Comparative Protein Quality of Triticale, Wheat, and Rye

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ABSTRACT

The protein qualities of triticale, wheat, and rye were evaluated, with growing rats as test subjects. The Protein Efficiency Ratio (PER) of triticale was equal to the PER of rye, whereas that of wheat was significantly lower than PER of the other two cereals. Supplementation of 5% triticale protein with 5% casein raised the PER to a value equal to that of casein. A similar increase in PER was obtained when rye was supplemented with casein, whereas the PER of wheat supplemented with casein was lower than that of supplemented rye, triticale, or of casein fed alone. Examination of amino acid concentrations in test diets and in blood plasma of rats fed these diets indicated that lysine was severely limiting in triticale and wheat, and less limiting in rye. Further amino acid limitations were not determined. The superiority of titricale to wheat was believed to be due to a higher content of lysine and sulfur amino acids. Triticale was proposed to be a potentially useful cereal for human consumption, although further studies on its nutritive value are necessary.

At the present time wheat contributes a substantial proportion of the world food supply. However, rapidly increasing populations in many countries have led to pressure for heavier-yielding cereal grains with higher protein qualities than that of wheat. Triticale, a hybrid cereal produced by cross-breeding wheat and rye, has been suggested to have a higher yield potential than the hard red spring wheats now grown in Western Canada[1]. Although wheat (1,2) and rye (3,4) have been shown to be similarly limiting in several amino acids, rye was observed to have a somewhat higher protein quality than wheat (3,4), and this trait may have been inherited in triticale. In view of the potential value of triticale as a food for human consumption, a comparison of the nutritive value of protein from wheat, rye, and triticale was carried out and is reported herein.

MATERIALS AND METHODS

A sample of Rosner triticale was obtained from the Plant Science Department, University of Manitoba; wheat and rye samples were purchased from a local grain dealer. The grains were ground to pass a 20-mesh screen in a laboratory Wiley mill. Diets containing 10% protein[2] from casein, triticale, wheat, rye, or equal-part mixtures of casein + wheat, casein + triticale, or casein + rye were fed to groups of 10 weanling male Wistar rats (initial weights 55 to 65 g.) housed in individual screen-bottomed cages in a randomized complete block design. Food and water were provided *ad libitum*. Weight gains and feed intakes were recorded weekly. Upon completion of 21 days of feeding, the animals were removed from test and decapitated, and blood was collected from each animal. The PER was calculated for each rat and was adjusted to a value of 2.500 for casein. Statistical analyses for

[1] Personal communication: E. N. Larter, Plant Science Department, University of Manitoba, 1968.

[2] The diets contained (%): mineral mixture (USP 14), 4.0; vitamin mixture (10), 1.0; corn oil, 4.0; purified cellulose, 4.0; protein, 10.0; corn starch, to make 100.
Protein contents were (%): Casein (N × 6.25) = 86.3%; wheat (N × 5.7) = 13.5%; triticale (N × 5.7) = 16.1%; rye (N × 5.7) = 12.6%.

diet and replicate effects on performance data were carried out according to standard procedures (5).

Duplicate 1-g. samples of each diet were hydrolyzed in 450 ml. 6*N* HCl under nitrogen in sealed Mason jars at 120°C. for 20 hr. A 50-ml. aliquot of each hydrolysate was evaporated to dryness under vacuum and was made up to 25 ml. with pH 2.2 citrate buffer. Duplicate amino acid analyses of each hydrolysate were performed by column chromatography according to standard 4-hr. procedure on a Beckman Model 116 amino acid analyzer. Blood samples from each dietary group were pooled and analyzed for free amino acid concentrations by microbiological assay (6). Comparison of mean values were made by the method of Tukey as described by Steele and Torrie (5).

RESULTS AND DISCUSSION

Feeding trials with livestock have indicated that feed intakes and weight gains of animals fed triticale were lower than when barley was fed (see footnote 1); this suggested that an unknown palatability factor, perhaps similar to that in rye, was present in triticale. In the present study, rats fed a diet containing 10% triticale protein consumed less feed and gained at slower rates than when triticale was fed in combination with casein or when casein was fed alone (Table I); a similar effect was observed when either wheat or

TABLE I. PERFORMANCE DATA

	Dietary Protein Content and Source[a]						
Criteria	10%, Casein	10%, Triticale	5%, Triticale; + 5%, Casein	10%, Wheat	5%, Casein; + 5%, Wheat	10%, Rye	5%, Casein; + 5%, Rye
Weight gain, g.	63.7a	31.8bc	67.2a	21.5c	62.6a	37.8b	73.1a
Feed intake, g.	220.6a	177.3b	234.0a	180.3b	240.3a	203.0b	239.6a
PER	2.50a	1.55c	2.49ab	1.03d	2.25b	1.61c	2.64a

[a] Means with same letter(s) not significantly ($P < 0.05$) different

rye was fed as the sole protein source; this suggests that the lowered feed intakes encountered when cereal was fed alone may have been due to the amino acid composition of the cereal protein. Triticale was therefore equal to either wheat or rye in terms of acceptability by the animals used in this study. Both rye and triticale had (Table I) PER values significantly higher than that of wheat. Several workers have produced evidence to show the superiority of rye over wheat with respect to PER (4,7,8).

