Manufacture Of High Quality Yogurt

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A topic of extreme interest for the dairy food industry today is that of yogurt. There are many ways to manufacture yogurt; however, in order to consistently manufacture a high quality yogurt, certain basic principles must be followed.

U.S. sales figures for yogurt have increased steadily from 442,000,000 pounds in 1975 to 1,083,000,000 pounds in 1992. The 1993 figures reflect a 10.2% jump to 1,285,000,000 pounds. The dairy food industry must continue to be more innovative with regard to formulating, processing, and marketing our dairy products. This is particularly true for a product with excellent nutritional properties like yogurt. Manning (Dairy Foods, Feb., 1992) indicated that "Our marketing challenge is no longer to maintain growth via new lowfat and nonfat products, but to defend our current user base and to re-ignite category growth in the 90s".

The standard of identity for lowfat yogurt describes this product as, "The food produced by culturing one or more of optional dairy ingredients (cream, milk, partially skimmed milk or skim milk, used alone or in combination) with a characterizing bacterial culture that contains a lactic acid producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* .... Lowfat yogurt, before the addition of bulky flavors, contains not less than 0.5% nor more than 2% milkfat and not less than 8.25% milk-solids-not-fat and has a titratable acidity of not less than 0.9%, expressed as lactic acid."

When I think of high quality yogurt, I think of yogurt that can be easily spooned with a smooth, creamy appearance and that will hold on the spoon without wobbling like jello and not running off like a liquid. It would also be expected to have a natural taste, e.g., blueberry yogurt should taste like blueberries and I should not have to read the label in order to determine what flavor of yogurt I am eating.

On the flip side of this however, the results of an Oregon State University study show something different. The OSU researchers used a 182 member consumer panel and an 11 member panel of people trained in describing the sensory characteristics of food. These two groups rated 14 commercial brands of prestirred strawberry yogurt. A couple of conclusions were as follows:

> "Tasters preferred yogurt that was sweet with a 'jammy artificial strawberry flavor' and had the flavor of 'cooked' milk". "The panelists associated real fresh strawberry flavor with sourness and astringency characteristics that they did not particularly like."

In other words, panelists apparently did not like a strong "yogurt" flavor (Oregon's Agricultural Progress, Oregon Agricultural Experiment Station, Spring/Summer, 1990).

The basic factors which affect yogurt quality are: (1) mix composition, (2) heat treatment, (3) incubation - temperature/time/type, (4) cooling, (5) fruit/color and (6) storage/distribution. These different factors will be discussed in more detail.

Most people think of yogurt as being a product cultured with microorganisms that are helpful to the human body. According to Oberman (Oberman, N.H., In: *Micro. of Ferm. Foods* [Woods], 1985), the original microflora of yogurt was:

(A) Essential microflora – consisting of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*,

(B) Non-essential organisms represented by homofermentative lactic acid strains other than in group (A) and by heterofermentative lactic acid bacteria. Some of them may be used beneficially for supplementing the original microflora: For example, *Lactobacillus acidophilus, Bifidobacterium bifidum, Propionibacterium shermanii, Streptococcus lactis* subsp. *diacetylactis,* and

(C) Contaminants: Yeasts, molds, coliforms, and other undesirable microorganisms.

Puhan (Puhan, Z., May, 1990, Cult. Dairy Prod. J.) described the intestinal bacteria which have been isolated for selected benefits:

1. *Bifidobacterium*:	*B. bifidum* *B. infantis*
2. *Lactobacillus*:	*L. acidophilus* *L. casei*
3. *Streptococcus*:	*S. faecium*
4. *Propionibacterium*:	*P. freudenreichii* subsp. *shermanii*

Much work is being done around the world with regard to these bacteria that have potential health benefits.

He (Puhan, 1990) further described (Tables 1 and 2) different types of fermented milk products containing either *Lactobacillus acidophilus* or *Bifidobacterium*. As one can see, there are many types of products already in existence and certainly more on the "drawing board" which can benefit the consumer as well as the dairy food industry.

