A Gas Production Formula Containing Guar or Xanthan Gum in Place of Wheat Flour

B. L. BRUINSMA and K. F. FINNEY[1]

Cereal Chem. 59(5):402–404

ABSTRACT

Guar gum (1 g) or xanthan gum (1 g) was a highly desirable replacement for 10 g of wheat flour in a gas-production formula that also included 0.8 g of sucrose, 0.15 g of NaCl, 0.53 g of compressed yeast, nutrients, and 15 ml of distilled water. Neither guar gum nor xanthan gum was enzymatically hydrolyzed into fermentable sugar. The 6% added sucrose in the wheat flour formula was increased to 8% in the guar or xanthan formula to compensate for the gas production contributed by wheat flour. Na_2HPO_4, NH_4Cl, bacto-yeast nitrogen base, a nutrient solution, and $(NH_4)_2HPO_4$ were used to determine the response of guar and xanthan gums to phosphorus (P) and nitrogen (N). Guar responded to both P and N, whereas xanthan responded only to N. When guar gum was used in the gas production formula, a 1:1 ratio of P to N was desirable, and the amount was about 8 mg of each per test. A solution of $(NH_4)_2HPO_4$ (37.7 mg per test) was highly desirable because it provided 8.0 mg of N and 8.8 mg of P and gave optimal gas production. The guar gum (1 g) was less expensive and more readily available and gave somewhat higher gas production than xanthan gum. The guar-containing formula is ideal in gas production studies when it is desirable to eliminate the wheat-flour variables or when the presence of flour components is undesirable.

Several factors can cause errors in the determination of gas production as an index of yeast activity (AACC 1961). Also, certain nutrients (Ling and Hoseney 1977), the amount of water (Shogren et al 1977), certain metal ions (Finney et al 1949), and amount and type of mixing (Finney et al 1981) affect gas production. The flour variable is one that many researchers would like to eliminate. Atkin et al (1945) eliminated flour by using a relatively complicated solution that contained potassium, magnesium, phosphate, and sulfate ions, thiamine, pyridoxine, nicotinic acid, a source of yeast-available nitrogen, sodium citrate buffer, sugar, and yeast. However, a shaking mechanism was required to keep the yeast in suspension. We report a simple, defined, highly reproducible, economical, and readily available formula in which flour is replaced with one of two water-soluble gums, guar, and xanthan. The gum absorbs large amounts of water and forms a gel-like medium that holds all ingredients in suspension to facilitate uniform gas production.

MATERIALS AND METHODS

The control flour (RBS-78) was a blend of straight grade flours milled from many hard winter wheats harvested throughout the Great Plains of the U.S. in 1977. It contained 12.3% (14% mb) protein and 13.5% moisture.

Guar gum was obtained from Colony Import and Export Company, New York, NY. Xanthan gum (Keltrol) was obtained from the Kelco Company, Clark, NJ. A nutrient solution, NH_4Cl, bacto-yeast nitrogen base (YNB), and $(NH_4)_2HPO_4$ were sources of nitrogen and phosphorus, except for NH_4Cl. YNB contains micronutrients including vitamins and minerals. Na_2HPO_4 was a source of phosphorus only. All chemicals were at least chemically pure.

Gas production was determined on a 12-channel recording gasograph (Rubenthaler et al 1980). The formula was 10 g (14% mb) of RBS-78 flour, 0.6 g of sucrose, 0.15 g of NaCl, 0.53 ± 0.02 g of compressed yeast (50:50 blend of weekly shipments from Anheuser-Busch, Inc. and Standard Brands, Inc., in amounts sufficient to produce 69 gasograph units (GU) of gas in 135 min), and 15.0 ml of water.

When RBS-78 flour was replaced with 0–7 g of guar or xanthan gum, and sucrose was varied from 0 to 1g, 2 ml of nutrient solution also was added. The nutrient solution (Ling and Hoseney 1977) contained 5.0 g of $(NH_4)_2HPO_4$, 3.5 g of $MgSO_4 \cdot 7 H_2O$, 1.5 g of KCl, 7.5 mg of thiamine · HCl, 7.5 mg of pyridoxin · HCl, 250 ml of citrate buffer (0.264*M*, pH 5.4), and enough distilled water to make 500 ml. The buffer contained 55.5 g citric acid and 27.0 g of NaOH/1,000 ml of solution (adjusted to about pH 5.4).

To demonstrate the importance of phosphorus and nitrogen on gas production of formulas containing guar or xanthan gum, the nutrient solution was replaced with Na_2HPO_4, NH_4Cl, bacto-yeast nitrogen base, or $(NH_4)_2HPO_4$.

