

Effects of Aspartame on alcohol fermentation in Aspartame-added bread processing

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The addition of aspartame to white bread dough affected the gas production due to baker's yeast. After 3 hours of incubation, the total gas production of 3% aspartame-added dough decreased about 0.4 times that of standard dough. Gas production decreased with increasing concentrations of aspartame. On the other hand, the expansion of aspartame-added dough increased with increasing concentration of aspartame. The dough containing 3% aspartame expanded the same as standard dough. The ratio of internal gas production to total gas production increased by about 3 times that of standard dough with sugar. The addition of aspartame to white bread dough inhibited the activity of alcohol dehydrogenase. The characteristics of aspartame-added bread allows extension of the dough with gas, keeps the gas in the dough, preserves gas release, and leads to a normal loaf volume, though the addition of aspartame to white bread dough regulated alcohol fermentation of the yeast and the total gas production decreased.

Introduction

Many attempts have been made to popularize bakery products because they are an easy, convenient and inexpensive means of taking in hygienically prepared, ready-to-eat nutrition¹⁾⁻⁸⁾.

Aspartame, one of the most widely used intense sweeteners, was discovered accidentally in 1965 during the synthesis of a pharmaceutical product for ulcer therapy. It is an artificial sweetener composed of two amino acids, aspartic acid and phenylalanin, which combine to form a dipeptide that is subsequently methylated to a methyl ester. Although it is not strictly a non-nutritive sweetener (it provides about the same amount of energy as sucrose on an equal weight basis, approximately 16.8 KJg⁻¹), only very small amounts are needed in foods because of

its intense sweetness, and thus its energy contribution to the diet is insignificant in most cases⁹⁾⁻¹²⁾.

We describe herein the relationship between aspartame and alcohol fermentation due to baker's yeast in aspartame-added bread processing.

Materials and Methods

1. Materials

Wheat flour "Kameria" and dry yeast "Super kameria" were obtained from Nisshin Flour Milling Co., Tokyo, Japan. The flour contained 12% protein, 1.8% lipid, 69% carbohydrate and 14.5% water. Aspartame (100%) was kindly provided by Ajinomoto Co..

2. Measurement methods

Table 1. shows the dough formulae of white

bread, standard bread and aspartame-added bread. Aspartame was added at 0 to 3% (aspartame subjected to baking process / total weight of dough, w/w) to white bread dough, mixed, fermented at 30°C for 90 min and then baked at 180°C for 20 min. The loaf volume was measured by rapeseed displacement. The rheological properties of the bread were measured with a PHEONER RE 3305 (Yamaden Co.) 1hr after baking. The bread was cut into 3 X 3 X 3 cm pieces with an ultrasonic wave cutter (Yamaden Co.).

Table 1. White bread, standard bread and aspartame-added bread formulae

	Amount(g)	Ratio(%)
Wheat flour	5.6	100
Sugar or Aspartame	0.3	5.4(3%)
Butter	0.2	3.6
Dried non-fat milk	0.1	1.8
Salt	0.1	1.8
Water	3.6	64.3
Dry yeast	0.06	1.1
Total	10.0	—

*Standard bread, aspartame-added bread and white bread contained sugar, aspartame and no sugar, respectively

3. Gas production and expansion

Portions of 10 g of standard bread and aspartame-added bread dough, which were prepared from the formulae shown in Table 1., were placed in flat-bottomed tubes or syringes. The expansion of the dough in the flat bottomed tubes was measured by determining the height of the dough during dough development (fermentation) at 30°C for 3 hours. Gas production of the dough in the syringes was calculated by measuring the accumulation of carbon dioxide.

4. Alcohol dehydrogenase assay

The standard reaction mixture contained aspartame (0, 0.25, 0.5, 1%), 200 μmol of ethyl alcohol or acetaldehyde, 1 μmol of NAD⁺ or NADH, 200 μmol of Tris-HCl buffer (pH 8.5), and 0.005% of alcohol dehydrogenase in a final volume of 1.0 ml. The substrate was replaced by

water in a control. Incubation was done at 30°C in a cuvette with a 1 cm light path. The reaction was started by the addition of NAD⁺ or NADH and monitored by measuring the initial change in absorbance at 340 nm with a Hitachi 150-20 double beam spectrophotometer.

Results and Discussion

1. Characteristics of aspartame-added bread

As shown in Fig. 1. and 2., the loaf volume and specific loaf volume [loaf volume (ml)/

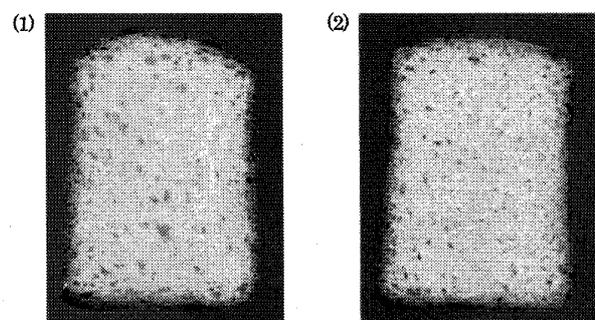


Fig. 1. Photographs of standard bread and aspartame-added bread

(1), standard bread (control); (2), aspartame-added bread. Standard bread and aspartame-added bread contained 3% sugar and 3% aspartame, respectively. Photographs show the middle cutaway view of each bread.