In general, yogurt may be evaluated for the following: *Viscosity* (unstirred or

Table 1. Fermented Milk Products Containing Lactobacillus Acidophilus

Product	Microorganisms Involved
Acidophilus milk	*L. acidophilus*
Acidophilus paste	*L. acidophilus*
Acidophilus buttermilk	*L. acidophilus*, mesophilic starter[a)]
Acidophilus natural buttermilk	*L. acidophilus*, mesophilic starter[a)]
Acidophilus yoghurt	*L. acidophilus, S. thermophilus, L. delbrueckii* subsp. *bulgaricus*
Biogurt	*L. acidophilus, S. thermophilus*
Acidophilus-yeast milk	*L. acidophilus*, lactose-fermenting yeasts
Acidophilin	*L. acidophilus, S. lactis*, kefir culture

[a)] *S. lactis, S. lactis* subsp. *cremoris, S. lactis* subsp. *diacetylactis, L. mesenteroides* subsp. *cremoris*

Source: Puhan, Z., May, 1990, *Cult. Dairy Prod. J.*

Table 2. Fermented Milk Products Containing Bifidobacteria

Product	Microorganisms Involved
Bifidus milk	*B. bifidum* or *B. longum*
Bifighurt	*B. bifidum, S. thermophilus*
Biogarde	*B. bifidum, L. acidophilus, S. thermophilus*
Biokys	*B. bifidum, L. acidophilus, P. acidilactici*
Special yoghurt	*B. bifidum, B. longum, S. thermophilus, L. delbrueckii* subsp. *bulgaricus*
Special yoghurt	*B. bifidum, B. longum, L. acidophilus, S. thermophilus, L. delbrueckii* subsp. *bulgaricus*

Source: Puhan, Z., May, 1990, *Cult. Dairy Prod. J.*

stirred) - Brookfield viscometer or Zahn cup

Syneresis - amount of whey liberated at a certain temperature for certain time

Penetrometry – Precision Universal Penetrometer

Quality control properties – composition, culture activity, etc. In evaluating yogurt, we have to consider several things:

1. Flavor (taste + odor + mouthfeel + aftertaste)
2. Body/texture
3. Appearance

Sensory properties – it is important to note that appearance is the first thing observed by the consumer. If the container is dirty or smudged or if the product itself looks poor when the lid is removed, the product will not have a positive impression. For example, a strawberry yogurt, lacking strawberries, does not have great appeal for a consumer. Also, a product with excessive whey on top does not mean to the consumer a "liquid with high nutrition value" but rather, a disgusting-looking product.

Even though appearance is the first thing noted by the consumer, today we will first evaluate flavor then look at the body and texture, and finally determine how yogurt is processed.

Yogurt Flavor

Yogurt flavor is affected by four basic factors:

1. Dairy ingredients
2. Acidity
3. Sweetness (both type of sweetener and the relative intensity of the sweetness).
4. Flavor – type of flavoring whether natural or imitation and intensity of the flavor can certainly have an impact, good or bad.

In plain yogurt mix, some flavor compounds which one would expect to find a "good" yogurt are: acetaldehyde, diacetyl, acetone and volatile fatty acids. The effects of storage time (Table 3) and temperature (Table 4) on diacetyl, acetone, and acetaldehyde in addition to pH, mean sweetness, and mean flavor are shown. These correspond to directions given by Connolly (Connolly, E.J., 1987, ACDPI Mini Clinic) who indicated that the optimum aroma and flavor of yogurt are usually obtained when the acetaldehyde content is between 23-40 ppm at a pH range between 4.0 and 4.3. Also, storage at a slightly higher temperature, for example 10°C as opposed to 4°C, causes an increase in acidity, a decrease in sweetness, and a decrease in overall flavor acceptability.