RESULTS AND DISCUSSION

Concentration of Sucrose

When sugar was omitted from the formula containing 1 g of guar or xanthan in place of 10 g of flour, gas production was essentially zero (Fig. 1). Thus, none of the carbohydrate gels were enzymatically hydrolyzed into fermentable sugar. When sugar was omitted from a formula containing 10 g of flour instead of guar or xanthan, about 28 GU of gas was produced from the fermentable components of flour (Rubenthaler et al 1980). Thus, the 6% sugar in the formula containing flour was increased to 8% in the studies with guar and xanthan. Also, flour nutrients utilized in yeast metabolism are not present in the inert gums. Without added

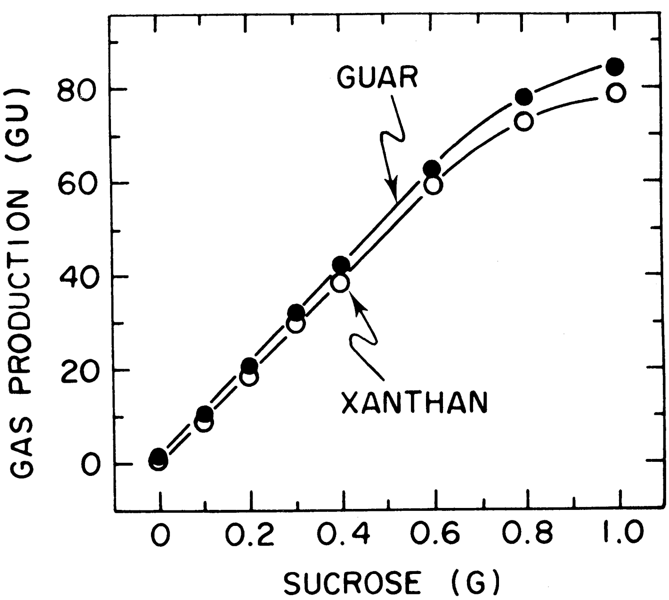

Fig. 1. Gas production for various amounts of sucrose in the formula that contained 1 g of guar or xanthan gums instead of 10 g of wheat flour. Other ingredients were 0.15 g of NaCl, 0.53 g of compressed yeast, 2 ml of nutrient solution, and 15 ml of total distilled water.

[1]Research chemists, U.S. Grain Marketing Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Manhattan, KS 66502.

Mention of firm names or trade products does not constitute endorsement by the USDA over others not mentioned.

nutrients, gas production in the gum suspensions containing 8% sucrose was only 55–57 GU. When 2 ml of nutrient solution was added, gas production of guar was 77.9 GU, and that of xanthan was 72.5 GU (Fig. 1); both values were appreciably greater than that (69 GU) of the control flour with 6% sugar and with no added nutrient solution. When 2 ml of nutrient solution was included in the formula with flour, gas production was 75.1 GU, about midway between the values for guar and xanthan.

Concentration of Gums

Gas production increased rapidly from 37.5 to 70.7 GU as guar increased from 0 to 0.25 g, increased slowly to 75.9 GU for 1 g of guar, remained approximately constant for 1–2 g, and then decreased with further increases of guar (Fig. 2). Less than 0.75 g of guar was insufficient to maintain a uniform distribution of yeast. More than 2 g of guar bound so much water that the gel was exceedingly firm and free water apparently was a limiting factor.

Gas production increased from 37.5 to 70.7 GU as xanthan gum increased from 0 to 0.25 g, increased somewhat to 72.9 GU for 0.5 g xanthan, and then remained constant at about 72.5 GU as xanthan increased to 6 g. At equal concentrations, the xanthan gel was softer than that of guar. Apparently, xanthan does not bind water as tightly as does guar, a probable explanation for the broad plateau for xanthan.

At optimum concentration of gum, gas production in guar gel was about 3 GU more than in xanthan gel. Guar gum (1 g) presently is preferred because it is less expensive, more readily available, and gives somewhat higher gas production than xanthan gum. Guar gums from Henkel Corp. (Minneapolis, MN), T.I.C. Gums, Inc. (New York, NY), and Hercules Corp. (Chicago, IL) were similar to the guar gum used in our studies.

Response to Phosphorus (P)

As phosphorus (P) was increased from 0 to 4 mg in the formula containing 1 g of guar in place of 10 g of flour, gas production increased from 57 to 67 GU (Fig. 3, bottom). Little response (1.5 GU) to phosphorus occurred when xanthan was in the formula.