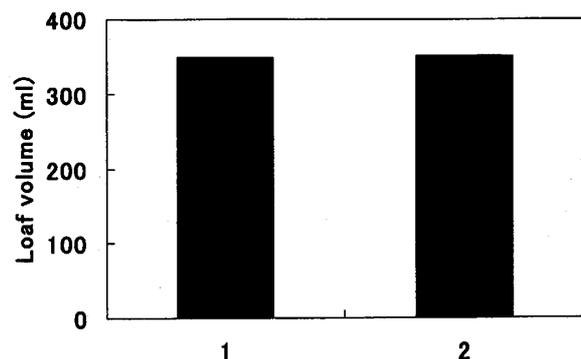


Fig. 2. Effects of the addition of aspartame on loaf volume after baking

1; standard bread (control); 2, aspartame-added bread. Standard bread and aspartame-added bread contained 3% sugar and 3% aspartame, respectively.

bread weight(g)] of the bread containing 3% aspartame dough were almost same as those of standard bread.

The addition of aspartame to white bread caused it to soften to the touch. The firmness of the dough containing aspartame, as measured with a rheolometer, decreased after adding aspartame. (Table 2).

Table 2. Physical properties of the breads

Breads	N/m ²
White bread(no sugar)	2.108 X 10 ⁴
Aspartame-added bread (3% aspartame)	1.327 X 10 ⁴
Standard bread (3% sugar)	1.679 X 10 ⁴

2. Effects of the addition of aspartame on gas production

The production of gas during fermentation (dough development) in aspartame-added bread processing was investigated. To estimate the effects of addition of aspartame to white bread dough on gas production by alcohol fermentation, 3% aspartame was added to the white bread dough (Table 1.) with dry baker's yeast. The doughs containing 0% (white bread without sugar), 3% aspartame (aspartame-added bread) or 3% sugar (standard bread with sugar) were incubated anaerobically at 30°C.

Figure 3 shows the effects of adding aspartame on gas production. The white bread dough and standard bread dough produced a lot of gas, but the dough containing 3% aspartame produced less gas due to alcohol fermentation. The total gas production decreased by about 0.4 times that of standard dough. The gas production decreased with increasing concentrations of aspartame. Therefore, the addition of aspartame affected the gas production by baker's yeast.

3. Effects of the addition of aspartame on expansion

The standard dough and aspartame-added dough were expanded by incubation at 30°C for

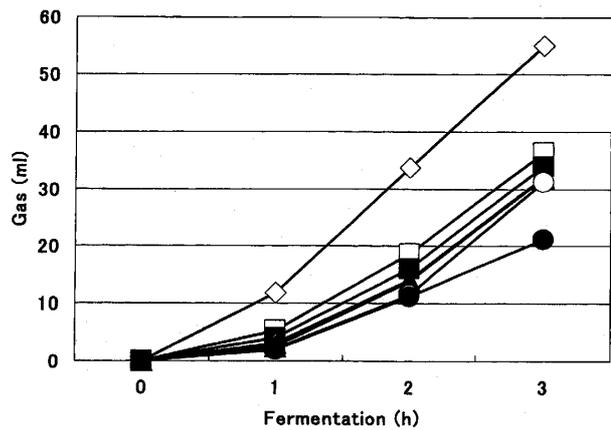


Fig. 3. Effect of aspartame concentration on the production of gas

□, 0% (white bread without sugar); ■, 0.0015%; △, 0.01%; ▲, 0.15%; ○, 1.5%; ●, 3% aspartame-added dough; ◇, standard dough with 3% sugar. Gas production of the dough was calculated by measuring the accumulation of carbon dioxide during fermentation at 30°C for 3 hours.

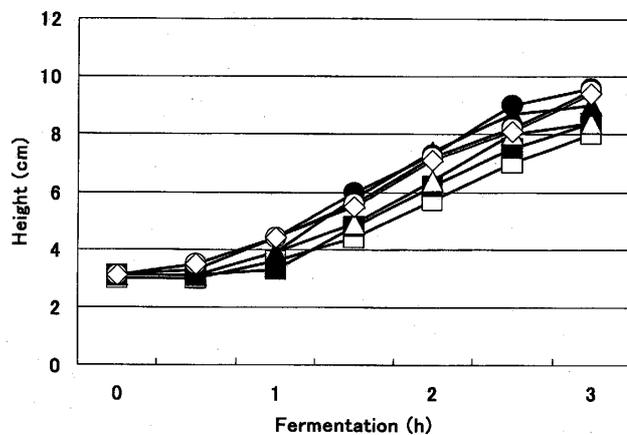


Fig. 4. Effect of aspartame concentration on expansion

□, 0% (white bread without sugar); ■, 0.0015%; △, 0.01%; ▲, 0.15%; ○, 1.5%; ●, 3% aspartame-added dough; ◇, standard dough with 3% sugar. The expansion of the dough was measured by determining the height of the dough during development (fermentation) at 30°C for 3 hours.