As important as the flavor of yogurt is, body and texture are also of vital importance. Factors which affect body and texture are:

1. Protein content of the milk
2. Heat treatment – especially as it relates to the nearly complete denaturation of serum proteins.
3. pH
4. Temperature
5. Milk salts
6. Stabilization

Connolly (1987) indicated that nearly complete denaturation of serum proteins may be demonstrated by heating milk for any of these treatments:

Table 3. Effect of Storage Time on Diacetyl, Acetone, and Acetaldehyde Levels

Storage time	Diacetyl	Acetone	Acetaldehyde
(d)	---------- (ppm) ----------		
0	1.0[a]	2.1[a]	29.0[c]
12	1.2[ab]	2.1[a]	26.0[d]
24	1.4[b]	2.0[a]	22.2[e]

[abcde] Values with different supercripts are significantly (P>0.05) different.

Source: McGregor J.U. and C.H. White, 1987, *J. Dairy Sci.*, 70:1828.

Table 4. Effect of Storage Temperature on Diacetyl, Acetone, and Acetaldehyde; pH, Mean Sweetness, and Mean Flavor

Storage time	Diacetyl	Acetone	Acetaldehyde	Acidity	Sweetness[1]	Flavor[2]
(°C)	---------- (ppm) ----------			(pH)		
4	1.2[c]	2.3[c]	27.0[c]	4.15[c]	2.6[c]	7.9[a]
10	1.3[c]	1.8[d]	25.1[d]	4.05[d]	2.3[d]	7.7[b]

[1] Mean sweetness values accodring to a 0 to 5 Hedonic scale (0 = non perceived sweetness; 5 = extremely sweet).

[2] Mean flavor values according to a 1 to 10 Hedonic scale (1 = least preferred and 10 = most preferred).

Source: McGregor, J.U. and C.H. White, 1987, *J. Dairy Sci.*, 70:1828.

170°F (76.7°C) - 1 hour
180°F *(82.2°C) - 30 minutes
192°F (88.9°C) - 5 minutes

These guidelines can satisfy almost any processing plant with regard to heating of yogurt mix.

Many fat replacers or fat mimetics have been developed in the past few years. Glicksman (Food Techn., Oct., 1991) listed and described the current (at that time) fat mimetics:

Fat-Replacer Ingredients

1. Synthetic fat substitutes - Olestra™
2. Emulsifiers - lecithin, MDG
3. Hydrocolloids - carrageenans, locust bean gum
4. Starch derivatives - Maltrin™
5. Homicelluloses - Fibrex™
6. β-glucans
7. Soluble bulking agents
8. Microparticulates - Simplesse™
9. Composite materials
10. Functional blends

To totally understand the stabilization of yogurt, one must recognize the water distribution in the yogurt coagulum. These three are described as follows (Connolly, E.J., 1987, ACDPI, Mini Clinic):

Bound water – water of hydrated proteins. This represents the firmness of coagulum or its consistency.

Capillary water – water held during the process of filament formation.

Free water – water present as invisible droplets mostly finely divided within the coagulum.

Connolly indicated that due to the relatively high proportion of free water, it is important to take precautions during yogurt production to prevent any serum separation. Thus, efficient control of free water is highly dependent upon extent of protein hydration and mechanical activity.

By increasing the protein content of milk, the level of bound water is increased which accordingly increases the firmness of the coagulum. Thus, the addition of 2% skim milk powder or the concentration of milk by 10-15% significantly improves the consistency of yogurt (Connolly, 1987). Having the pH of the yogurt below 4.6, an increase in the hydration of proteins will be noted.

Milk salts have a definite effect on protein hydration. An improper salts balance will cause a weak consistency and result in serum residual separation. Connolly (1987) indicated that this can be overcome by adding 2-3 ounces of calcium chloride per 100 gallons of milk.