Supplementation of triticale or rye diets with an equal amount of casein raised their PER's to values equal to that of rats fed casein as the sole source of protein (Table I), whereas the addition of casein to a wheat diet did not raise the PER to the statistical equivalent of casein. Of the three cereals tested, wheat was lowest in lysine content (Table II), with triticale somewhat higher than wheat, and rye considerably higher than the other two cereal proteins. Several workers (2,4) have shown lysine to be first-limiting in cereal grains. Thus, lysine may have been the first-limiting amino acid in the cereals,

TABLE II. AMINO ACID COMPOSITION[a] OF TEST DIETS

Amino Acid	Dietary Protein Content and Source						
	10%, Casein	10%, Triticale	5%, Triticale; 5%, Casein	10%, Wheat	5%, Casein; 5%, Wheat	10%, Rye	5%, Casein; 5%, Rye
	% of diet						
Aspart. acid	0.68	0.51	0.59	0.49	0.59	0.74	0.71
Threonine	0.37	0.29	0.33	0.32	0.35	0.33	0.35
Serine	0.46	0.40	0.43	0.41	0.44	0.37	0.42
Glut. acid	2.30	3.19	2.75	3.71	3.00	3.12	2.71
Proline	1.11	1.21	1.16	0.91	1.01	0.90	1.01
Glycine	0.19	0.42	0.30	0.39	0.29	0.43	0.31
Alanine	0.30	0.39	0.35	0.36	0.33	0.44	0.37
Valine	0.63	0.47	0.55	0.48	0.55	0.45	0.54
Methionine	0.26	0.15	0.21	0.10	0.18	0.13	0.20
Isoleucine	0.54	0.41	0.48	0.40	0.47	0.37	0.46
Leucine	0.92	0.69	0.80	0.65	0.79	0.56	0.74
Tyrosine	0.50	0.32	0.41	0.36	0.43	0.27	0.39
Phenylal.	0.49	0.49	0.49	0.48	0.49	0.42	0.45
Lysine	0.71	0.33	0.52	0.29	0.50	0.47	0.59
Histidine	0.27	0.24	0.26	0.25	0.26	0.26	0.27
Arginine	0.33	0.49	0.41	0.51	0.42	0.52	0.42

[a] Mean values for duplicate hydrolysates of each diet. Amino acid composition of cereal-casein mixtures calculated from amino acid analyses of individual protein sources.

the limitation of which was most severe for wheat, somewhat less critical for triticale, and a lesser problem with rye. Plasma lysine levels of animals fed the unsupplemented cereal diets were low in comparison to plasma lysine levels of animals fed either casein or a mixture of casein + cereal (Table III), which was considered to verify the suggestion that lysine was the first-limiting amino acid in the unsupplemented cereals.

TABLE III. PLASMA AMINO ACID CONCENTRATIONS (POOLED BLOOD SAMPLES FOR EACH DIETARY GROUP)

Amino Acid	Dietary Protein Content and Source						
	10%, Casein	10%, Triticale	5%, Triticale; 5%, Casein	10%, Wheat	5%, Casein; 5%, Wheat	10%, Rye	5%, Casein; 5%, Rye
	μM per 100 ml. plasma						
Lysine	93.5	5.7	50.9	9.7	59.6	12.0	52.1
Methionine	10.5	5.0	6.9	4.9	6.3	5.0	6.7
Threonine	89.2	35.1	21.1	39.3	18.2	24.3	19.1

Ericson (2) demonstrated an additional growth increment of rats fed wheat bread supplemented with lysine and threonine over that achieved by supplementation with lysine alone; McLaughlan et al. (9) have proposed lysine and threonine to be first- and second-limiting amino acids respectively in wheat, followed by the sulfur amino acids. Kihlberg and Ericson (4) observed that rye was first-limiting in lysine, followed by methionine + cystine; the sulfur amino acids have also been implicated as first-limiting in rye (4).

The methionine content of wheat was the lowest of the three cereals examined (Table II) and may have been responsible for wheat having a low PER relative to the other grains even when supplemented with casein, since

casein is known to be limiting in methionine. However, differences in dietary methionine were not reflected in plasma methionine contents when the unsupplemented diets (Table III) were fed. It is difficult to attach any particular significance to the differences in plasma methionine concentrations observed when the cereals were supplemented with casein (Table III), although these values appeared to relate to dietary concentrations (Table II). In addition, no account has been taken of cystine contents of the diets, which would influence the methionine requirement markedly. The decrease in plasma threonine when wheat or triticale was supplemented with casein (Table III) was suggested to be a consequence of increased utilization of threonine for body protein synthesis when the lysine deficiencies of wheat and triticale were reduced by supplementation. When rye was fed alone, the lysine deficiency was less severe than for the other two cereals; thus plasma threonine concentrations of rats fed rye were affected by casein supplementation to lesser extents. Kihlberg and Ericson (4) proposed that the superiority of rye to wheat as a protein source is due to a less severe threonine limitation in rye. In this study, however, the order of limitation of amino acids following the first-limiting (lysine) was unclear.

This study has shown that triticale may be equal to rye in terms of protein quality, and that both triticale and rye were significantly higher in protein quality than wheat, although all three of these cereals were limiting in lysine. Further work is necessary to establish the exact order of limitation of amino acids in triticale.

From the results of this investigation it would appear that triticale may represent a potentially valuable cereal crop for human consumption, although further evaluation of that potential is necessary.

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