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## LONG-TERM FEEDING EFFECT OF TRITICALE AND RYE GRAIN ON RAT PERFORMANCE\*

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Seventy-per cent triticale and rye diets with equal levels of all nutrients fed to rats of two consecutive generations ensured good performance and reproduction of animals. Compared with the rye-fed animals, the rats fed the triticale diet were 20% larger during the entire growth period, with mature individuals having longer and better mineralized bones and showing no enlargement of internal organs.

### INTRODUCTION

Past research shows that antinutritional properties of rye are due to a complex of factors rather than to a single cause. These factors are mainly water-soluble carbohydrates [2, 4, 15, 20, 27, 29], alkyl resorcinols [16, 18, 30], inhibitors of proteolytic enzymes [6, 12, 19], and also caryopsis structure [9, 22]. The antinutritional effect of these factors depends on the species and age of the animal, on the use this animal is put to, and also on the duration of the rye diet. Fernandez et al. [11] and Wagner and Thomas [26] observed the adaptation of chicken and laying hens to rye-rich fodder. On the other hand, the possible cumulation of certain compounds in internal organs may increase the antinutritional effect of rye supplied with the diet for a prolonged period [18].

In short-term experiments triticale grain is as a rule marked by nutritional indices superior to those of rye, and this despite the lower biological value of its protein. However, having genus of wheat and rye it may have inherited certain drawbacks of its parent species that may not be apparent in the short term. Since triticale is to be grown on 30% of the land sown heretofore with rye, and given that the Polish triticale cultivars have not yet been used in prolonged feeding we launched comparative studies involving the two cereals fed to successive generations of experimental rats.

\* Experiments for this research were performed in 1983-84 by D. Boros as part of herPhD. thesis.

In our experiments we sought to determine the effect of triticale and rye grain on reproduction, development and growth of young animals, the consumption and utilization of fodder, and also changes in the mass of internal organs.

## MATERIAL AND METHODS

Two experiments were performed with consecutive generations of out-bred Wistar rats. In the first of these the animals were fed Lasko triticale grain and Dańkowskie Żłote rye from the 1981 crop; the second experiment was carried out with the same triticale cultivar and selective Dańkowskie rye harvested in 1982. All the grain was grown in identical soil and climate conditions in Laski.

Eight male and eight female rats, all sexually mature, were selected for each group, and mated to form the parent generation. Mating signaled the beginning of the experiment, and observations continued for the next two rat generations. Animals from each generation were observed from the moment of their birth till the 27th day after the birth of their offspring. Four males and four females from each litter were selected for further observation three days after their birth. On the 27th day of the life of generations I and II, when the young were separated from their parents, one male and one female from each litter (of average weight for the given litter) were selected for further observations. Starting on the 27th day of life, the rats of each generation were weighed every three days until their 70th day. The animals were watered and fed ad libitum, the consumption being closely monitored in selected periods of their growth. Following this period, the animals were sacrificed and bled completely, their livers, kidneys and spleen weighed, and the femur used for ash content determinations. Body length (up to tail base) was also measured.

Diets fed to the animals were identical as to grain content (70%), caloric value, and protein content (20% in dry mass). The different amounts of protein in rye and triticale were adjusted to the same level with wheat gluten, and the 20% protein content in both diets was achieved with casein additions. Also added were vitamins and mineral salts required by the rats. The composition of diets is described in Table 1.

## RESULTS AND DISCUSSION

The two experiments with successive rat generations indicate that Lasko triticale is superior to both Dańkowskie Żłote and selective Dańkowskie rye as feed component. Triticale has a more favourable effect on rats in their reproduction and intense growth periods. Table 2 presents the effect of triticale and rye grain on pregnant and lactating female rats.