Stabilizers play a very important role in making good yogurt. Connolly (1987) also suggested commonly used stabilizers and potential usage ranges. These are as follows:

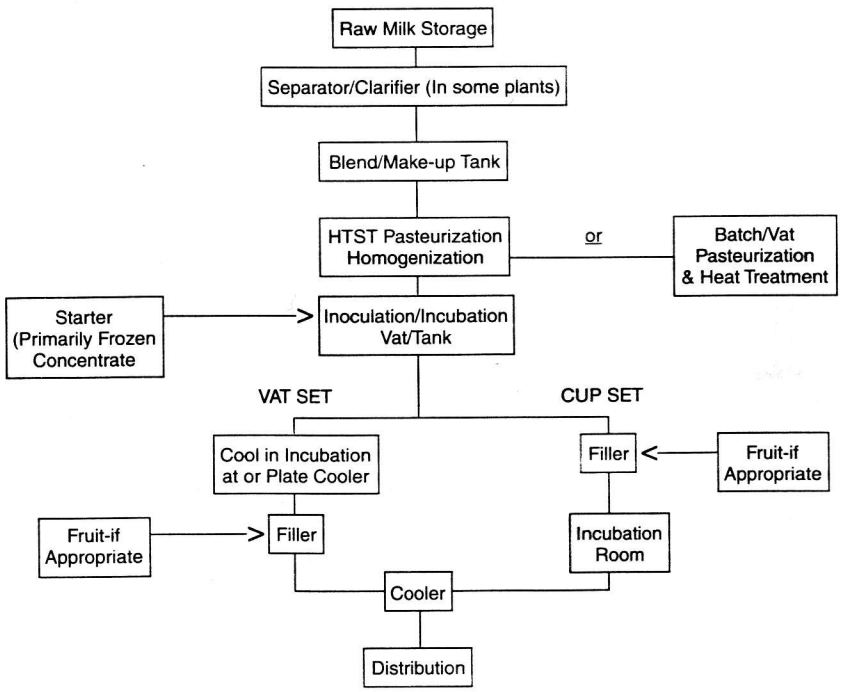
Gelatin 0.2 - 0.7%
Starches 0.2 - 4.0%
Agar 0.4 - 1.0%
Locust bean gum 0.2 - 0.6%
guar gum 0.3 - 0.5%
Pectins 0.05 - 0.8%

One of my former Ph.D. students, Dr. Kim Keating (J. Dairy Sci., 73:54, 1990), found that carrageenan gum, guar gum, locust bean gum, xanthan gum, low methoxyl pectin, gelatin 200, and gelatin 250 interact with milk proteins. The interactions which occurred between the gum stabilizers and the milk proteins had adverse effects on yogurt's body and texture, especially as the concentration of stabilizers increased. She reported that although an increase in gelatin content increased the water-holding capacities of the gel, it did not improve the physical characteristics of yogurt.

Another one of my graduate students, Lori Cotton (finishing up her Ph.D. work) determined sweetness: sourness ratios in vanilla-and strawberry-flavored yogurts (Cotton, L.N. and C.H. White, 1992, J. Dairy Sci. [Supp. 1], 75:103). Also, she looked at plain and other fruit-flavored yogurts. She basically found a 1:1 ratio to be best for the "fruit" or "berry" yogurts and a 0.8:0.9 ratio for plain or lemon yogurts. She reported that vanilla-flavored yogurts received significantly higher technical quality ratings than strawberry-flavored yogurts. It was the investigators' intent to determine whether or not technical quality could be an effective tool in predicting consumer acceptability. They found that significant correlations existed for technical quality when compared to sweetness, sourness, and sweetness: sourness ratios for the vanilla flavored yogurts. Also, significant differences existed between commercially processed yogurts for technical quality and sourness. No significant differences were noted in sweetness between commercially processed yogurts. Finally, strawberry-flavored yogurts sweetened with aspartame received significantly higher sourness ratings than strawberry yogurts sweetened with sucrose.

