The feed consumption was studied precisely, likewise the intensity of growth by weight gains of animals' bodies. Average feed conversion and protein efficiency – PER were calculated from the results obtained.

Each group was composed of six animals, individually housed in balance cages. Different groups were fed always by one diet. The microclimate of the stable was checked every day (air temperature was set to 23 °C, relative air humidity 55%). The overpressure system provided ventilation.

The second experiment in 1997 comprised 12 animals of the same origin like in the previous experiments. The conditions of rearing and nutrition were identical. Animals were divided into two groups according to the fed varieties – Siria and Ritmo. Each cage contained two feeders. One cage contained the diet with the variety cultivated intensively, the second one contained ecologically cultivated variety. The feed was also administered ad libitum. The trial lasted 10 days. Protein content in variety Siria cultivated ecologically was 12.4%, and intensively 12.8%, in variety Ritmo it was 11.6% and 12.1%.

In 1998 the balance trial with laboratory rats was established to set the difference in the protein quality in both wheat varieties (Šárka and Estica), cultivated conventionally and ecologically according to the above-mentioned conditions. The experiments studied biological value of proteins (BV), nitrogen balance (NB), coefficient of true digestibility, coefficient of apparent digestibility and net protein utilisation (NPU).

The determination of biological value was done after Thomas and Mitchell (K a c e r o v s k ý et al., 1990). Nitrogen balance is expression of the difference of nitrogen accepted and excreted by excrements. Coefficient of true digestibility manifests a percentage between digested nitrogen (diminished by percentage of metabolic N) and accepted nitrogen. Net protein utilisation (NPU) expresses the relationship between nitrogen balance (enlarged by metabolic endogenous nitrogen) and nitrogen intake. Fecal metabolic (Y) nitrogen (mg/day) and urinary endogenous (Z) nitrogen (mg/day) were calculated from average weight (W) of laboratory rats (g) in balance period according to the formula:  $Y = -3.601 + 0.110 W$ ,  $Z = 10.30 + 0.076 W$  (K a c e r o v s k ý et al., 1990).

The experiment included 24 males of model animals, bred identically with the system used in the first experiment. Adaptation period lasted four days. Each group contained six animals. Balance period continued seven days.

In 1999 the trial was repeated to test the feeding value of identical wheat varieties (Šárka with protein content 13,2% and Siria 12.6%) like in the previous years and

included a high-quality bread wheat of the variety Hana, with protein content 16.2%. The trial was conducted under the same conditions and evaluated by a similar way like in the previous years.

The second experiment in the given year was replicated to test the feeding value from the conventional and ecological cultivation of the varieties Estica and Šárka. Protein content in variety Estica cultivated ecologically was 11.4% and intensively was 11.97%, in variety Šárka was 11.13% and 14.16%. It was again conducted and assessed in the same way like in the previous years.

Characteristics of the varieties used:

Hana – high-quality baking wheat of the quality A, registered in the years 1985–2000.

Siria – the Czech variety of the quality B, registered in 1994, with high content of proteins.

Šárka – the Czech variety of the quality B, registered in 1997.

Estica – the Holland late variety, unsuitable for baking utilisation of the quality C, registered in 1996.

Ritmo – the Holland late variety, unsuitable for baking utilisation of the quality C, with low content of proteins, registered in 1996.

Samara – the Czech semi-late variety, unsuitable for baking utilisation, with medium content of proteins, registered in 1995.

## RESULTS

The growth experiment with five wheat varieties (Table 1) did not bring significant differences among feeding values. PER values solely were on the limit of significance.

The experiment of the orientation character with administration of the varieties Ritmo and Siria, cultivated ecologically and conventionally (with higher intensity), showed a significant preference of diet uptake in rats (Table 2), when wheat was cultivated ecologically.

In the second experimental year the diets were not administered to the choice of rats to one cage but each group of rats obtained only one diet from each variety – with wheat cultivated ecologically and the second group cultivated conventionally. The situation was similar with the variety Šárka (Table 3).

The feed conversion was statistically significantly better in mixtures with ecologically cultivated wheat. Differences were insignificant in daily intake of nitrogen. Differences in the growth rate were significantly higher, except for the variety Šárka. However, in this variety like in the previous experiments, weight gains of animals were higher than with the variety Estica. In other indicators the values were better in the diet with ecological wheat, but not statistically significantly. This experiment was replicated with the same variety in the next year (Table 4).