Table 1. Composition of experimental diets

Component	Experiment 1		Experiment 2	
	rye (10.83)	Triticale (14.06)	rye (11.07)	Triticale (14.38)
Rye grain	70	—	70	—
Triticale grain	—	70	—	70
Gluten	2.8	—	2.8	—
Casein	11.8	11.8	11.6	11.6
Mineral salts mixture	4	4	4	4
Vitamins mixture	1	1	1	1
Soybean oil	8	8	8	8
Wheat starch	2.4	5.2	2.6	5.4
Protein contents in diet	20.0%	20.0%	20.0%	20.0%

The first-generation females fed the triticale diet consumed 1.8 g more food daily than the females fed the rye diet, their body mass gain was 24.7 g greater, and their young gained weight faster. The kind of diet did not affect the number of young rats in each litter. There was no further effect of triticale grain and the second-generation rats gained weight similarly as the first-generation animals. This means that no antinutritive substances accumulated in them, and so probably no such substances are present in the triticale grain used in the experiments. However, an adverse effect of this kind was observed in the case of the rye diet: body weight of second-generation animals on the third day of their life was 18% lower than of the first-generation rats. The rye diet also significantly reduced the growth of young rats by the 21st day of their life. Rye-fed animals weighed 34.9 g on average as compared to 40.8 g attained by rats fed the triticale diet.

Observations in two experiments with two generations of young rats from their birth to their 70th day (i.e. till their full physiological maturity) revealed that animals fed the triticale diet achieved a higher body mass (Table 3, Fig.). In the first experiment this mass was 3.1% higher on the 12th day, and 11.4% higher on the 70th day, with the peak disparity (21.4%) occurring on the 35th day of life. In the second experiment the differences were not as great, ranging from 5.5% on day 3 to 10.6% on day 70, the maximum figure — 15% — also occurring on day 35.

In general, rats fed grain from the 1982 crop, both triticale and rye, gained more weight than animals fed the grain harvested in 1981.

During six weeks after separation from their mothers, the rats consumed 1.3 g more triticale diet daily, and gained 0.5 g weight more than their rye-fed opposite numbers (Table 4). Both sexes reacted to the kind of diet in the same way. However, within each group the sex of the animal significantly affected body mass increments.

Table 2. Effect of long-term feeding of pregnant and lactating rat females with triticale or rye grain

	Parent generation		First generation	
	Rye	Triticale	Rye	Triticale
Number of females	8	8	10	8
Body mass gain in pregnancy	—	—	111.9 ± 17.8 a	136.6 ± 21.7 b
Diet intake during pregnancy g/rat/day	—	—	16.9 ± 2.4 a	18.7 ± 1.7 a
Number of living litters	7	7	10	8
Number of young litter born				
alive	10.0	11.9	12.0	12.4
range	9-11	10-13	10-15	10-16
born dead	0.0	0.0	0.4	0.0
Weigh of offspring:				
3 days after birth	8.2 ± 1.2 b	7.6 ± 0.5 b	6.7 ± 0.8 a	7.6 ± 0.5 b
21 days after birth	36.6 ± 3.7 ab	37.8 ± 3.9 ab	34.9 ± 3.8 a	40.8 ± 3.7 b

Values marked with the same letter do not differ significantly at P = 0.05

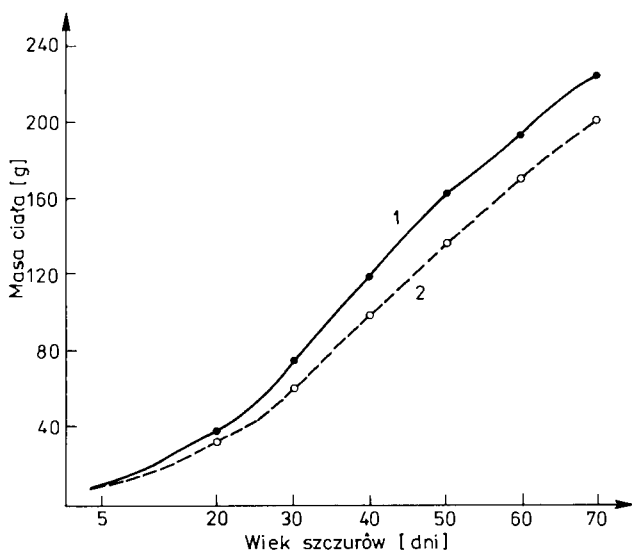


Fig. Growth curve for rats fed triticale and rye diets; 1 — triticale, 2 — rye

Diet consumption per unit body mass increment was the same in both groups, and so the higher consumption of the triticale-based diet led to a correspondingly higher body weight increase. Rats fed with rye grain had a significantly enlarged liver, the organ where intense metabolic processes take place, including possibly detoxification of the organism (Table 5).

