Fermentation of Blanched-Bean Soymilk with Lactic Cultures

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ABSTRACT

Soymilk obtained through blanching and grinding of soaked beans was examined for its suitability for fermentation with certain lactic cultures. Acid production as well as flavor and texture characteristics of the fermented soymilk were substantially improved by lactic fortification. Citrated soymilk on culturing, had a slightly improved flavor. Cultured whey-soymilk had a slightly weaker consistency but better flavor than lactose-enriched soymilk.

Lactic fermentation of soymilk has aroused world-wide interest in recent years, in view of its significance for extending the use of soybean, a valuable vegetable-protein source (10,14). Since the early work of Gehrke and Weiser (3,4), who demonstrated the suitability of soymilk as a growth medium for lactic cultures, several other reports have appeared, particularly during the last decade. However, unlike cow milk, the aboriginal habitat for lactic acid bacteria, soymilk varies widely in its chemical nature, and so in its ability to support growth of these organisms. This is largely due to variation in the method of manufacture (17).

The processing treatments which affect main constituents of soymilk as well as certain growth factors, are important in determining the milk’s suitability for lactic cultures. Soymilk composition is considerably influenced by treatments like soaking (8) and blanching (15), which are integral parts of the processes such as the “Illinois” one (13). The heat treatment of soymilk is also one of the decisive processing aspects that governs, to a measurable extent, lactic acid production by the culture organisms (2,6,7). Therefore, heat treatment effected through blanching of soybean may also have some implications for lactic fermentation of the resulting soymilk. The present study was undertaken to assess the blanched-bean soymilk as a substrate for lactic culture growth with special emphasis on sensory quality of the fermented product.

MATERIALS AND METHODS

Soymilk was prepared by the method of Nelson et al. (13), with the following modifications: (a) 0.25% sodium bicarbonate was used for soaking and blanching soybeans (dry beans-to-water ratio, 1:4, w/v), (b) blanched soybeans were dehulled before grinding. Homogenized soymilk (approx. 6% solids) was heated at 80°C for 30 min before cooling to the inoculation temperature. Whey-soymilk was prepared using citric acid whey (from chana- or paneer - making in the Experimental Dairy of the Institute) in place of water while disintegrating blanched, dehulled soybeans. The whey pH was adjusted from 5.5 to 6.6 before use because, in the absence of neutralization of whey, the resulting whey-soymilk did not have sufficient stability in spite of the alkaline reaction (pH 7.4) of soymilk before mixing it with whey; even neutralizing the acid whey-soymilk from pH 5.8 to 7.0 failed to give a coagulum.

The cultures, LF-40 (a lactic culture comprised essentially of streptococci), Streptococcus diacetilactis (DRC 1), Streptococcus thermophilus (HST) and Lactobacillus bulgaricus (W) were supplied by the Dairy Bacteriology Division of the Institute. They were propagated by growing them in sterilized litmus milk at 21°C (the first two cultures) or 37°C (the other two) for 14-16 h and holding below 10°C before weekly transfer. Inoculated (1.5%) soymilk was cultured for 14-16 h at 30°C with S. diacetilactis and LF-40, and at 37°C with the remaining cultures.

Cultured soymilk was evaluated for texture and flavor by a trained panel of judges. While texture was assessed arbitrarily on a five-point non-numerical scale as determined from the ‘comments’ by individual panelists, flavor was scored directly on a nine-point numerical preference scale (ranging from “like extremely”-9 to “dislike extremely”-1). The pH of the product was determined using a digital pH meter.

RESULTS AND DISCUSSION

Effect of lactose fortification

Soymilk, in general, requires addition of a fermentable carbohydrate for adequate acid production by most lactic cultures (1). The blanched-bean soymilk appeared to be no exception. The pH of the non-fortified soymilk incubated with LF-40 and S. diacetilactis decreased from an initial of 7.52 to 5.78 and 5.81, respectively. No coagulum formation was noticed; partial precipitation resulted in settling with a very turbid supernatant liquid. Poor acid development in plain soymilk was also observed by Angeles and Marth (1), the pH decreasing...
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from 6.50 to 5.93, 6.08 and 5.83 with *Streptococcus lactis*, *Streptococcus cremoris* and *S. diacetilactis*, respectively. However, substantial acid production by a mixed culture of *S. lactis*, *Leuconostoc cremoris* and *Leuconostoc dextranicum* (pH drop from 6.1 to 4.6) was reported earlier (4); this might be due to the different nature of soymilks used in the experiments.

Table 1 shows that enrichment of soymilk with lactose appreciably enhanced acid production by LF-40 culture. With an increasing level of added lactose the degree of acid development increased and concurrently, the texture and flavor characteristics of the resulting product also improved. One percent lactose gave a fairly firm body with moderate whey separation (appearing clear on top of the coagulum) and a definite “lactic” or “cultured” flavor with a distinct “cereal-like” impression. Acid production corresponding to a pH value near 4.5 seemed to be satisfactory from the viewpoints of texture and flavor, unlike the observations made by Kothari (7). Mital and Steinkraus (9) also found that soymilk fermented with different lactic cultures was acceptable flavor-wise although less preferable than the cow milk product. It is, however, noteworthy that some panelists, conversant with the taste of soymilk, tended to prefer rather lower acidity probably because of the accentuating effect of acid on the cereal-like flavor of the product.

