EFFECT OF L-ARABINOSE AND D-XYLOSE ON DOUGH FERMENTATION AND CRUST BROWNING[1]

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ABSTRACT

Addition of L-arabinose and D-xylose led to inhibition of the gassing power of simple flour-water doughs. In doughs also containing 10% D-glucose, 1% L-arabinose had little effect on gas production. Baking tests, employing 2.5 and 5.0% of the pentoses in a formula containing 5.5 and 8.0% total sugar, showed the pentoses to have no effect on loaf volume but to prolong proof time, bring about a duller crumb color, and produce a markedly thicker and darker crust.

Except for a report (3) some years ago that L-arabinose and D-xylose exert a softening action in bread, the effect of pentose sugars on breadmaking does not appear to have been recorded in the literature. Since wheat flour contains pentosans composed of L-arabinose and D-xylose (4,5), it seems conceivable that at least traces of free pentoses might be found in dough as a result of enzymatic hydrolysis, and hence the effect of these sugars on breadmaking is of interest. The presence of pentoses in cereals is indicated by the work of Williams and Bevenue (10), who found arabinose in flour extracts treated with baker's yeast, and Rehfeld (8), who reported small amounts of arabinose in rye meal extracts. Bass and Meredith (2) also reported arabinose and xylose among the reaction products between green malt-enzyme preparations and barley gums, while Preece and Hobkirk (7) found free pentoses liberated from arabo-xylan by enzymes prepared from wheat and barley. The present paper describes work on the pentoses, particularly in relation to their action on dough fermentation and the browning reaction in bread.

Materials and Methods

The L-arabinose and D-xylose used in this work were C.P. materials, supplied, respectively, by the Amend Drug and Chemical Co. and the Matheson Company. The D-glucose was the "Baker Analyzed" reagent supplied by the J. T. Baker Chemical Co. Commercial dextrose (glucose monohydrate), employed in the baking studies, was obtained from Corn Products Sales Co.

Gassing-power studies were conducted in Blish-Sandstedt pressure-

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meters by the routine procedure (1) except for the sugar additions as noted. The flour employed (12.1% protein, 0.43% ash on 14% moisture basis) was a commercially milled hard red winter wheat flour.

A laboratory sponge-dough procedure was used to make the bread in this work; details of this method, except for sugar levels, have been reported elsewhere (6). The flour employed in breadmaking (12.1% protein, 0.45% ash on 14% moisture basis) was commercially milled from a blend of hard red winter and spring wheats.

Results and Discussion

Figure 1 shows the effect of various amounts of D-glucose, L-arabinose, and D-xylose on the sixth-hour gassing power of doughs.

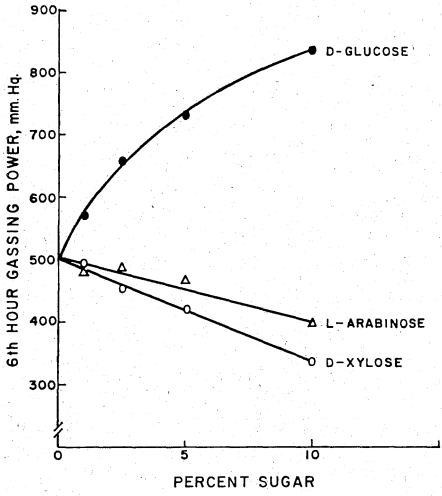

Fig. 1. Effect of increased sugar levels on the 6th-hour gassing power of dough.

Increased levels of D-glucose, expectedly, led to increased amounts of gas produced after 6 hours of fermentation. The pentoses were not fermented, which was not unexpected since baker's yeast is known to be unable to utilize L-arabinose or D-xylose (9). Our data further show that increased pentose appeared to inhibit dough fermentation progressively as indicated by decreased gassing power; D-xylose exhibited a somewhat more potent inhibitory effect on fermentation than L-arabinose. At least a portion of the inhibited gassing power can probably be explained on the basis of increased osmotic pressure on the dough system. In contrast to the doughs containing pentose, the doughs made with D-glucose undoubtedly lost some of their sugar as

fermentation progressed, thus lowering the osmotic pressure on the dough and permitting increased gassing power.

The effect of 1% L-arabinose on gassing power of doughs also containing different amounts of D-glucose is noted in Table I. These data indicate that the pentose depressed gassing power of doughs made with up to 5% D-glucose by an average of roughly 5%. Virtually no depression occurred in the dough containing 10% D-glucose along with the 1% L-arabinose.

TABLE I

EFFECT OF 1% L-ARABINOSE ON 6TH-HOUR GASSING POWER OF DOUGHS CONTAINING VARIOUS D-GLUCOSE LEVELS

D-Glucose	6TH-HOUR GASSING POWER	
	0 L-Arabinose	1% L-Arabinose
%	*mm Hg*	*mm Hg*
0	490	455
1	553	547
2.5	657	619
5.0	722	688
10.0	831	830

The effects of the sugars in baking are summarized in Table II.