Table 3. Effect of prolonged feeding of laboratory rats with triticale and rye grain.

a. grain from 1981 crop

Diet	Body mass on 3, 24 and 70 days after birth		
	3	24	70
Triticale:			
Lasko	7.1	48.4	224.4
Rye:			
Dańkowskie Złote	7.1	40.9	201.5
Difference in % assuming rye group = 100%	0	18.3	11.4
b. grain from 1982 crop			
Triticale:			
Lasko	7.7	52.6	261.6
Rye:			
Dańkowskie selective	7.3	47.2	236.6
Difference in % assuming rye group = 100%	5.5	11.4	10.6

Table 4. Diet intake and body mass gain in growing rats (28-70 days old), fed triticale or rye diets

Characteristic	Triticale			Rye		
	females	males	mean value	females	males	mean value
Diet intake g/rat/day	13.8	16.9	15.3	12.5	15.5	14.0
Body mass gain g/rat/day	3.46 ± 0.21a	5.73 ± 0.58c	4.60	3.14 ± 0.25b	5.11 ± 0.24a	4.13
Diet utilisation body mass gain/diet intake	4.0	2.9	3.3	4.0	3.0	3.4

Table 5. Effect of long term triticale and rye grain diet on mass of internal organs (g/100g body weight) ash content in femur (%) and body length (cm) in experimental rats

Characteristic	Triticale	Rye	F emp.	F tab.	
				p ≤ 0.05	p ≤ 0.01
Liver	3.67 ± 0.35**	3.98 ± 0.32	14.28	3.98	7.01
Kidneys	0.73 ± 0.04	0.72 ± 0.04	0.38	3.98	7.01
Spleen	0.23 ± 0.03*	0.21 ± 0.03	4.46	3.98	7.01
Ash content	61.8 ± 1.5**	58.9 ± 4.0	11.77	4.03	7.17
Body length	24.8 ± 1.4**	23.3 ± 1.1	11.27	4.13	7.44

\* — differences significant at p = 0.05

\*\* — differences significant at p = 0.01

According to the literature, this liver enlargement is caused by alkyl resorcinols. Pawlik et al. [18] carried out an eight-week experiment with chicken which showed that augmentation of feed with ground rye grain or alkyl resorcinols preparation led to drops in the level of albumins, total protein and seromucoid in blood plasma. Tłuścik et al. [24] additionally demonstrated a significant decrease of cholinesterase activity in the plasma of eight-week rats fed a diet with 80% ground rye as compared with figures for a wheat diet.

These changes are indicative of liver damage in both animal species, although no accumulation of alkyl resorcinols was observed in the organ. In their studies of the balance and metabolism of rye alkyl resorcinols Tłuścik et al. [23] demonstrated a ca 50% absorption of these compounds in the intestine, and the presence of three of their metabolites in urine.

It may be that as a result of prolonged feeding of animals with a rye-rich diet the adverse effect of alkyl resorcinols becomes more pronounced in view of intensified metabolic processes in the liver. This would account for the absence of any effect of considerably varied alkyl resorcinols content (272-1292 mg/kg of grain) on nutrition indices in a two-week study of growth of rats and chicken by Rakowska et al. [21]. What was observed in rye-fed animals, however, was an inhibition of skeleton development evidenced by shorter body length and lower ash content in the femur. These results confirm earlier findings [1, 3, 8, 13, 14, 28] that rye contains substances reducing the absorption of vitamin D<sub>3</sub> and calcium, and also vitamin A and fat, notably saturated long-chain (C<sub>18</sub>) triglycerides, all of which leads to poorer growth and signs of rachitis in animals.