Yogurt Manufacture

In general, most yogurt, whether vat-set or cup-set, is made in the following manner:



From raw storage silos, milk is separated and fortified normally with milk solids either in the form of nonfat dry milk or condensed skim. The blended sample along with the sweetener, in some cases, is then pasteurized and homogenized. The milk can be run through a HTST system and subsequently heat-treated in a vat. At any rate, following processing of the blended mix, the product is then inoculated, in most cases by direct-to-the-vat frozen concentrate. Then, as the diagram illustrates, if cup set yogurt is being made, the mix is immediately pumped into the filler and into the individual cups which are then incubated in a room at the appropriate temperature ranging anywhere from 90-114°F. Following incubation, cup yogurt is then cooled as rapidly as possible and sent through distribution. If the yogurt is vat set, and it is estimated that 80% of the yogurt made in the U.S. is vat set, the mix is incubated in the vat until breaking pH (normally around pH 4.50) is achieved. Yogurt is then cooled, normally in the incubation vat, or cooling can be accomplished by passing the bro-

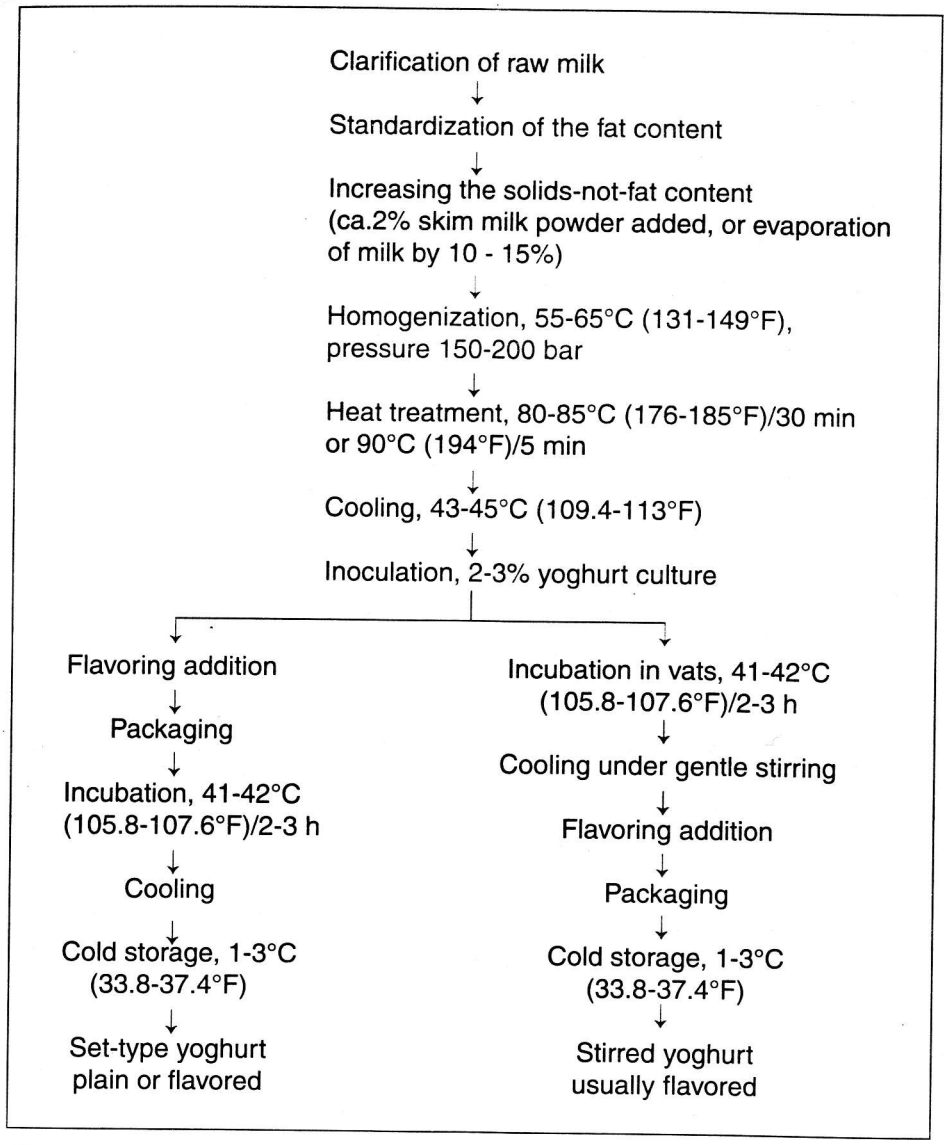


Figure 1. Flow diagram of manufacturing yogurt. Source: Kurmann, J.K., J.L. Rasic and M. Kroger. 1992. *Encyclopedia of Fermented Fresh Milk Products.* Van Nostrand Reinhold, New York, NY.

ken yogurt through a plate cooler. Yogurt is then filled into cartons, sent to the cooler and forwarded for distribution. In a more formal outline, Kurmann, Rasic and Kroger (1992) outlined the manufacture of yogurt (Fig. 1).

Puhan (*Cult. Dairy Prod. J.*, May, 1990) described technological improvements (Table 5) and "new" technology for yogurt-type products. For the "new" technology, the raw milk is standardized and prepared for fermentation and subjected to continuous heat treatment with homogenization and heating to incubation temperature. For the stirred milk product, there is a separate cultivation of special cultures which would then be added to the incubation vessel along with the normal starter culture. Dr. Puhan is describing more of a bulk starter and not that of a direct frozen concentrate. In addition, membrane technologies to include UF would be added as a means of concentrating the special cultures as well as the basic yogurt mix. An important feature is the automatic pH control system to end the fermentation process so as to wind up with a more consistent product. He indicated that membrane technologies offer the possibility of making use of the desired properties and avoiding the inferior