# LYSINE AND TRYPTOPHAN INCREASES DURING GERMINATION OF CEREAL GRAINS[1]

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ABSTRACT Cereal Chemistry 53(2): 222-226

During germination of wheat, barley, triticale, rye, and oats, increases in lysine and tryptophan and decreases in prolamine occurred. Little or no increase in lysine and tryptophan occurred in germinating rice; this may possibly be related to the low prolamine content of rice.

In view of the general world shortage of food, and more especially the shortage of high-quality protein, any procedure which would improve the nutritional value of immediately available food supplies (*e.g.*, any type of cereal grain), and thus exert a sparing effect on those food stores, could be of value.

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Recently we reported (1) that, during the germination of maize seed, the overall levels of lysine and tryptophan, the two essential amino acids for man and first-limiting amino acids in maize, increased while there was an accompanying decrease in the amount of the nutritionally poor protein, zein. The increases in lysine and tryptophan made their concentrations comparable to the nutritionally desirable levels found in the seed of the maize mutant *opaque*-2; this result occurs within the first 4 days of germination at 28°C. The increases in lysine and tryptophan are confined to the embryo.

The possibility of similar changes occurring during the germination of other cereal grains has now been investigated with the result presented herein.

## MATERIALS AND METHODS

Mature seeds of two varieties each of wheat (*Triticum aestivum* L. em. Thell.), "Avon" (CI 13477) and "Genessee" (CI 12653); barley (*Hordeum vulgare* L.), "Harrison" (CI 10667) and "Paoli" (CI 15235); triticale (*Triticale hexaploid* L.), "Fasgro 203" and "Fasgro 205"; oats (*Avena sativa* L.), "Noble" (CI 9194) and "Dal" (CI 9159); and one variety each of rye (*Secale cereale* L.), "King II," and rice (*Oryza sativa* L.), "Starbonnet," were used.

Seeds were surface-sterilized by treatment with 70% ethanol for 1 min, 10% Chlorox® bleach for 3 min, followed by three rinses in sterile, deionized water. Batches of 50 seeds each on 1% agar in 9-cm petri dishes were incubated at 28°C in the dark. Samples were harvested at 24-hr intervals for 5 days, washed to remove traces of agar, frozen in Dry Ice, and lyophilized. The dried material was reduced to a fine powder for total nitrogen (2), lysine (3), tryptophan (4), and prolamine (5) analyses by grinding first in a Waring Blendor and then in a miniature ball mill. Data are expressed on a weight basis. A factor of 6.25 was used to convert nitrogen to protein values. The data are reproducible; similar results have been obtained in three different experiments.

## RESULTS AND DISCUSSION

In general, for all cereal grains tested, increases in the amounts of lysine and tryptophan and decreases in prolamine were observed during germination (Fig. 1). However, not all these changes were equally striking quantitatively. Further, the extent of the lysine and tryptophan increases appears to be inversely correlated with the amount of prolamine present and its rate of mobilization. Thus, oats, containing the lowest measurable amounts of prolamine except for rice (see below), had the slowest rate of prolamine decrease during germination and also showed a low rate of increase in lysine. In contrast, wheat, producing some of the largest increases of lysine and tryptophan observed in this study, showed a rapid decline in prolamine from a high initial value. These increases in lysine and tryptophan and decreases in prolamine during germination are in line with our earlier findings in maize (1), and correlate well with the amino acid changes observed by Dupuy *et al.* (6) in maize and Folkes and Yemm (7) in barley.

Our analysis indicated a complete absence of prolamine from rice (Fig. 1). This discrepancy probably arose because the method employed to determine the