It is showed convincingly from the results that the variety Šárka has a better feeding value than the variety Estica. In addition, better feeding value in ecologically

Table 1. The survey of the values of feeding experiment with five wheat varieties

Indicator	Variety	Siria	Šárka	Estica	Ritmo	Samara
Feed conversion	$\bar{x}$ g/g	6.54	5.87	5.92	6.57	6.54
	<i>s</i>	0.54	0.61	0.32	0.99	0.49
Total feed consumption	$\bar{x}$ g	259.73	264.43	266.70	270.28	275.98
	<i>s</i>	24.95	12.80	34.89	13.54	20.77
Feed consumption per day	$\bar{x}$ g/day	12.99	13.22	13.34	13.51	13.80
	<i>s</i>	1.25	0.64	1.74	0.68	1.04
N consumption per day	$\bar{x}$	1.30	1.33	1.37	1.35	1.41
	<i>s</i>	0.12	0.06	0.18	0.07	0.11
Daily weight gain	$\bar{x}$ g/animal	2.0	2.27	2.26	2.10	2.13
	<i>s</i>	0.25	0.21	0.35	0.28	0.29
PER Index	$\bar{x}$	1.54	1.71	1.65	1.55	1.50
	<i>s</i>	0.12	0.18	0.09	0.24	0.12

$\bar{x}$  = average, *s* = standard deviation

Table 2. Diet consumption of the diet containing ecology and conventional wheat

Variety	Ritmo	Ritmo	Siria	Siria
Cultivation	ecology	conventional	ecology	conventional
Average $\bar{x}$	89.16	31.50	104.17 <sup>+</sup>	25.17 <sup>+</sup>
Standard deviation <i>s</i>	32.15	28.43	24.71	11.74

<sup>+</sup> significantly different ( $P < 0.05$ )

Table 3. The survey of indicators characterising the quality of crude protein of varieties cultivated ecologically and conventionally

Indicators	Variety	Estica	Estica	Šárka	Šárka
	Cultivation	ecology	conventional	ecology	conventional
Feed conversion	$\bar{x}$ g/g	3.6485 <sup>+</sup>	6.5600 <sup>+</sup>	3.0467 <sup>+</sup>	4.1979 <sup>+</sup>
	<i>s</i>	0.7305	0.6357	0.4584	0.6547
Daily intake of CP (N x 6.25)	$\bar{x}$ g	1.00	1.03	1.15	1.18
	<i>s</i>	0.03	0.14	0.10	0.07
Daily weight gain	$\bar{x}$ g	2.89 <sup>+</sup>	1.73 <sup>+</sup>	4.01	2.77
	<i>s</i>	0.48	0.25	0.83	0.49
NPU (Net protein utilisation)	$\bar{x}$	40.61	38.92	48.65	41.29
	<i>s</i>	2.76	1.18	7.04	4.16
BV biological value	$\bar{x}$ %	48.28	47.40	55.17	49.78
	<i>s</i>	2.48	1.18	7.04	2.93
Coefficient of true digestibility	$\bar{x}$ %	84.03	82.15	87.88	82.88
	<i>s</i>	2.28	2.90	3.01	4.88
NB nitrogen balance	$\bar{x}$ %	47.26	47.04	71.61	58.03
	<i>s</i>	5.48	9.47	18.67	7.62

$\bar{x}$  = average, *s* = standard deviation, <sup>+</sup> significantly different ( $P < 0.05$ ), <sup>++</sup> ( $P < 0.01$ )

cultivated wheat is evident in majority of indicators and is statistically significant. Estica and Šárka are highly significantly better in feed conversion. Šárka was much better in the values of gains under ecology cultivation. PER values that are higher in ecologically cultivated wheat are also important.

The third lot of growth experiments studied the feeding value of selected varieties of wheat and triticale. The results are presented in Table 5.