properties of microbial metabolites. He further stipulated that separate cultivation offers the possibility of combining microorganisms which usually grow under different circumstances. At any rate, following incubation, the product is cooled by a cooler mounted on the top of the filler. In this way, Puhan indicated, a higher viscosity of stirred fermented milk could be achieved. The product is then put in cold storage and marketed. With regard to set fermented milk products, the normal starter culture is prepared as usual and the product is inoculated in line. He indicated that this allows more flexibility in the manufacture of these products. The product, in our case, yogurt, is then cup filled and put in the hot room. Following incubation, the product is either put in cold storage or, pasteurization can be accomplished if desired – I would not recommend this.

Connolly (1987) described in detail the processing of yogurt. The three basic parts of processing yogurt are:

A Blending – this involves dissolving an uniform suspension of ingredients with as little air incorporated as possible.
B. Pasteurization (Batch or HTST) and homogenization.
C. Preinoculation preparation – final checks:
(1) Compositional profile to ensure that the desired level of fat, protein and total solids have been achieved;
(2) Microbial profile to ensure that the desired microorganisms are present and active and that undesirable organisms like coliforms and yeasts have been excluded;
(3) Sensory evaluation;
(4) Acidity (titratable acidity or pH); and
(5) Hold-back sample – this is a sample that will be retained in the lab for comparative purposes if necessary.

Inoculation and incubation – in this we want to ensure that there is sufficient agitation when the starter is added. Whether a bulk starter (1% addition) or a frozen concentrate, be sure that there is sufficient agitation. When using a frozen concentrate, follow the directions of the manufacturer. In addition, temperature of incubation must be considered. Normally there is a range from 90-110°F. This will vary based on the scheduling require-

Table 5. Technological Improvements for Present Processes for Fermented Milks

- - -	Continuous inoculation of milk for set-type fermented milks
- - -	Better control of acidification; stopping the fermentation at optimal pH
- - -	Optimization of stirring during the cooling process
- - -	Filling at low temperatures possible for better control of post-acidification (applies particularly to plain-fermented milks)
- - -	Manufacture of Kefir directly from grain on industrial scale
- - -	Prevention of recontamination at all levels of manufacture