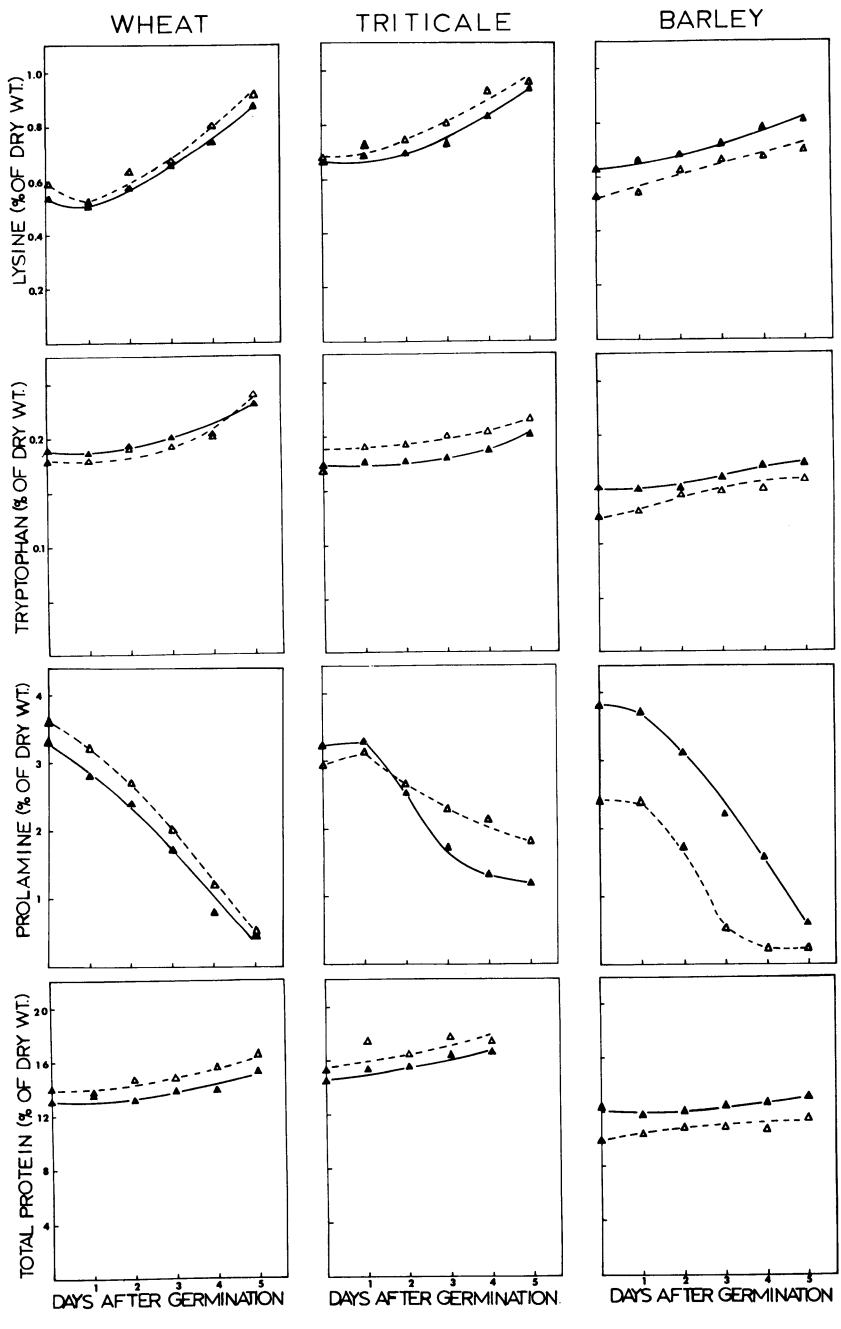


Fig. 1. Changes in lysine, tryptophan, prolamine, and total protein during the germination of wheat (Avon, △---△; Genessee, ▲——▲), triticale (Fasgro 203, △---△; Fasgro 205, ▲——▲), and barley (Harrison, △---△; Paoli, ▲——▲).