When 8 mg of N as NH_4Cl was constant and P was increased from 0 to 6 mg in the formula containing 1 g of guar, gas production increased from 57.5 to 73.5 GU (Fig. 3, top). No gas production response occurred for guar to 8 mg of N when no P was added. For xanthan gum at 0 mg P, gas production increased from 56.5 GU (Fig. 3, bottom) to 70.5 GU (Fig. 3, top) by the addition of 8 mg of N. When N was constant at 8 mg, gas production for xanthan gum increased only 1.0–1.5 GU as P was increased from 0 to 11 mg. When 8 mg of N is constant in the formula, about 8 mg of P probably will ensure that it would not be a limiting factor.

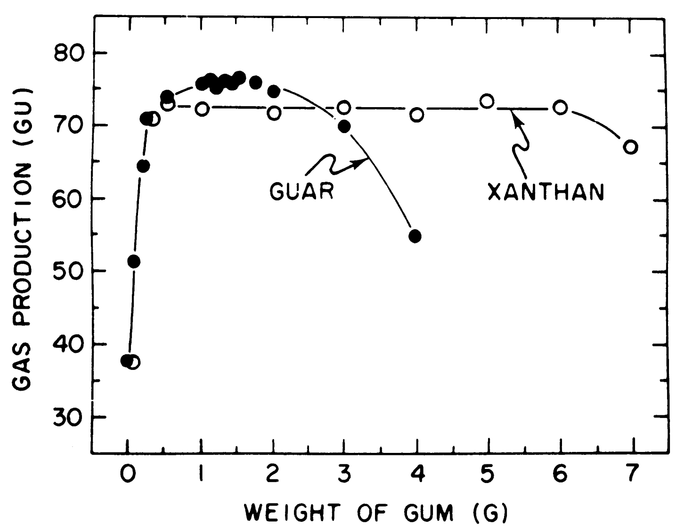

Fig. 2. Gas production when various amounts of guar or xanthan gums replaced 10 g of wheat flour. Other ingredients were 0.8 g of sucrose, 0.15 g of NaCl, 0.53 g of compressed yeast, 2 ml of nutrient solution, and 15 ml of total distilled water.

Response to Sources of Nitrogen (N)

When N as $(NH_4)_2HPO_4$ was increased from 0 to 10 mg in the formula containing 1 g of guar gum, gas production increased sharply to about 4 mg and then leveled off to an optimum of about 75 GU at 8 mg of N (Fig. 4, top left). Similar but somewhat lower

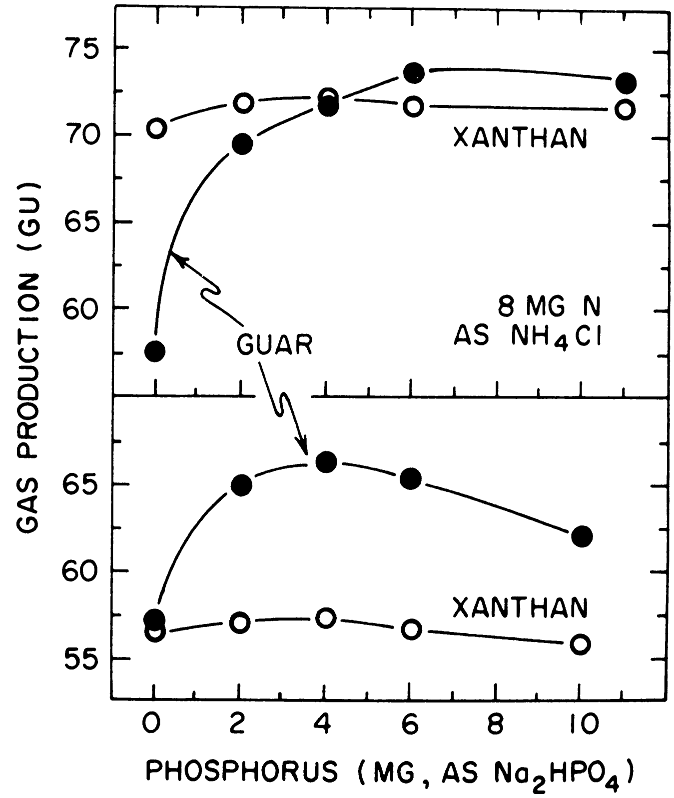

Fig. 3. Gas production response to phosphorus (as Na_2HPO_4) in the formula that contained 1 g of guar or xanthan gum and 8 mg of added N (as NH_4Cl, **top**) and no added N (**bottom**). Other ingredients were 0.8 g of sucrose, 0.15 g of NaCl, 0.53 g of compressed yeast, and 15 ml of total distilled water.