Source: Puhan, Z., May, 1990, *Cult. Dairy Prod. J.*

ments or the type of yogurt which is being made. Finally, the end of fermentation must be considered. Normally one desires a final pH of 4.0-4.4. More processors are now breaking yogurt at higher pH values, e.g., 4.5-4.7, due to preferences by consumers for less tartness in yogurt. With regard to cup-set yogurt (predominant type today), the cups are removed from the incubation or hot room to a cooling chamber and then to cold storage. With stirred or Swiss style-type yogurt, mechanical cooling is conducted.

According to Earl Connolly (1987), mechanical cooling entails four basic phases:

1. *Shock cooling* – initial cooling begins to effectively reduce bacterial multiplication. Drop from incubation temperature down to 86°F.
2. *Dysgentical stage* – the organisms are rendered biologically deficient. No more bacterial growth will take place (from 86° down to 68°F).
3. *Lact-less phase* – the lactic acid fermentation has stopped (68° down to 58°F).
4. *Holding phase* – The temperature is brought down to storage range to 40°-35°F. Generally accomplished in the consumer package.

In breaking the gel, a gentle, wide sweep agitation aids in the cooling process and helps prevent whey separation. Also, some processors force the gel through some type of device to ensure smoothness of the finished product. This is not always mandatory. In addition, the shear effect on the gel with reduced viscosity as it passes through pumps, lines, blenders, and filling equipment must be considered. Every effort should be made to reduce the negative effects of shearing.

Flavoring materials may be added in any of several ways (Connolly, 1987):

1. Sometimes cold fruit is added directly into the gel at the termination of incubation. This practice aids in cooling of the gel and generally reduces stress placed upon the gel by eliminating a separate fruit incorporation phase.
2. Sometimes a fruit is injected into a line blender as a gel passes to the filler.
3. The use of separate, smaller and specifically designed flavor tanks accommodates this function as well.

Finally, Connolly (1987) described the positive attributes of the package itself: airtight, resistant to shock, strong and durable, minimal headspace, and protects yogurt from light.

The use of alternative sweeteners has played a significant role in providing the consumer's product with low caloric content. Keating and White (1990) reported on a study involving several alternative sweeteners. Their results are as follows:

1. Plain, strawberry and cherry Swiss-style lowfat yogurts were made utilizing alternative sweeteners.
2. Alternative sweeteners used sucrose (control), aspartame, calcium saccharin, sodium saccharin, sorbitol, fructose, fructose with monoammonium glcyrrhinate (MAG), sucrose with MAG, acesulfame-K and dihydrochalcones.
3. Aspartame and sorbitol yogurts were highly favored by the expert panel.
4. The fructose containing yogurts were significantly more viscous. In addition, they appeared to enhance the growth of the lactobacilli.
5. Sucrose with MAG had a significantly ($P<0.05$) higher mean score, followed by sorbitol and aspartame which were not different.
6. Five sweetened yogurts using each culture were evaluated by a 60 member consumer panel. The results indicated that the sucrose, aspartame, and sucrose with MAG yogurts were acceptable.

The most common yogurt defects that are seen in commercial fruit-flavored yogurts in the U.S. are as follows:

Flavor

Acetaldehyde
Lacks "typical" yogurt flavor
Unnatural fruit flavor

Appearance

Color leaching

Atypical color
Free whey
Lumpy

Body/Texture

Gel-like
Too firm
Weak
Ropy

In Table 6, Puhan (1990) described some new developments in the production of fermented milks. He highlighted three areas: health aspects, new technology and new microbiology. A summary of his comments are enclosed in the table.

