Quality of Yogurt

ABSTRACT

Yogurt consumption in the United States has increased spectacularly during the last decade. Product quality and satisfaction of consumer expectation are discussed since they are essential for the continued successful growth of the yogurt market. Much emphasis is placed on yogurt flavor, body, and texture. The coming identity crisis for yogurt is dealt with since “yogurt without bacteria” has now made its appearance. The results of a brief microbiological evaluation of yogurt and of a consumer preference survey are presented also.

THE QUALITY CONCEPT

Product quality and consumer satisfaction are fundamental to the successful and repeated sale of dairy products. Consumer satisfaction is a simplified definition of quality. One author lists 13 definitions of the word quality (4). For example, we might call “quantity” the “degree to which a specific product satisfies the wants of a consumer.” A second expression may be the “degree to which a class of products possess potential satisfaction for people generally.” This is often called “quality of design.” A third type of quality is “quality of conformance,” namely, the property of conforming to predetermined specifications. If the quality of design is satisfactory and a product conforms to these quality specifications, the quality itself will be assured.

YOGURT QUALITY IN AN EXPANDING MARKET

Unfortunately, in the relatively young yogurt market, there are few standardized quality specifications. Manufacturers rely on consumer reactions and on parallels that can be drawn from other products. They also rely on plain common sense, provided that common sense has been honed by the diligent application of available knowledge and expertise. It is unfortunate that the yogurt market is pervaded by considerable confusion on the American continent when it comes to legal standards (6), microbial content (1), gross composition and caloric content (8), and general quality features (3). This confusion is probably due to the rapid sales growth yogurt has experienced here in the last decade (Table 1). Prior to 1970, only sketchy sales and production figures were available since yogurt was a relatively insignificant commercial product. Earlier sales were estimated as follows: 1965, 27.7; 1960, 20.0; and 1955, 7.7 million kg. In 1974, yogurt amounted to a $125 million market. Extrapolation of these figures will tell us that a $1 billion market is in sight (Table 2). Present yogurt consumption in the US stands at about .68 kg/person. In a number of countries it approaches 10 kg (Table 3). If we would double yogurt consumption every 4 yr in the USA, we would still not reach that of these European countries and already consume $1000 million worth.

The future looks bright for the yogurt industry, but optimism alone will not bring us those desirable figures. The future of yogurt depends very much on the quality we put into it.

| US yogurt sales ('000 000 kg) | 1970 | 78  |
|                             | 1971 | 107 |
|                             | 1972 | 129 |
|                             | 1973 | 148 |
|                             | 1974 | 164 |

Revised July 7, 1975.

1 Authorized for publication on May 16, 1975 as Paper No. 4868 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

Received July 7, 1975.
TABLE 2. Projected per capita yogurt sales in the USA and possible future size of the yogurt market.

<table>
<thead>
<tr>
<th>Year</th>
<th>(kg/person)</th>
<th>Projected Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>.4</td>
<td>$125 million</td>
</tr>
<tr>
<td>1974</td>
<td>.8</td>
<td>250</td>
</tr>
<tr>
<td>1978</td>
<td>1.5</td>
<td>500</td>
</tr>
<tr>
<td>1986</td>
<td>6.0</td>
<td>1000</td>
</tr>
</tbody>
</table>

The subject of quality assessment encompasses specifications, sampling and testing procedures, and recording or reporting. Specifications usually are set by those who have developed or are selling the product. Increasingly, however, government regulatory agencies also are exerting pressure that product testing be consistent with the requirements of these agencies. The nutrition labeling program is a case in point, as are federal and state standards for the composition of food products. Few legal specifications for yogurt exist at this time (6).

Sampling and testing procedures for yogurt are often self-devised but are usually taken from the standard methods that are applied to related dairy products.

THE MANY FACES OF YOGURT

Regardless of plant specifications or regulatory requirements, the consumer is the final judge of quality. Consumers as a group, as is reflected by sales or market surveys, may even change established criteria of quality. This is especially true for foods that have many identifiable and different quality parameters, such as coffee, wine, beer, and even yogurt, which all may vary regionally and annually in their quality attributes. The yogurt sold along the West Coast is considerably different from the product sold in the Eastern United States. A European used to a less viscous yogurt finds the American pudding-like product unique and different.

Yogurt quality is particularly difficult to standardize because of the many forms, varieties, manufacturing methods, ingredients, and consumer preferences that exist. Since these factors will always play an important role, it is unlikely that a uniform yogurt quality concept will ever emerge, such as has been developed for other dairy products. There are a number of common denominators, however, that have a bearing on yogurt quality. Since a number of products are recognized within the broad category entitled yogurt, we feel obliged to strive for top quality in each of these yogurt subgroups. This situation makes yogurt and yogurt products an interesting, challenging, but also a confusing area to work in.