PAG\* [17] recommends long-term nutrition and toxicological testing on consecutive generations of laboratory animals in studies of new species of plants and those containing poorly researched antinutritive substances.

The available literature does not report studies of long-term feeding with triticale grain, so our results cannot be compared with other findings. It would be advisable, however, to carry out similar long-term experiments with other

\* Protein Advisory Group of FAO/WHO.

triticale cultivars. It is possible that some of these cultivars feature antinutritive substances accumulating in animal organism that are responsible for reduced growth rate of pigs fed triticale-rich diets, a phenomenon observed towards the end of the fattening period by Bowland [7], Ernst et al. [10], Bertoni and Caleffi [5] and Urbańczyk [25]. It must be stressed though that animals fed both the compared diets were healthy and reproduction was not affected.

## CONCLUSIONS

1. Triticale grain fed to rats as principal source of energy and nutritive components (70% of the diet) resulted in normal growth and reproduction of two consecutive generations of animals.

2. Compared with figures for rye-fed rats, the growth indices in various periods of organism development, mineralization of bones, and enlargement of parenchymatous organs were all much better in triticale-fed rats.

3. Considerable differences in figures from two repetitions of the experiment using the same cereal species grown in the same place but in two different years indicate that the nutritive value of grain is altered by different weather conditions.

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## WPLYW DŁUGOTRWALEGO ŻYWIENIA ZIARNEM PSZENŻYTA I ŻYTA NA WZROST, ROZWÓJ ORAZ PŁODNOŚĆ SZCZURÓW

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### Streszczenie

Na podstawie dwóch doświadczeń wielopokoleniowych na szczurach stwierdzono, że ziarno pszenżyta Lasko odznacza się wyższą przydatnością paszową przy długotrwałym jego podawaniu niż żyto. Korzystniej wpływało na zwierzęta w okresie reprodukcji, a także intensywnego wzrostu. Nie stwierdzono następczego działania ziarna pszenżyta i w drugim pokoleniu zwierzęta podobnie przyrastały jak w pierwszym. Świadczy to o nienagromadzeniu się u nich substancji antyodżywczych, więc prawdopodobnie nie występowały w testowanym pszenżycie. Takie działanie stwierdzono przy skarmianiu ziarna żyta. W drugim pokoleniu masa ciała potomstwa po urodzeniu (w 3 dniu życia) była o 18% niższa niż w pierwszym. Żywienie ziarnem żyta powodowało również istotną redukcję wzrostu młodych szczurów w 21 dniu życia. Na diecie żytniej osiągnęły średnio 34,9 g, a na przynajmniej 40,8 g. Prowadząc obserwacje wzrostu szczurów od momentu urodzenia do 70 dnia życia przez dwa kolejne pokolenia, średnio w dwóch doświadczeniach stwierdzono wyższą o ok. 11% masę ciała zwierząt karmionych ziarnem pszenżyta w porównaniu z żytem.

Dzienne spożycie diety pszenżyciowej w ciągu 6 tygodni było o 1,4 g wyższe, a dzienny przyrost masy ciała o 0,5 g wyższy niż na diecie żytniej. Zużycie paszy na jednostkę przyrostu masy ciała w obu porównywanych grupach było zbliżone, jednakże wyższemu spożyciu diety pszenżyciowej towarzyszył proporcjonalnie wyższy przyrost masy ciała, a więc określona masa ciała grupa ta osiągnęła w krótszym czasie. Zwierzęta karmione ziarnem żyta miały istotnie powiększoną wątrobę, narząd, w którym zachodzą intensywne procesy metaboliczne, ewentualnie też detoksykacyjne. Ponadto stwierdzono u nich istotnie słabszy rozwój kości, który przejawiał się skróceniem długości ciała i niższą zawartością popiołu w kości udowej. Wyniki te potwierdziły wcześniejsze badania kanadyjskie o występowaniu w życie substancji obniżających wchłanianie wit. D<sub>3</sub>, wapnia i tłuszczu, co w konsekwencji wywołuje objawy krzywicy u zwierząt.