3 hours, and the volume (height in cm) of the aspartame-added dough was found to be almost the same as that of the standard dough with

sugar, as shown in Fig. 4. The dough containing 3% aspartame expanded the same as standard dough containing 3% sugar during incubation at 30°C for 3 hours. The expansion of aspartame-added dough increased with increasing concentrations of aspartame, in spite of a decrease in gas production (Fig. 3.).

As shown in Fig. 5., the ratio of internal gas to total gas of the aspartame-added dough was higher than standard dough with sugar and white bread dough without sugar.

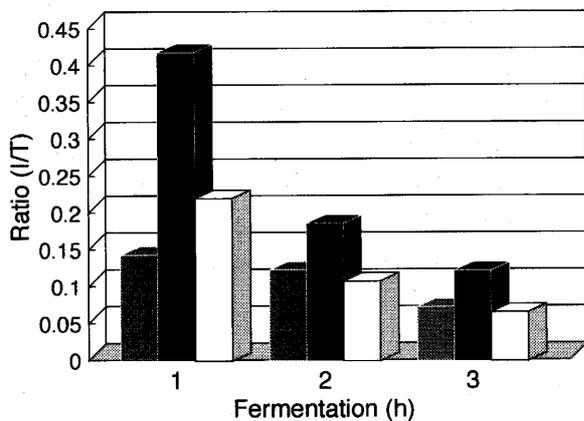


Fig. 5. Ratio of internal gas to total gas production
 ■, standard dough with sugar;
 ■, aspartame-added dough;
 □, white dough without sugar.

4. Effects of the addition of aspartame on alcohol dehydrogenase

As shown in Fig. 6., aspartame inhibited both reactions (one from ethyl alcohol to acetaldehyde and the other from acetaldehyde to ethyl alcohol) of the alcohol dehydrogenase of baker's yeast. Therefore, it seems that the addition of aspartame to white bread dough regulates alcohol fermentation by baker's yeast under anaerobic conditions, thus decreasing gas production.

Aspartame was not utilized by baker's yeast (data is not shown) in alcohol fermentation. In general, wheat flour contains fermentable sugars (about 0.5%). The baker's yeast utilized the fermentable sugars and produced gas (carbon dioxide) by alcohol fermentation.

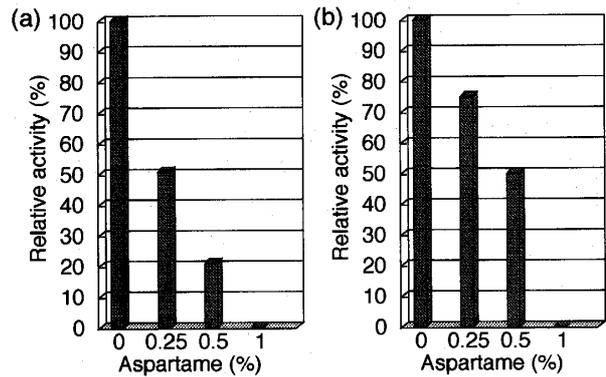


Fig. 6. Effect of aspartame on alcohol dehydrogenase
 The reactions were (a), from ethyl alcohol to acetaldehyde; (b), from acetaldehyde to ethyl alcohol.

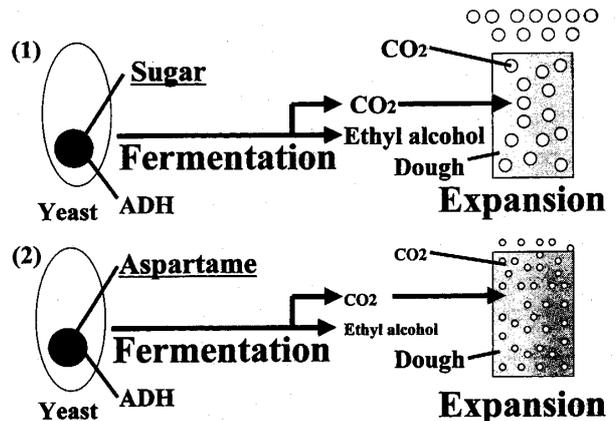


Fig. 7. Scheme of the development mechanism of dough containing aspartame
 (1), standard dough with sugar; (2), aspartame-added dough.

However, dough containing aspartame expanded the same as standard dough containing sugar. The aspartame-added bread was soft to the touch, and its firmness was less than standard bread containing sugar or white bread without sugar. Therefore, we concluded that these characteristics of aspartame-added bread are because it allows extension of the dough with gas, keeps the gas in the dough, preserves gas release better than dough with or without containing sugar, and leads to a normal loaf volume, though the addition of aspartame to white bread dough regulated alcohol fermentation

of the yeast and the total gas production decreased, as shown in Fig. 7.

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