The typical yogurt flavor can only be detected in plain yogurt. Fruit or flavored yogurt is only as good as the fruit mixture or flavoring that has been added. The 1973 survey by the United Dairy Industry Association revealed that only 10.6% of all yogurt is sold as plain. A survey in Central Pennsylvania in 1975 of 400 households (or 161 regular yogurt-consuming households) showed that 21% preferred plain yogurt and the majority preferred a fruit yogurt (Fig. 1). It was also noted that consumption of Swiss-style yogurt is about the same as sundae-style yogurt (Fig. 2). In any case, fruit plays an enormous role in yogurt sales. Since so much flavored and fruit yogurt is sold, its quality lies mainly in the hands of the fruit and flavor suppliers. This is true, with regard to flavor, color, and microbial contamination. Of course,
we cannot shift the whole burden of quality onto the ingredient suppliers. The dairy industry is still responsible for the care and treatment of all ingredients, and for all phases of manufacturing, product storage, and distribution.

HOW TO EVALUATE QUALITY IN YOGURT

Yogurt quality can be assessed in two ways: expert analysis through sensory evaluations (subjective tests), and technical or laboratory analysis (objective tests) with the measurement of chemical, physical, and microbiological properties. Sensory evaluations are usually rapid, inexpensive (if no taste panel is involved), and superior even to electronic equipment, but they lack the objectivity of laboratory tests. Sensory evaluations should always complement the more exact, impartial laboratory determinations.

Assessment of yogurt quality can take place at any time, but is usually made about 24 h after production and should include, if possible: sensory evaluation (taste, aroma, visual appearance, body, and texture); microscopic examination; titratable acidity and pH measurement; compositional analysis (fat, protein, and total solids); acetaldehyde production test; test for coliform organisms; shelf life test after 4 days of storage at 15 C; and fill of container.

Taste and Aroma

There is some international controversy over what a good plain yogurt should taste like. The flavor depends almost entirely on the culture organisms and their metabolism during incubation. Off-tastes and odors are usually by-products of faulty fermentation. The characteristic flavor of yogurt is due to lactic acid, which has no odor of its own, and to trace amounts of acetaldehyde, diacetyl, and acetic acid. The original milk components and their concentrations also play a role, especially the fat and solids-not-fat. There may also be certain additives that contribute to flavor. In flavored yogurt, the fine, delicate taste and aroma or the occasional objectionable, astringent flavor are effectively masked. Work in West Germany has dealt with the acetaldehyde test that can be carried out on the whey of filtered yogurt (10, 11).

The flavor of yogurt is different from that of other cultured milk products. This is mainly due to the high, almost 90%, proportion of acetaldehyde among the carbonyl compounds present (about .005% or 50 ppm in the product). The development of a blue color in neutralized yogurt whey after addition of several drops each of three reagents is indicative of acetaldehyde. The stronger the blue color, the more acetaldehyde is present, and the more flavorful the yogurt. In this way, a numerical value can be assigned to the aroma or flavor quality which otherwise would only be an opinion. This test is said to be good for normal cows' milk yogurt only. With the use of concentrated milk, the color reaction is ob-
scured. The test is as follows. Five ml of filtered yogurt whey is neutralized dropwise with a saturated NaOH solution until cloudiness occurs. Then, 3 drops of a saturated solution of sodium nitroprusside and 3 drops hexamethylenimine (or 5 drops piperidine) are added, with shaking after each addition. After 1 min or 45 s, the development of a blue color is noted.

A high-quality yogurt with a pleasant taste depends very much on the ratio of two bacterial species: *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The streptococcus:lactobacillus ratio in the final product should be 1:1 and not above 3:2 for optimum results. It can be adjusted by controlling incubation time and temperature. A quick count of the rod:cooccus ratio can easily be made by a simple microscopic examination of a drop of yogurt. Either a Gram stain or a methylene blue stain is adequate. It is mainly the incubation which makes yogurt manufacture an art rather than a science. The trial-and-error approach is often as fruitful as the strict control of all variables. It should be understood that the lactobacilli do not produce flavor optimally until the milk is acidified by the streptococci to pH 4.0 to 4.4.

Acid development and development of yogurt flavor go hand in hand. Yogurt is thus a product of bacterial symbiosis. After inoculation, the streptococci grow rapidly until a pH of about 5.5 is reached. Thus, the growth of the lactobacilli is progressively favored. If incubation is not halted at between pH 4.0 to 4.4, the lactobacilli will continue to grow. Since they are also capable of producing acid as well as flavor, the acidity would go well below pH 4.0. The streptococci would then disappear, the optimum bacterial ratio would be upset, and the product would be extremely sour. Acid development may be monitored by titrating the acidity of the incubating yogurt or by measuring pH. Yogurt milk will become solid at an acidity of about .6% (expressed as lactic acid). The pH at this point is about 5.3 depending on the type of milk and the protein content (2). Market research must determine whether a low- or high-acid yogurt is desired. The latter may have a titratable acidity of well above 1.0%. In general, North American consumers prefer a mild culture taste.