These data show that the pentoses had no appreciable effect on loaf volume, but did lower grain quality somewhat at the higher usage level. Proof times (loaves were proofed to a standard height) were lengthened when the pentoses were included in the dough, again illustrating their retarding effect on gas production. The pentoses also brought about a dulling of the crumb color; at the higher pentose sugar level, a yellowish cast was evident in the crumb. Another effect of the pentoses was to produce a darker and noticeably thicker crust. Figure 2 illustrates these effects.

TABLE II

EFFECT OF D-GLUCOSE[a], L-ARABINOSE, AND D-XYLOSE ON BAKING

D-Glucose,[a] %	5.5	3.0	3.0	8.0	3.0	3.0
L-Arabinose, %	0	2.5	0	0	5.0	0
D-Xylose, %	0	0	2.5	0	0	5.0
Total sugar, %	5.5	5.5	5.5	8.0	8.0	8.0
Loaf volume, cc.	2663	2663	2688	2663	2655	2704
Grain score	7.6	7.6	7.0	8.0	7.0	6.6
Proof time, minutes	61	66	67	64	74	74
Crumb color	creamy white	dull	dull	creamy white	dull	dull
Crust color	golden brown	chestnut	chestnut	chestnut	dark chestnut	dark chestnut
Average crust thickness, mm.	2	5	5.5	2.5	5	5.5

[a] Commercial dextrose. Sugar percentages based on flour.

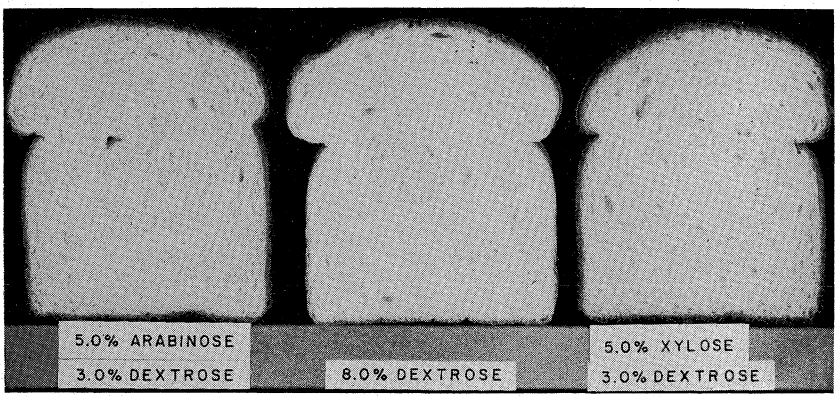

Fig. 2. Effect of pentose on the browning reaction of bread crust. From left to right the three breads were made with 1) 5.0% arabinose and 3.0% commercial dextrose, 2) 8.0% commercial dextrose, and 3) 5.0% xylose and 3.0% commercial dextrose.

Toasting experiments demonstrated that slices from the pentose loaves developed color far more quickly and uniformly than the loaves made with glucose. Further, the pentose-containing slices, particularly the slices made with D-xylose, appeared to develop a more golden color than the slices containing all glucose.

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Literature Cited

1. American Association of Cereal Chemists. Cereal laboratory methods (6th ed.). The Association: St. Paul, Minn. (1957).
2. Bass, E. J., and Meredith, W. O. S. Enzymes that degrade barley gums. III. Studies of beta-polyglucosidases of green malt. Cereal Chem. **32:** 374–381 (1955).
3. Epstein, A. K., and Harris, B. R. Retarding staling of bread. U.S. Patent 2,009,440. Retarding staling of yeast-leavened bread. U.S. Patent 2,040,249.
4. Gilles, K. A. The present status of the role of pentosans in wheat flour quality. Baker's Dig. **34** (5): 47–52 (1960).
5. Montgomery, R., and Smith, F. A review of carbohydrates of wheat and other cereal grains. J. Agr. Food Chem. **4:** 716–720 (1956).
6. Ponte, J. G., Jr., Titcomb, S. T., Rosen, Jocelyn, Drakert, W., and Cotton, R. H. The starch damage of white bread flours. Cereal Sci. Today **6:** 108–110, 112, 121 (1961).
7. Preece, I. A., and Hobkirk, R. Non-starchy polysaccharides of cereal grains. VII. Preliminary study of pentosan enzymolysis. J. Inst. Brewing **61:** 393–399 (1955).
8. Rehfeld, G. Importance of rye mucins in preservation of freshness in bakery products. Ernahrungsforschung **6:** 82–95 (1961). (J. Sci. Food Agr. **12:** ii–222 (1961).)

9. SOWDEN, J. C. Occurrence, properties, and synthesis of the monosaccharides. *In* The carbohydrates, ed. by W. Pigman, pp. 77–137. Academic Press: New York (1957).
10. WILLIAMS, K. T., and BEVENUE, A. The chromatographic examination of sugars in wheat flour. Cereal Chem. **28:** 416–423 (1951).