Influence of Yogurt Containing Live Starter Culture on Lactose Utilization in Humans

Stanley E. Gilliland[1] and H. S. Kim[2]

Story in Brief

The appearance of hydrogen in the breath following consumption of milk is an indication of "lactose malabsorption". The amount of hydrogen is a measure of the severity or intensity of the malabsorption or inability to digest the lactose in the small intestine. Breath hydrogen production was determined following the consumption of both heated and nonheated cultured yogurt. Significantly less hydrogen was produced when the subjects consumed the nonheated cultured yogurt than when they consume the heated product. This suggests that lactose hydrolysis was improved in the small intestine of the individuals consuming the nonheated cultured yogurt containing live starter bacteria. The yogurt starter bacteria do not survive and grow in the intestine, however, increased lactase activity in the presence of bile indicates that these bacteria could function as a source of an enzyme to hydrolyze lactose in the small intestine.

Introduction

Milk consumption by persons who lack the ability to digest lactose (lactose malabsorbers) often results in development of symptoms such as cramps, flatulence and diarrhea. This discourages the consumption of milk products by such individuals. Thus, they tend to eliminate milk, a major source of calcium and high quality protein, from the diet.

Fermented or cultured dairy products such as yogurt and buttermilk have been suggested for use by persons lacking the ability to utilize lactose. It was suggested that the starter culture bacteria in these products might exert lactase activity in the intestines after the products were consumed. The bacteria in these starter cultures do not normally grow in the intestinal tract, thus, their only means of providing an improvement in lactose utilization would be to supply the enzyme to hydrolyze lactose.

In the dairy industry, at present, there is some controversy over whether or not cultured yogurt should be pasteurized after the fermentation process. The advantage for pasteurizing such a product would be to extend shelf life of the product. However, such a thermal process would result in reducing the lactase activity in the product. The product then would presumably be of no benefit with regard to improving lactose utilization in the human. No research has been reported to date to present objective data showing whether or not viable starter culture bacteria in yogurt would influence the utilization of lactose in humans who normally cannot digest lactose.

---

[1]Professor [2]Former Graduate Student

The objectives of this study were to determine whether the presence of viable culture bacteria in yogurt is useful in improving lactose utilization in persons classified as lactose malabsorbers and to determine whether bile enhances the ability of yogurt cultures to hydrolye lactose.

Material and Methods

Cultured yogurt was made in the laboratory in one liter portions. To prepare the heated or pasteurized yogurt, one liter of cultured yogurt was heated in a hot water bath to 65 C and held for 3 min with frequent stirring. It was then immediately cooled in an ice-water mixture. Examination of the heated yogurt revealed no viable bacteria. The yogurt preparations were stored under refrigeration until used. They were used within 48 hr of preparation.

Lactose malabsorption in humans was measured using a breath hydrogen test (BHT). Following an overnight fast, (12 hr) the test subjects consumed yogurt at a rate of 4 g/kg body wt. Breath samples were then collected initially and at one-half hr intervals for 3-4 hr. The samples were collected and assayed for hydrogen by gas chromatography.

Test subjects who indicated that they had problems digesting lactose were screened for the ability to hydrolyze lactose using the BHT in which direct acidified yogurt was used as the test dose. This was done to confirm if lactose malabsorption did occur and if an acid product could be used as a test dose. Only those test subjects which exhibited an increase breath hydrogen of at least 30 ppm during the test period were accepted as test subjects (Use of human test subjects was approved by the Oklahoma State University Institutional Review Board for the Protection of Rights of Human Subjects).

After the initial BHT to confirm that the subjects were lactose malabsorbers, they were subjected, at 7-day intervals, to the BHT using both the cultured or heated cultured yogurt as the test dose.

An enzymatic method described by Taylor (1970) was used to quantitate lactose in the yogurt samples. This assay not only permitted quantitation of lactose but also permitted us to measure any free glucose which might have been in the yogurt preparations.

Lactose hydrolyzing activity of the yogurt preparations was measured using o-nitrophenyl-β-D-galactopyranoside (ONPG) as a substrate as described by Citti et al (1965).

Results

Breath hydrogen excretion data for the six test subjects after consuming either heated or nonheated cultured yogurt are summarized in Table 1. For the unheated cultured yogurt, breath hydrogen values ranged from 2.9 to 15.7 ppm (average of 9.9 ppm) and for heated yogurt they ranged from 5.8 to 43.1 ppm (average of 22.8 ppm). There was significantly less breath hydrogen excreted when the subjects consumed the nonheated yogurt than when they consumed the heated yogurt ($P < .05$).