Bitterness in yogurt is mainly due to peptides caused by the proteolytic activity of *L. bulgaricus* during storage (9). This is particularly associated with suboptimal incubation temperatures, since it usually is not observed with temperatures of 42 to 44 C.

**Body and Texture**

The consistency of yogurt is probably as important as flavor. Adequate firmness without syneresis is essential for a top-quality product. Wheying-off may be indicative of faulty fermentation and off-flavors. The oldest method of obtaining good body and texture is prolonged heating of the milk to bring about an increase in solids by the evaporation of water. The addition of milk solids to the yogurt milk or mix is much simpler, and the nutritional value is better than when made from plain milk. Milk fat also contributes to the body and texture if the mix is homogenized. Stabilizers also may be used to obtain desirable body and texture. Some yogurt cultures produce a bacterial "slime" which acts as a natural stabilizer. However, this approach to stabilization is still under development.

After compositional conditions are met, certain processing factors must be controlled. A final pH of 4.1 to 4.2 after normal souring is optimal; above pH 4.5 a weak coagulum is obtained. Although the incubation temperature for yogurt has usually been 43 C, a slightly lower one of 40 to 42 C will result in a better body within an incubation time of a few hours. The practice of incubating overnight by lowering the temperature to below 32 C also has found commercial adherents. It is important to avoid agitation during incubation and to cool the yogurt immediately after incubation to 0 to 5 C. Swiss-style yogurt should be held at least 16 h at 3 to 5 C. Mixing and pumping should be as gentle as possible.

With fruit yogurt, it is important to use a highly concentrated fruit preparation. According to the federal standard of identity, fruit preserves must have a minimum of 45% fruit, the remainder being sugar and water. A fruit preserve with a fruit percentage higher than 45% is less likely to produce body weakness in Swiss-style yogurt. The most notable advance in yogurt fruit technology has been a reduction in sugar solids in sundae-style yogurts. This has helped minimize syneresis that usually results from the relatively large differential in osmotic pressure between the yogurt and the fruit layer...
Any type of fruit can be used for making fruit yogurt: frozen, canned, dried; and that is the order of use in the USA. There are now more than 30 flavors available from the fruit processing industry. The most recent trend is toward an “all natural” product: no artificial color, no “chemical” preservatives, and only “natural” additives.

The “natural” concept has acquired a special significance during the past two decades of increased use of so-called “chemical or synthetic food additives.” There are several major national brands of yogurt on the market that carry the word “natural” on their labels. In a recent Central Pennsylvania yogurt consumer survey, 2/3 said they preferred a “natural” yogurt over other brands that contained “synthetic” flavoring, colors, preservatives, and stabilizers. The remaining third did not discriminate (Fig. 3). Although there is no evidence that one type of yogurt has any harm or benefit over the other, it nevertheless behooves the yogurt industry to recognize this overwhelming public sentiment.

The use of stabilizers depends on legal restrictions. Gelatin at .3 to .8% could be used, but the yogurt might not be purchased by consumers obeying certain dietary laws because gelatin is a meat product of uncertain origin. The same could be said about rennet; however, use of this enzyme has always led to a grainy texture. Suitable stabilizers include modified starch, carrageenan, alginate, carboxymethylcellulose, and related substances, also locust bean gum and other gums. These may be used singly or in combinations. All stabilizers are approved food additives. When properly chosen, they play an important role in improving the body, texture, mouthfeel, and appearance of yogurt. Good yogurt can be made without the use of added stabilizers. Unfortunately, a yogurt without stabilizer is more vulnerable to a number of stress factors than one that has been stabilized properly.

Leakage of whey (syneresis) from yogurt is a common defect and must be controlled. The following list includes most of the factors that have a bearing on wheying-off in yogurt. Syneresis is caused by: broken coagulum due to rough handling, particularly at elevated temperatures, wrong acidity, and by abnormal milk; protein content below 3.4%; low fat content; high mineral content of the milk; insufficient heat treatment of the milk; heating of the coagulum during incubation or thereafter; the use of rennet as a stabilizer; insufficient acid formation, e.g., pH 4.8; cultures capable of forming enzymes that coagulate milk protein; high carbon dioxide content; and high incubation temperatures. Syneresis is prevented by: homogenization of the fat; increasing protein content to above 3.5%; low milk mineral content; milk sterilization or heat treatment, leading to some protein degradation; slightly lower incubation temperature; cooling of the coagulum without shock, agitation, or vibration; choice of the lowest temperature possible if the yogurt must be mixed, as in Swiss-style; sufficient acid development, i.e., pH 4.0 to 4.4; use of “slime-producing” cultures; use of hydrocolloid or other stabilizers; and care in the handling and transporting of yogurt.