Table 6. New Developments in the Production of Fermented Milk

Health aspects	The benefit of fermented milks will be of increasing importance:
	- - - Interaction with microbial flora in gut (*L. casei, L. acidophilus, B. bifidum*,etc.)
New technology	Special microorganisms are needed. Their abilities to grow in milk may be poor which calls for development of new technologies.
	Various techniques can be used:
	- - - Membrane techniques (membrane fermentor)
	- - - Separate cultivation
	- - - Use of partly fermented milk (relatively high pH better survival of special microorganisms)
New microbiology	Specific beneficial characteristics may be incorporated in starter bacteria by the use of genetic engineering techniques.

Source: Puhan, Z., May, 1990., *Cult. Dairy Prod. J.*

Another graduate student, Gilbert Bourgouin, looked at solid sources (high and low heat NDM, WPC and UF [2X and 4X]), heat treatment (Batch, HTST, UHT) and packaging temperature (60°F vs. 80°F). The higher packaging temperature had higher viscosity and resistance to penetration but lower WHC and high syneresis. Batch (vat)-heated yogurt had significantly higher viscosity, penetration resistance and WHC while UHT treated yogurts generally had lower viscosity with mixed syneresis values. The UF solids (16% UF) resulted in highest viscosity, penetration resistance (firmer), and WHC. The NDM and WPC solids sources resulted in higher flavor and appearance scores.

It is extremely important to recognize that yogurt can be successfully made only when using top quality ingredients. This includes dairy ingredients as well as other ingredients such as fruits and stabilizers. Quality control checks, especially with lowfat/nonfat products, must be made to ensure the high quality attributes of milk, cream, skim milk powder, condensed skim milk, stabilizers, fruit/syrup blends, etc.

In addition, cleaning and sanitizing of all equipment in the plant can not be over emphasized. The clean-up crew of a dairy plant can either keep the dairy plant out of trouble and producing high quality products or it can get the plant in trouble from a shelf-life and/or a regulatory standpoint.

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REFERENCES

Connolly, E.J. 1987. Quality Yogurt. Presented to Am. Cult. Dairy Prod. Inst., Mini Clinic.

Cotton, L.N. and C.H. White, 1992. Sensory characteristics of commercial yogurt. J. Dairy Sci. (Suppl. 1). 75:103.

Glicksman, M. 1991. Search for the Oily Grail. Food Tech., Oct.

IDF-Standard 47:1969. "Standards of identity for fermented milks." In: Puhan, Z. 1990. Dev. in the Tech. of Ferm. Milk Prod., Cult. Dairy Prod. J., May.

Keating, K.R. 1991. Determination of Protein-Stabilizer Interactions in Yogurt. Ph.D. Dissertation. Mississippi State Univ.

Keating, K.R. and C.H. White. 1990. Effect of Alternative Sweeteners in Plain and Fruit-Flavored Yogurts. J. Dairy Sci. 73:54-62.

Kurrmann, J.K., J.L. Rasic and M. Kroger. 1992. *Encylopedia of Fermented Fresh Milk Products.* Van Nostrand Reinhold, New York, NY.

Manning, J. 1992. Dairy Foods. Feb. p. 11.

McGregor, J.U. and C.H. WHite. 1987. Effect of Sweeteners on Major Volatile Compounds and Flavor of Yogurt. J. Dairy Sci. 70:1828-1834.

Oberman, H. 1985. Fermented milks. In: *Microbiology of Fermented Foods.* Vol. 2. (Ed.) B. J. B. Woods, Elsevier Appl. Sci,. Pub., New York, NY.

Oregon's Agricultural Progress. 1990. Oregon Agricultural Experiment Station, Spring/Summer.

Puhan, Z. 1990. Developments in the Technology of Fermented Milk Products. Cult. Dairy Prod. J., May, p.4.

Ryan, J.M., C.H. White, R.H. Gough and A.L. Burns. 1984. Consumer Acceptance of Fruit-Flavored Yogurt Drinks. J. Dairy Sci. 67:1369-1375.

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