## DISCUSSION

Variety differences were manifested in the results of nutritional value that represent particularly protein component of cereal grain followed from these results. It was confirmed by many authors, e.g. Fuchsová et al. (1987), Michalík, Karlubík (1988), Heger et al. (1990). Quality food varieties had worse results in our experiment. They were represented by the variety Hana,

Table 4. The survey of indicators of feeding value of wheat cultivated ecologically and conventionally

Indicator	Variety	Estica	Estica	Šárka	Šárka
	Cultivation	ecological	conventional	ecological	conventional
Feed conversion	$\bar{x}$ g/g	5.61	6.19 <sup>++</sup>	4.88 <sup>++</sup>	5.40
	<i>s</i>	0.19	0.24	0.33	0.17
Daily weight gain	$\bar{x}$ g/day	2.47	2.27	3.27 <sup>++</sup>	2.76 <sup>++</sup>
	<i>s</i>	0.26	0.29	0.25	0.22
Feed consumption	$\bar{x}$ g/day	13.82	14.05	15.91	14.89
	<i>s</i>	1.29	1.90	0.85	1.28
Intake of crude protein	$\bar{x}$ g/day	1.34	1.31	1.55 <sup>+</sup>	1.56 <sup>++</sup>
	<i>s</i>	0.13	0.18	0.08	0.13
PER Index	$\bar{x}$	1.84	1.73	2.12 <sup>++</sup>	1.77 <sup>++</sup>
	<i>s</i>	0.06	0.07	0.14	0.06

$\bar{x}$  = average, *s* = standard deviation, <sup>+</sup> significantly different ( $P < 0.05$ ), <sup>++</sup> ( $P < 0.01$ )

Table 5. The survey of basic results in selected varieties of wheat and triticale

Indicator	Variety	Šárka	Hana	Siria
Feed conversion	$\bar{x}$ g/g	4.41	5.36 <sup>++</sup>	5.06 <sup>+</sup>
	<i>s</i>	0.2	0.32	0.18
Daily weight gain	$\bar{x}$ g	3.30	2.82 <sup>+</sup>	2.80
	<i>s</i>	0.23	0.27	0.49
Feed consumption	$\bar{x}$ g/day	14.58	15.07	14.15
	<i>s</i>	1.28	1.52	2.51
Lysine intake	$\bar{x}$ g/day	0.0715 <sup>+</sup>	0.0497 <sup>++</sup>	0.0566 <sup>++</sup>
	<i>s</i>	0.0063	0.0050	0.0100
PER Index	$\bar{x}$	2.21 <sup>++</sup>	1.84 <sup>++</sup>	2.07 <sup>+</sup>
	<i>s</i>	0.10	0.11	0.07

$\bar{x}$  = average, *s* = standard deviation, <sup>+</sup> significantly different ( $P < 0.05$ ), <sup>++</sup> ( $P < 0.01$ )

bread-making wheat. Unsuitability of bread-making varieties for food purposes is known for a long period of time. In this connection some authors report that the feeding value of gluten proteins is worse. The reason consisted in low solubility, insufficient hydrolyzability of proteolytic enzymes of the digestive system of monogastric animals. Another reasons were unbalanced spectrum and low content of essential amino acids, particularly lysine.

Heger et al. (1986) presented the content of 0.59% lysine in gliadin and in glutenin 1.63% lysine, while its content is higher – 3.85% in albumin + globulin. Michalík and Karlubík (1988) reported in prolamine 0.2–1.0% lysine, 1.5–5.0% lysine in glutenin, while in albumin it was 4.8% and in globulin 3–5%.

The question of convincing preference of feed diet with ecologically cultivated wheat with model animals is still open. Mostly it is assumed better palatability. It was proved in degustations of bio-foods but with a low statistical significance.

