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Yogurt: Nutritive and Therapeutic Aspects

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ABSTRACT

This review deals with the nutritive value of yogurt in terms of its chemical composition, vitamin content and digestibility. The reported therapeutic benefits of yogurt for gastrointestinal disorders, coronary heart disease and other maladies are also discussed.

Belief in the beneficial effects of yogurt for human health and well-being has existed in many civilizations for a long time. According to a Persian tradition, Abraham owed his fecundity and longevity to yogurt, and in comparatively more recent times Emperor Francis I of France was said to have been cured of a debilitating illness by yogurt made from goat's milk (Rosell, 1932). The work of Metchnikoff in Paris at the beginning of this century (Metchnikoff, 1910) on the beneficial effects of yogurt bacteria in man and other animals represents a milestone in the search for the truth on this topic. He believed that yogurt was an effective means of combating a range of organic illnesses from dryness of skin to atherosclerosis. He attributed the longevity and good health of Bulgarian peasants to their high consumption of a fermented milk called 'Yahourth', or yogurt as we know it today. His work gave impetus to the study of the physiological effects of yogurt, a product which today holds a reputation as a highly nutritious food and a useful therapeutic agent.

NUTRITIVE VALUE

Composition

In terms of overall composition, yogurt is similar to milk. However there are many respects in which the compositions of milk and yogurt differ. These differences result in two ways - from deliberate additions to milk or yogurt (from fortification of the basic milk mix and the use of additives) and from changes brought about by bacterial fermentation. The effects on composition of these two processes are summarized in Tables 1 and 2, respectively. From Table 1 it is obvious that the composition of yogurt varies considerably according to the type of yogurt manufactured. With all methods of fortification the percentage of protein is increased, thus yogurt will almost invariably have a higher protein content than milk. The major change resulting from fermentation is production of lactic acid from lactose. However, several other important changes also occur.

The composition of milk and yogurt is given in Table 3. The data have been compiled from several sources and are presented as typical for skim milk and low-fat yogurt made from low-fat milk fortified with skim milk powder. The data given for yogurt composition in many publications differ considerably due to different types of yogurt analysed and different analytical methods employed. From these data is it obvious that yogurt is a well-balanced nutritious food.

One aspect of yogurt composition which has received little attention is the nutritive value of the bacterial cell mass which constitutes about 1% of the dry matter in yogurt (Blanc, 1973). There are reports which suggest that the bacterial protein may be a rich source of essential amino acids (Erdman et al., 1977; Shankar and Laxminarayana, 1974).

Vitamins

The vitamin content of yogurt vis a vis milk has been the subject of some debate in the literature. Some authors have considered yogurt to be a rich source of vitamins while others have shown that the content of many vitamins decreases during yogurt production.

Davis (1978) claimed that yogurt was a "B vitamin factory" but Acott and Labuza (1972) showed that, with the exception of nicotinic acid, yogurt contained lower amounts of vitamins that did whole milk. Vitamins A_1, B_{12}, C, choline and biotin were, respectively, 56, 72, 71, 95 and 61% lower in plain yogurt than in whole milk.

The level of vitamins in yogurt is influenced by several factors.

The vitamin content of the raw milk mix. Although the vitamin content of raw milks may not vary greatly, the various processing treatments and methods of fortification can have significant consequences on vitamins levels. For example, as shown in Table 4, the use of reverse osmosis to concentrate milk for yogurt manufacture can greatly enhance the vitamin level because almost

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TABLE 1. *Compositional differences between milk and yogurt caused by fortification and additives.*

Additives	Components increased in yogurt
Fortification	
Concentration/evaporation	All major constituents
Skim milk powder	All major constituents
Butter milk powder	All major constituents, relatively large increase in phospholipids
Caseinates	Mostly protein
Skim milk concentrated by ultrafiltration	Mostly protein
Skim milk concentrated by reverse osmosis	Mostly protein and lactose
Addition	
Sweetened fruit pulp	Carbohydrate (usually sucrose), polysaccharide, fibre, protein, acids
Stabilizer	Polysaccharide (from e.g. gums) or protein (from e.g. gelatin)
Flavors/colors	Usually carbohydrate (sweetening) and flavors/colors in minor amounts
β-galactosidase	Galactose, glucose, oligosaccharides (lactose decreases)