The lactose content of the heated and nonheated cultured yogurt was 4.36 percent and 4.23 percent respectively (Table 2). The uninoculated yogurt mix contained 6.26 percent lactose. Thus, it appears that the starter culture reduc-

ed the lactose content of the yogurt mix by approximately 2 percent during the culturing process. The enzymatic method used for measuring lactose in these samples was designed to permit the measurement of free glucose as well. However, no free glucose was detected in any of the samples.

The lactose hydrolyzing activity of the cultured yogurt containing viable starter bacteria was greatly increased in the presence of oxgall (Table 3). In the absence of bile the nonheated yogurt exhibited 6.8 units of enzyme activity compared to only 0.6 units for the heated yogurt. The addition of .5 and 1 percent oxgall increased the activity to 19.8 and 16.7 units respectively for the nonheated yogurt ($P<0.01$). The same levels of oxgall added to the pasteurized yogurt had little or no effect on lactose hydrolyzing activity ($P>0.05$).

Table 1. Influence of viable starter culture in yogurt on breath hydrogen production following ingestion of yogurt.

Subject	ppm H_2 in breath[a]	
	Heated Yogurt[b]	Unheated Yogurt
1	43.1	15.7
2	5.8	6.7
3	23.7	2.9
4	22.5	13.5
5	20.9	5.4
6	20.7	15.3
MEAN	22.8[c]	9.9[c]

[a]Increase above basal level
[b]Three min at 65 C after culturing process (starter culture killed)
[c]Significantly lower for unheated yogurt ($P<0.05$)

Table 2. Lactose content of yogurt and uninoculated yogurt mix

Sample	% Lactose[a]
Mix	6.26
Unheated Yogurt	4.23
Heated Yogurt[b]	4.36

[a]Each value represents the average from three batches; lactose determined enzymatically.
[b]Three min at 65 C after culturing process.

Table 3. Influence of oxgall on lactase activity of yogurt.

Concentration Oxgall (Percent)	Units of lactase activity/g[a]	
	Unheated Yogurt	Heated Yogurt
0	6.8[b]	0.6[d]
0.5	19.8[c]	0.9[d]
1.0	16.7[c]	1.2[d]

[a]1 unit = 1 u mole o-nitrophenol released from ONPG per min; each value represents an average from four trials; values in same column followed by different superscripts are significant ($P<0.01$), others not different ($P>0.05$).

Discussion

It has been suggested that individuals suffering from lactose malabsorption might be able to consume yogurt without developing the symptoms normally associated with lactose malabsorption. However, no supporting data was presented. Data in the present study show that consumption of yogurt containing viable starter culture bacteria by lactose malabsorbers resulted in reductions in the amount of breath hydrogen produced. Thus, it appears that lactose utilization was improved by the presence of these viable bacteria in the yogurt.

The comparison of the heated and nonheated cultured yogurts shows that the presence of viable starter bacteria at the time of consumption is very important in improving lactose hydrolysis (for reducing lactose malabsorption) in the digestive tract of humans. This points out a real advantage for not pasteurizing cultured yogurt after the culturing process to kill the starter bacteria. By pasteurizing the cultured yogurt, we would eliminate or greatly reduce one of the highly desirable roles of yogurt in the diet, especially for those persons who can not properly digest lactose.

Since the starter culture bacteria *(Lactobacillus bulgaricus* and *Streptococcus thermophius)* used for the manufacture of yogurt do not survive and grow in the intestinal tract, we may assume that the organisms only serve as a source of an enyzme for hydrolyzing the lactose. However, results from other experiments have shown that the culture does not utilize or hydrolyze lactose except as needed for growth. This indicates that the culture must be growing if it is to hydrolyze any lactose in milk. The lactose hydrolyzing enzyme of these bacteria is intracellular and thus lactose must be transported into the cell before it can be hydrolyzed. Because of this, if the organisms are unable to grow in the intestines, they should be unable to hydrolyze the lactose in the yogurt after ingestion. However, after being consumed, yogurt is exposed to bile in the intestines which could alter the premeability of the bacterial cells so that lactose could enter the nongrowing cells and be hydrolyzed. This effect of bile on yogurt starter bacteria was demonstrated by the experiments which showed that the presence of oxgall increased the ability of the yogurt culture to hydrolyze lactose. Thus, nongrowing cells could easily function as a source of the enzyme in the intestinal tract.

If yogurt is to be beneficial to persons who are unable to utilize lactose, it is important that we insure that the yogurt contains adequate enzyme activity. This means that if it is to function in this capacity, the yogurt should not be sterilized by heating after manufacture. Additionally, the yogurt should not be mistreated in other ways such that the enzyme activity would be reduced.

Literature Cited

Citti, J. E., W. E. Sandine, and P. R. Elliker. 1965. J. Bacteriol. 89:937.
Taylor, G. C. 1970. Australian J. Dairy Tech. 25:7.