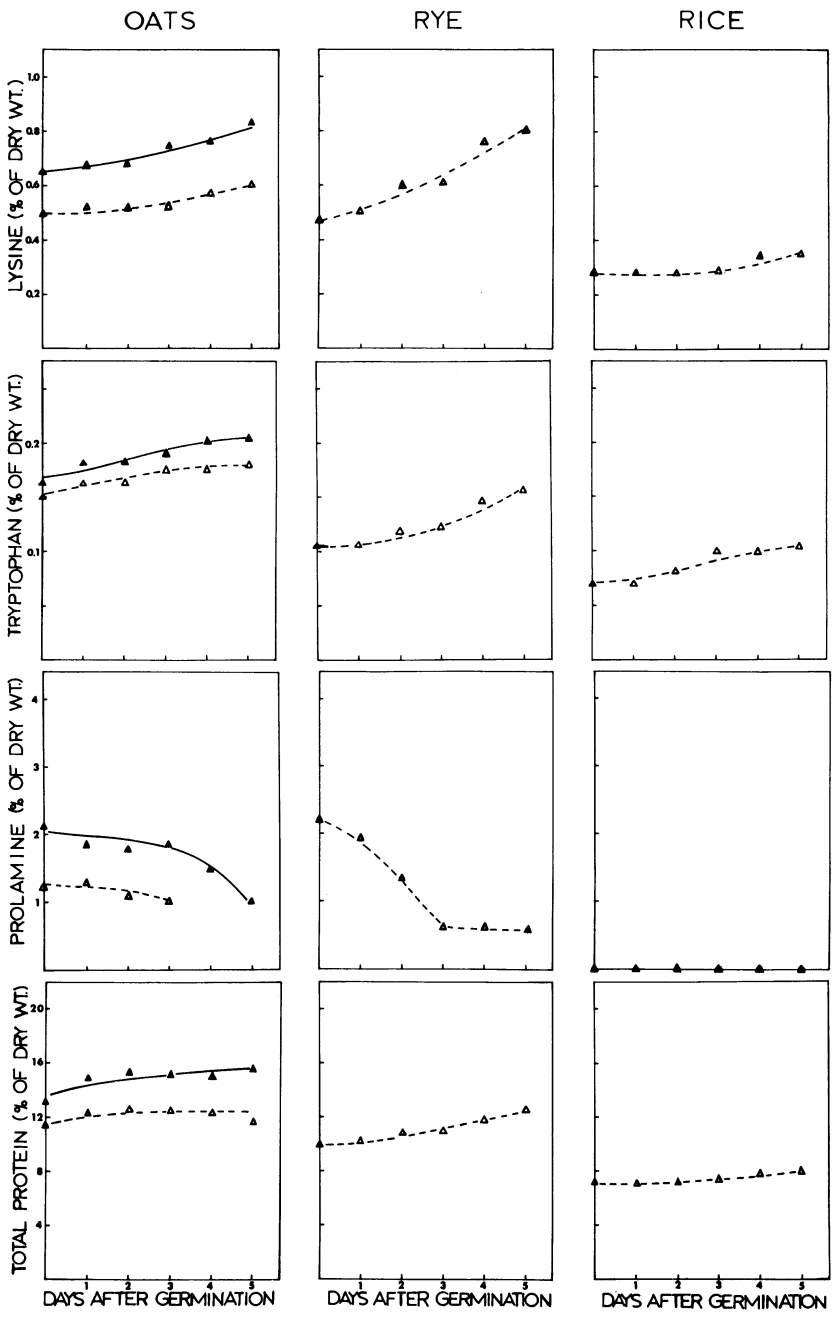


Fig. 1 (*continued*). Changes in lysine, tryptophan, prolamine, and total protein during the germination of oats (Noble, △---△; Dal, ▲——▲), rye (King II, △---△), and rice (Starbonnet, △---△).

prolamine content was originally developed to measure the prolamine (zein) of maize, and was used in the present work without modification. The justification for this was that we were primarily interested in discerning trends occurring during germination and not in determining absolute amounts. For precise analyses, the procedure obviously requires the optimal conditions to be worked out separately for each cereal.

The total protein (as percentage of dry weight) increased slightly in all cases during germination (Fig. 1). These protein increases, in no case exceeding 14% of the starting protein content, may be attributable to a loss of dry weight through respiration during germination. Thus, the germinated material on a unit weight basis would contain more seeds and therefore more nitrogen than the ungerminated samples. Whatever the reason for these small increases in total protein, they are quantitatively insufficient, except for rice, to account for the increased lysine and tryptophan levels shown in Fig. 1.

The above results demonstrate that, as with maize, the process of germination seems to offer a method for improving the nutritional value of the proteins of wheat, barley, triticale, oats, and rye by increasing the lysine and tryptophan contents. The results with rice are less promising, a finding probably associated with the low levels of prolamine in rice. This is suggested by an apparent correlation in the other cereals between prolamine content, its rate of mobilization, and the extent of the increases in lysine and tryptophan. The practical use and actual nutritional quality of these germinating seeds remain to be examined.

**Acknowledgments**

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