TABLE 2. *Changes in composition occurring during yogurt fermentation.*

Decrease	Increase
Lactose	Lactic acid
Protein	Galactose
Urea	Glucose
Fat	Polysaccharides
Some vitamins (e.g. B_{12}, C, biotin, choline)	Peptides
Some organic acids (e.g. hippuric, orotic)	Free amino acids
	Ammonia
	Free fatty acids (volatile and longer chain)
	Some vitamins (e.g. folic acid)
	Some organic acids (e.g. succinic, fumaric, benzoic)
	Some nucleotides (e.g. CMP, AMP, UMP, GMP, NAD)
	Flavor compounds (e.g. acetaldehyde, acetoin, diacetyl)
	Enzymes (e.g. β-galactosidase, LDH, protease, peptidase)
	Bacterial mass (inc. nucleic acids, lipids, carbohydrate, protein)

all of the vitamins are retained by the membrane and the milk is not subjected to high heat treatments. By contrast, use of UF concentration causes losses of most vitamins due to their small molecular size. However, folic acid and vitamin B_{12} are largely retained because they are protein bound (see Table 4).

The vitamin content of yogurt made from milk fortified with skim milk powder depends on the type of heat treatment used in powder manufacture. Yogurt made with high-heat powder has lower levels of the heat-labile vitamins than that made with low-heat powders. Yogurt can also gain considerable vitamin enrichment when fruit, especially fresh fruit, is added and even when some stabilizers are used, e.g. folic acid from carrageenan (Reddy et al., 1976).

Heat treatment. The relatively high heat treatments used in yogurt manufacture cause significant decreases in some vitamins. Those most susceptible are C, B_6, B_{12} and folic acid. The more severe the heat treatment, the greater is the loss. The presence of dissolved oxygen in milk greatly enhances the sensitivity of the vitamins to heat (Hartman and Dryden, 1974). Thus the air agitation of milk silos which saturates the milk with oxygen, may dispose it to heavy vitamin loss on subsequent heat treatment.

Production and utilization by starter bacteria. At the fermentation stage some vitamins are consumed by starter bacteria while others are actively synthesized. The

TABLE 3. *Composition of milk and yogurt.*[a,b]

Constituent (per 100 g)	Milk (skim)	Yogurt (low fat, plain)
Energy value (KJ)	150.00	220.00
Major constituents (g)		
Protein	3.50	5.00
Fat	0.10	1.00
Lactose	5.00	5.00
Galactose	c.00	1.50
Lactic acid	c.00	1.00
Citric acid	0.20	0.30
Potassium	0.15	0.24
Calcium	0.12	0.18
Phosphorous	0.10	0.14
Chloride	0.10	0.18
Sodium	0.05	0.08
Bacterial mass	0.00	0.15
Minor constituents (mg)		
Orotic acid	7.00	4.00
Hippuric acid	2.00	c.00
Fumaric acid	1.00	8.00
Succinic acid	c.00	19.00
Benzoic acid	0.50	7.00
Cholesterol	2.00	7.00
Urea	0.40	0.02
Glucose	c.00	30.00
5' - CMP	0.60	c.00
5' - UMP	0.20	0.50
3' - + 5' - GMP	c.00	0.40
5' - AMP	c.00	0.10
NAD	c.00	0.60

[a]Values given represent typical values for skim milk and plain yogurt manufactured from low-fat milk fortified with milk solids.

[b]Compiled from: Anon (1973), Blanc (loc. cit.), Brathen (1977), Davis (1975a & b), Drawert & Leupold (1979), Freeley et al., (1972), UK Food Standards Committee (1975), Kieffer et al., (1964), Lembke (1963), McCance & Widdowson (1978), Okonkwo & Kinsella (1969), Svensen (1974).