Microbiological Contaminants

Another common problem with yogurt is contamination by coliform organisms. They are completely undesirable in any milk product. Since these gram-negative, gas-producing bacteria are killed during pasteurization, they are the result of post-pasteurization contamination. Proper plant management and sanitation techniques should be able to control these coliform problems. The same holds true for psychrotrophic bacteria.

Sporeformers, such as Bacillus subtilis, if present in the milk, survive the heat treatment and germinate during incubation. When this occurs, the batch of yogurt is lost. Thorough cleaning of all equipment and a purity check of the culture should follow.

Not much has been published about bacteriophage in yogurt. A slow starter culture may be the first indication when this problem arises. However, with the increasing use of fresh and frozen culture services, there may never be a bacteriophage problem in the yogurt industry.

A yeast and mold count indicates contamination with these organisms, particularly with fruit yogurt where a yeast or mold problem is more likely to arise. A reputable fruit supplier will undoubtedly have an effective quality control program for his products and adhere to rigid standards. A reasonable specification for a yogurt fruit mixture might state maximum counts in the fruit as follows: standard plate
count, 500/g; coliforms, 10/g; molds, 10/g; yeasts, 10/g; and salmonella, none. The presence of potassium sorbate at .1% or less may be helpful.

A BRIEF LOOK AT THE MICROBIOLOGY OF YOGURT ON THE MARKET

Investigation into the microbiological quality of yogurt sold in Central Pennsylvania revealed some undesirable contamination. Fourteen different yogurt samples from seven manufacturers were investigated. They included plain, sundae-style, and Swiss-style yogurt, both fruit yogurt and flavored yogurt.

Three containers of each yogurt were analyzed 2, 10, and 20 days after purchase. There were no coliforms in any of the products. Yeasts and molds were detected in seven samples, with the three highest counts in the products of one company (Table 4). A problem with plant sanitation, the fruit, the filling operation, or the containers could be suspected. At day 20, these three samples also had positive psychrotroph counts, namely, 4, 720, and 145/ml.

The total plate count of yogurt, as expected for a cultured milk product, is extremely high and extremely variable from product to product. It can be assumed that consumers of yogurt have always expected large numbers of viable bacteria in this product. A brief, informal survey of about 100 dairy technologists and related professionals supports that assumption. A survey of general yogurt buyers in Central Pennsylvania, however, indicated that 56% knew that yogurt contained large numbers of bacteria but 44% did not know they were consuming large numbers of viable bacteria. The subject of yogurt with bacteria versus yogurt without bacteria (sterilized or pasteurized yogurt) is discussed at length elsewhere (7).

Total plate counts per ml in eleven yogurt samples ranged as follows: day 2, 26 million to 4159 million; day 10, 700 million to 30,300 million; and day 20, 1200 million to 71,700 million. In all eleven samples, counts increased from day 2 to day 10 when held at 7 C. In seven samples, the counts continued to increase over the next 10 days of storage.

MUST YOGURT CONTAIN BACTERIA?

One company selling a pasteurized yogurt product claims a shelf life of 4 wk for its items. Three of its yogurts were analyzed and the total plate counts were not indicative of typical yogurt. With relatively low counts, the question arises whether a consumer will be defrauded because the traditional expectation of large numbers of bacteria in yogurt was not satisfied. The dairy industry obviously has a product identity problem that must be resolved. One solution would be to delete the term "yogurt" from products with no or low numbers of viable organisms. A new name would have to be coined. Resolution of this problem will also depend on the deliberations by the International Dairy Federation (of which the USA is not a member) and by the Codex Alimentarius Commission (FAO/WHO) presently drawing up standards for yogurt.

ACKNOWLEDGMENT

The author thanks Ida F. Dalmacio for conducting the microbiological work and Steven R. Fram for conducting the telephone survey.

REFERENCES


<table>
<thead>
<tr>
<th>Yogurt</th>
<th>Yeasts/ml</th>
<th>Molds/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 2</td>
<td>Day 10</td>
</tr>
<tr>
<td>Plain</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Vanilla</td>
<td>9</td>
<td>211</td>
</tr>
<tr>
<td>Strawberry</td>
<td>219</td>
<td>336</td>
</tr>
</tbody>
</table>
gurt produced commercially in Ontario. J. Milk Food Technol. 37:11.
5 Kivi, G. C. 1975. (Food Producers, Inc., Minneapolis.) Personal communication.