Infusion of Grain Sorghum with Lysine, Methionine, and Tryptophan

J. F. CAVINS, C. W. BLESSIN, and G. E. INGLETT, Northern Regional Research Laboratory[1], Peoria, Illinois 61604

ABSTRACT

Amino acid balance in grain sorghum was altered significantly by infusion of lysine, methionine, and tryptophan. Infusion is affected by such factors as time, temperature, and concentration of infusion solution. Infusion proceeds in two stages, one being concentration-dependent and the other concentration-independent. Amino acid solubility affects the maximum level of infusion possible. A wide range of amino acid levels can be obtained in the product by varying infusion conditions. The desired level of amino acid can be achieved by either infusion of the total lot, or infusion of a small batch to a high concentration followed by blending with noninfused grain.

The protein in grain sorghum is generally considered deficient in the essential amino acids lysine, methionine, and tryptophan. These deficiencies may be overcome by finding genetic sources with adequate levels of these amino acids and using these materials to develop acceptable varieties; however, such a search will take time. It is possible to increase the content of certain amino acids in dent corn (1) and in popcorn (2) to the level required for proper nutrition by infusion. In the present study, we investigated the possibility of infusing grain sorghum with amino acids to improve its essential amino acid pattern.

The extent of infusion of amino acids into grains is affected by such factors as temperature and concentration of the infusing solution (2), as well as time of infusion, amino acid, and to some extent variety. The degree to which each of these factors affects infusion was evaluated. Infusion rates for lysine, methionine, and tryptophan were determined separately.

MATERIALS AND METHODS

Materials

Three grain-sorghum varieties were selected. RS-626 is a medium, early maturing hybrid; and TE-77 is a full-season hybrid. Both hybrids were grown side by side at the Texas Agricultural Experiment Station, South Plains Research and Extension Center, at Lubbock. These two samples of grain sorghum were dried at air temperatures not exceeding 140°F. The third sample, of unknown origin and identity, came from the Amarillo Grain Exchange and was graded No. 2 yellow. Drying and handling conditions for this commercial sample are not known.

L-Lysine monohydrochloride F.C.C. was purchased from Merck and Co., Inc., Rahway, N.J.; DL-methionine N.F. and L-tryptophan U.S.P. came from J. H. Delamar and Sons, Inc., Chicago, Ill.

Methods

Infusion studies were conducted with 20-g. samples of grain sorghum submerged in 30 ml. of an aqueous solution of the particular amino acid. After infusion, the

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amino acid solution was decanted and the grain washed with three 100-ml. volumes of water to remove any amino acid on the surface of the kernels. The grain sorghum was drained and air-dried to approximately 12% moisture. Amino acid solutions are expressed on a weight/volume basis. Moistures were measured with a Cenco moisture balance Model No. 026680-1 (Central Scientific Co., Chicago, Ill.). All values are reported on a moisture-free basis and represent total lysine, methionine, and tryptophan in the grain.

Amino acid analyses of the noninfused sorghum samples were performed on acid hydrolysates of the grain in a Phoenix amino acid analyzer according to the procedure of Benson and Patterson (3). Tryptophan content of the original grain was determined by the method of Kohler and Palter (4). The quantity of amino acid infused into the grain was determined in duplicate by the ninhydrin procedure of Ferrel et al. (5).

RESULTS AND DISCUSSION

Lysine infusion of RS-626 grain sorghum is shown in Fig. 1. Infusion is concentration-dependent and follows a linear relationship (Fig. 1, part 1). Increasing temperature also increases infusion with a linear relationship (Fig. 1, part 2). Temperature can be used to decrease the infusion time, since a 45% solution for 0.5 hr. at 160°F. is nearly equivalent to a 45% solution for 4 hr. at 78°F. Infusion of sorghum with lysine at 78°F. for various time periods (Fig. 1, part 3) proceeds at a rate of 33 mg. lysine per 100 g. sorghum per hr. during the 4- to 48-hr. period, and is concentration-independent during this period. Identical infusion rates of 1,240 mg. lysine per 100 g. sorghum per hr. were also found for the 0.25- to 1-hr. infusions at 160°F. (Fig. 1, part 4), using three different concentrations of lysine. Results show infusion to be concentration-dependent during the first 15 min. and concentration-independent thereafter. Similar results were found for lysine infusion of TE-77 and No. 2 yellow sorghum.