**Effect of sodium citrate**

Diacetyl is one of the key compounds contributing to the flavor of cultured dairy products (5). Production of this aroma compound is greatly favored in milk (16) and soymilk (4) by addition of citric acid or sodium citrate before fermentation. The citrate or citric acid supplementation may also influence lactic acid production. It is evident from data in Table 2 that, in the absence of added lactose, acid production by both the cultures studied was retarded as a result of 0.1% citrate addition. However, with 0.5% lactose added to soymilk, the

<table>
<thead>
<tr>
<th>Lactose addition (°/o)</th>
<th>pH</th>
<th>Texture</th>
<th>Flavor (score)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coagulum</td>
<td>Wheying-offd</td>
</tr>
<tr>
<td>0.00</td>
<td>6.55</td>
<td>(Absent)</td>
<td>-</td>
</tr>
<tr>
<td>0.10</td>
<td>5.76</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>0.25</td>
<td>4.94</td>
<td>++</td>
<td>X</td>
</tr>
<tr>
<td>0.50</td>
<td>4.51</td>
<td>+++</td>
<td>XX</td>
</tr>
<tr>
<td>1.00</td>
<td>4.36</td>
<td>++++</td>
<td>XXX</td>
</tr>
</tbody>
</table>

aAverage from duplicate experiments.
bInitial soymilk pH, 7.43.
c: very weak, ++ : definitely weak, +++ : slightly weak, and ++++ : fairly firm.
dX: trace, XX : slight, and XXX : moderate.

eMeans with different superscripts differ (P less than 0.05).
inhibitory influence of citrate was appreciably reduced for LF-40 and completely eliminated for *S. diacetilactis*.

The change in acid production due to citrate enrichment was also reflected, to some extent, in the textural characteristics of the product. Citrated soymilk showed no coagulation/precipitation whatsoever in the absence of lactose, and formed a weaker clot (especially with LF-40) only in the presence of lactose (Table 2). Nevertheless, flavor-wise citrate-added cultured soymilk was rated slightly better than the control. The improved flavor score presumably may be ascribed to enhanced diacetyl production resulting from the citrate addition. Gehlke and Weiser (4) observed a 70% rise in diacetyl plus acetyl-methylcarbinol production by an aroma producer.*

Flavor-wise, the whey-soymilk product proved to be decidedly superior to plain soymilk (Table 3). While both had pronounced acid taste with a cereal-like background flavor, the former was pleasantly sweet with a slightly salty and heated-milk impression because of its whey solids content. There also seemed to be some influence of the culture. The product obtained with LF-40 (pre-

TABLE 3. Quality of soymilk (with 1% lactose) and whey-soymilk fermented with different culturesa.

<table>
<thead>
<tr>
<th>Culture</th>
<th>Type of soymilk</th>
<th>pHb</th>
<th>Coagulumc</th>
<th>Wheying offd</th>
<th>Flavoere</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF-40</td>
<td>Soymilk+lactose 4.33</td>
<td>++++</td>
<td>XXX</td>
<td>Lactic (5.8)a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whey-soymilk 4.36</td>
<td>++</td>
<td>X</td>
<td>Sweet-salty heated lactic (6.7)b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soymilk+lactose 4.38</td>
<td>++++</td>
<td>XXX</td>
<td>Lactic (5.8)a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whey-soymilk 4.35</td>
<td>++</td>
<td>X</td>
<td>Sweet-salty, heated, lactic (6.8)b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soymilk+lactose 4.74</td>
<td>+++</td>
<td>XX</td>
<td>Coarse, acid (5.7)a</td>
<td></td>
</tr>
<tr>
<td>S. diacetilactis</td>
<td>Whey-soymilk 4.54</td>
<td>++</td>
<td>X</td>
<td>Sweet-salty, lactic (6.6)b</td>
<td></td>
</tr>
<tr>
<td>S. thermophilus</td>
<td>Soymilk+lactose 4.06</td>
<td>+++</td>
<td>XXX</td>
<td>Coarse, high-acid (5.5)b</td>
<td></td>
</tr>
<tr>
<td>L. bulgaricus</td>
<td>Whey-soymilk 3.90</td>
<td>++</td>
<td>XX</td>
<td>Sweet-salty, heated, high-acid (6.5)b</td>
<td></td>
</tr>
</tbody>
</table>

aAverage from duplicate experiments.
bInitial pH: 7.65, soymilk, and 6.79 whey-soymilk.
c,d As per Table 1.
eMeans with different superscripts differ (P less than 0.05).
sumably consisting, at least in part, of aroma bacteria) and S. diacetilactis had a distinct "cultured" or "lactic" aroma which was largely lacking in soymilk cultured with the lactobacilli. However, on tasting the product, the flavor difference due to cultures was not so perceptible probably because of the predominance of the cereal-like acid taste sensation.

Thus blanched-bean soymilk fortified with 1% lactose could successfully be cultured with certain lactic acid bacteria. Replacing water with whey as the grinding medium during soymilk preparation resulted in a product with a little weaker body but with enhanced flavor.

REFERENCES

19. Personal communication with Dale Hardy, Director of Division of Retail and Manufacture Foods, Indiana State Board of Health, Indianapolis 46206.

Cousin, con't. from p. 619

multiplies microbial testing nine times. Food Proc. 37:(12)104-105.