## REFERENCES

- FUCHSOVÁ, D. – HEGER, J. – ŠAŠEK, A.: Frakční složení a nutriční hodnota bílkovin pšenice seté (Fraction composition and nutritional value of wheat proteins). Rostl. Výr., 33, 1987: 241–248.
- GOTTSCHIEWSKI, G. H. M.: Neue Möglichkeiten zur Effizienz der toxikologische Prüfung von Pesticiden. Rückständen und Herbiciden. Qualita Plantarum, 25, 1975: 21–42.
- HEGER, J. – SALEK, M. – EGGUM, B. O.: Nutritional value of some Czechoslovak varieties of wheat, triticale and rye. Anim. Feed Sci. Technol., 29, 1990: 89–100.
- HEGER, J. – FRYDRYCH, Z. – FUCHSOVÁ, D. – ŠAŠEK, A.: Amino acid digestibility and biological value of protein fractions isolated from wheat. Cereal Res. Commun., 14, 1986: 352–361.
- KACEROVSKÝ, O. – BABIČKA, L. – BÍRO, D. – JEDLIČKA, Z. – LOHNICKÝ, J. – MUDŘÍK, Z. – ROUBAL, P. – VENCL, B. – ZELENKA, J.: Zkoušení a posuzování krmiv (Feed testing and evaluation). Praha, SZN 1990: 179–183.
- MICHALÍK, I. – KARLUBÍK, M.: Nutriční kvalita bílkovin vo výžive monogastrických zvířat (Nutritional

quality of proteins in nutrition of monogastric animals).  
Poľnohospodárstvo, 34, 1988: 1079–1088.  
PETR, J. sen. – PETR, J. jun. – ŠKEŘÍK, J. – HORČIČKA,  
P.: Quality of wheat from different growing systems.  
Scientia Agric. Bohem., 29, 1998: 161–182.  
PETR, J. – LEIBL, M. – PSOTA, V. – LANGER, I.: Spring  
barley varieties – yield and quality in ecology farming.  
Scientia Agric. Bohem., 33, 2002: 1–9.

PETR, J. – MICHÁLIK, I. – TLASKALOVÁ, H. –  
CAPOUCHOVÁ, I. – FAMĚRA, O. – URMINSKÁ, D. –  
TUČKOVÁ, L. – KNOBLOCHOVÁ, H.: Extention of the  
spectra of plant products for the diet in coeliac disease.  
Czech J. Food Sci., 21, 2003: 59–70.

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**Krmná hodnota pšenice vypěstované v konvenčním intenzivním a v ekologickém zemědělství.**

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Ekologické zemědělství se v posledních letech rychle rozvíjí. Produkce biopotravin nepokrývá poptávku, zejména po drůbežím a vepřovém mase. Jednou z možných příčin je nedostatečná produkce krmiva pro monogastry.

V tříletých pokusech na modelových zvířatech jsme srovnávali krmnou hodnotu diet s odrůdami pšenice vypěstovanými podle zásad ekologického zemědělství (Metodického pokynu MZe ČR) a konvenčního intenzivního zemědělství, vedeného podle metodik ÚKZÚZ, s použitím syntetických hnojiv, herbicidů, fungicidů a regulátoru růstu.

Potvrdily se odrůdové rozdíly v krmné hodnotě. Jako méně vhodné ke krmným účelům se projeví odrůdy s vysokou potravinářskou (pekařskou) jakostí. Naopak, některé odrůdy nepotravinářské měly výsledky ve většině krmných ukazatelů nejlepší. Příčinou horší krmné hodnoty potravinářských odrůd může být obsah lepkových bílkovin, nerozpustných frakcí gliadinu a gluteninu, zejména pak  $\alpha$ -gliadinu. Ty jsou hůře rozpustné, nedostatečně hydrolyzovatelné proteolytickými enzymy zažívacího traktu monogastrů. Také mají nižší obsah esenciálních aminokyselin. U většiny nepotravinářských odrůd je obsah nerozpustných frakcí bílkovin nižší, zatímco obsah rozpustných albuminů a globulinů bývá vyšší, což souvisí i s vyšším obsahem esenciálních aminokyselin.

Pokus dále přesvědčivě prokázal lepší parametry krmné jakosti diet s pšenicemi vypěstovanými v ekologickém zemědělství ve srovnání s pšenicemi vypěstovanými intenzivně. Diety byly sestaveny tak, že v nich výhradním zdrojem proteinu (v množství ekvivalentním 10 % N x 6,25) byly sledované pšenice.

Pozoruhodná však byla přesvědčivá preference diet s pšenicí z ekologického zemědělství. Tu dosud nedokážeme věrohodně vysvětlit. Uvažuje se o lepší chutnosti diet, ale spíše se přikláníme k názoru, že pokusní potkani poznají i stopová množství reziduí použitých pesticidů, regulátorů a dalších cizorodých látek.

ekologické zemědělství; pšenice; odrůdy; krmná hodnota

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