The fact that infusion is concentration-dependent during the first 15 min. and not thereafter is evidence that two mechanisms of infusion are active. Infusion must therefore be similar to the process of water absorption in grain (6). Initial infusion, which occurs during the first few minutes, proceeds by capillary action. This infusion, which is concentration-dependent, involves liquid rapidly entering the kernel and filling all void spaces. It is also possible that the pericarp is loosened to some extent and the space just below it filled with liquid. On drying, the water

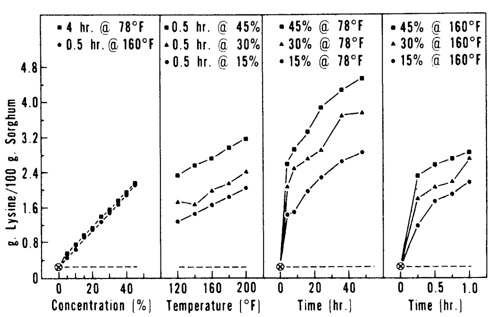

Fig. 1. Effects of time, temperature, and concentration on infusion of lysine in grain sorghum.

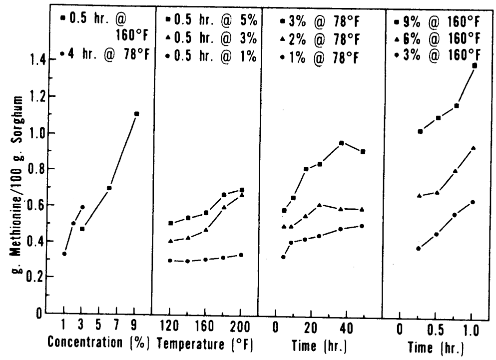

Fig. 2. Effects of time, temperature, and concentration on infusion of methionine in grain sorghum.

would evaporate, leaving the amino acid. The second process would involve diffusion further into the kernel and proceeding at a much slower rate. This secondary infusion is time- and temperature-dependent, however, not concentration-dependent.

Infusion of methionine (Fig. 2) and tryptophan shown in Table I followed trends similar to lysine infusion. The smaller increase in infusion at room temperature with respect to time and deviation from linearity in methionine infusion is probably due to the necessity of using lower concentration in the infusing solution. Tryptophan infusion was evaluated at only one concentration due to its lower solubility. No significant temperature effect was noted for tryptophan; however, this was not unexpected, since methionine at the 1% level showed very little increased infusion with temperature elevation. Infusion of tryptophan was affected most by time.

TABLE I. RELATIONSHIP BETWEEN TIME AND TRYPTOPHAN INFUSION IN GRAIN SORGHUM

Time hr.	g. Tryptophan/100 g. Sorghum RS-626	TE-77	No. 2 yellow
		Temperature, 78° F.	
0	0.19	0.21	0.17
4	0.32	0.38	0.42
8	0.37	0.42	0.40
16	0.39	0.44	0.40
24	0.42	0.49	0.44
36	0.52	0.50	0.55
48	0.51	0.51	0.58
		Temperature, 160°F.	
0.25	0.27	0.22	0.22
0.5	0.33	0.35	0.25
0.75	0.34	0.31	0.26
1	0.39	0.21	0.24

The rates of infusion of lysine, methionine, and tryptophan during the 4- to 48-hr. period at 78°F. are 32.0, 4.2, and 3.6 mg. per 100 g. sorghum per hr., respectively. As stated previously, the rate during this time is independent of concentration, and thus these infusion differences must be due to the amino acid. The infusion rates parallel the solubility of the amino acids in water, and thus the differences, which were detected only in the secondary infusion, may be related to solubility.

Infusion differences due to variety were not detectable with methionine and tryptophan and were very small with lysine. The small varietal differences in lysine infusion showed No. 2 yellow to be most susceptible and RS-626 to be least susceptible. These differences could be attributed to grain quality rather than to variety. The presence of stress cracks or other kernel damage could significantly alter the infusion process (6).

CONCLUSIONS

To meet the minimum daily requirements of man for lysine, methionine, and tryptophan (7) would require consumption of 670 g. of No. 2 yellow sorghum. Infusion of grain sorghum with lysine, methionine, and tryptophan solutions could lower the required consumption to one-sixth that of uninfused grain. Infusion proceeds by two separate processes, with one being concentration-dependent and the other concentration-independent. Infusion is directly proportional to time and temperature. The nature of the amino acid can have an effect on the infusion rate. The effects of time, temperature, and concentration allow for considerable flexibility in choosing infusing conditions to achieve the desired level of amino acids. It should be noted that until further studies determining the location of the infused amino acids are performed, the grain should be consumed in total to reap the total benefit of infusion.

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