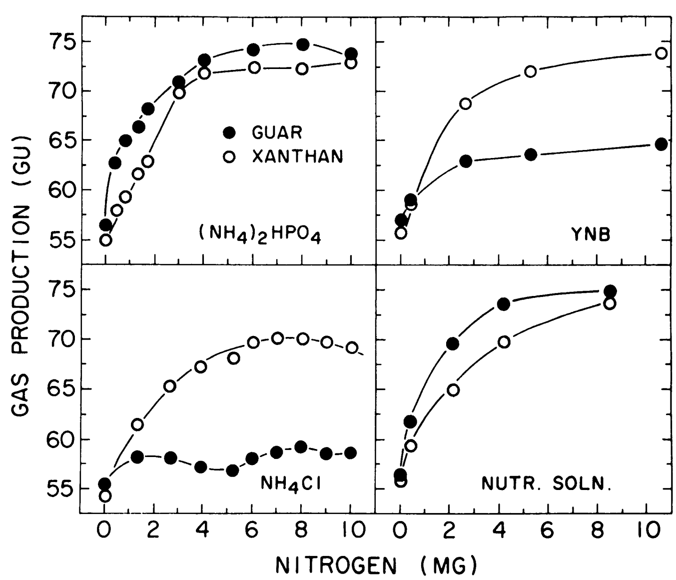

Fig. 4. Gas production response to nitrogen (N) in the formula that contained 1 g of guar or xanthan gum when the sources of N contained different amounts of phosphorus and were $(NH_4)_2HPO_4$ (**top left**), bacto-yeast nitrogen base (YNB, **top right**), NH_4Cl (**bottom left**), and nutrient solution (**bottom right**). Other ingredients were 0.8 g of sucrose, 0.15 g of NaCl, 0.53 g of compressed yeast, and 15 ml of total distilled water.

gas production values than those for guar were obtained when 1 g of xanthan gum was in the formula. When the nutrient solution was used as a source of N (Fig. 4, bottom right), gas production values for guar and xanthan were similar to those when $(NH_4)_2HPO_4$ was the source of N. Both $(NH_4)_2HPO_4$ and the nutrient solution contained 1.1 mg of P/1 mg of N.

When NH_4Cl was the source of N (Fig. 4, bottom left), gas production of the formula containing guar increased little with increasing N, because guar requires P (Fig. 3, bottom). When YNB was the source of N (Fig. 4, top right) gas production of the guar formula increased materially from 57 GU to 64.5 GU at about 10.5 mg of N. Gas production was higher than that for guar and NH_4Cl but not as high as for guar with the nutrient solution or $(NH_4)_2HPO_4$. YNB contained only about 0.23 mg of P/1 mg of N, so that P was limiting.

CONCLUSIONS

When guar gum was used in the gas production formula, a 1:1 ratio of P and N was desirable, and the amount was about 8 mg of each per test. A solution of $(NH_4)_2HPO_4$ (37.7 mg per test) was highly desirable because it simply provided 8.0 mg of N and 8.8 mg of P and gave optimal gas production.

The guar gum (1 g) was less expensive, more readily available, and gave somewhat higher gas production than xanthan gum. The guar-containing formula is ideal in gas production studies when wheat flour is variable or flour components are undesirable.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1961. Approved Methods of the AACC. Method 22-13, approved April 1961. The Association, St. Paul, MN.

ATKIN, L., SCHULTZ, A. S., and FREY, C. N. 1945. Influence of dough constituents on fermentation. Cereal Chem. 22:321.

FINNEY, K. F., CHUNG, O. K., BRUINSMA, B. L., and SHOGREN, M. D. 1981. Effect of type and amount of mixing and quantity of water on inhibitors of yeast activity in wheat flour doughs and slurries. Cereal Chem. 59:385.

FINNEY, K. F., McCAMMON, J. F., and SCHRENK, W. C. 1949. Effect of varying concentrations of certain metals and their salts on gas production and loaf volume. Cereal Chem. 26:140.

LING, R. S., and HOSENEY, R. C. 1977. Effect of certain nutrients on the gas produced in preferments. Cereal Chem. 54:597.

RUBENTHALER, G. L., FINNEY, P. L., DEMARAY, D. E., and FINNEY, K. F. 1980. Gasograph: Design, construction, and reproducibility of a sensitive 12-channel gas recording instrument. Cereal Chem. 57:212.

SHOGREN, M. D., FINNEY, K. F., and RUBENTHALER, G. L. 1977. Note on the determination of gas production. Cereal Chem. 54:665.

[Received December 28, 1981. Accepted March 29, 1982]