TABLE 4. *Retention (%) of vitamins during concentration by UF and RO.*[a]

Vitamin	RO	UF		
	Whole milk	Whole milk	Skim milk	Whey
Thiamine	100.0	62	77	33
Riboflavin	100.0	61	79	50
B_6	96.6	64	80	38
B_{12}	100.0	98	100	100
C	-	13	-	-
Folic acid	100.0	95	100	95
Nicotinic acid	92.1	59	69	31
Pantothenic acid	100.0	68	74	38
Biotin	100.0	63	84	40

[a]After: Glover (1971), Ford et al. (1978).

actual amounts consumed and synthesized depends on the strains of starter bacteria used, size of the inoculum and conditions of fermentation (Shahani et al., 1974).

Reddy et al. (1976) found that niacin and folic acid increased during yogurt manufacture while vitamin B_{12}, biotin and pantothenic acid decreased. The increase in folic acid, about 10-fold, was most marked. Shankar and Laxminarayana (loc. cit.) reported an increase in folic acid and a decrease in thiamine and riboflavin.

Cerna et al. (1973) examined the effect of lactic cultures on the vitamin content of milk and concluded that, with a mixed yogurt culture stored for 24 h at 4 C, there was little change in the vitamin levels with the exception of B_{12} which showed a significant decrease. They suggested that this loss of B_{12} could be reversed by incorporation of B_{12}-producing propionibacteria into yogurt. A similar suggestion was made by Karlin (1961) who found that the 80% loss of B_{12} during incubation of yogurt at 30 C for 7 days could be significantly reduced if *Propionibacterium freudenreichii* subsp. *shermanii* was added. The loss of B_{12} during the yogurt production was also reported by Rasic and Panic (1963). They observed a reduction from 5.28 to 3.50 μg/litre after boiling raw milk for 5 min and a further reduction to 1.87 μg/litre after yogurt manufacture. During storage at 4 C, the decline continued.

Though most workers have reported a net usage of B_{12} by the yogurt bacteria, two reports have indicated synthesis by these organisms. Mitic et al. (1974) found that three strains of *Lactobacillus bulgaricus* actively synthesized this vitamin and Shahani et al. (1974) claimed that the lactic starters used in the manufacture of cottage cheese and yogurt synthesized folic acid and B_{12}. It should be noted, however, that in the later report from the same laboratory, Reddy et al. (1976) reported a decrease in B_{12} during yogurt production. Reddy et al. (1976) showed that vitamin production was dependent on the time and temperature of incubation and found 42 C to be optimal for folic acid and niacin production (Table 5). At this temperature, folic acid content reached a maximum after 5 h of incubation and niacin after 3 h. Vitamin C in vitamin-fortified milk has been shown to be not utilized during fermentation with yogurt microflora (Czarnocka - Roczniakowa and Wojewodzka, 1970).

TABLE 5. *Effect of incubation temperature upon vitamin synthesis in yogurt.*[a]

Vitamin (μg/100 g)	Pasteurized milk +2% non-fat dry milk solids	Yogurt (3 h incubation) Incubation temp. (C)			
		37	40	42	45
Folic acid	0.371	3.736	4.042	4.317	3,928
Niacin	120.000	126	130	142	136

[a]After: Reddy et al. (1976).

Storage. Most vitamins decrease during storage so the level of vitamins will largely depend on the age of the yogurt. Some vitamins appear to be more stable during storage in yogurt than they do in milk. Reddy et al. (1976) found that storage at 5 C caused a decrease in the level of vitamins. Folic acid and vitamin B_{12} showed the greatest loss, 28.6 and 59.9%, respectively, in 16 days. Under similar conditions, milk lost 84.2% of its folic acid and 48.7% of vitamin B_{12}. The loss of biotin, niacin and

pantothenic acid in yogurt during storage was small. Although the decrease in some vitamins, e.g. biotin, vitamin B_{12}, pantothenic acid, during yogurt fermentation is due to their use as essential nutrients by the bacteria during growth, the decrease during storage at 5 C is probably due to chemical decomposition. This is supported by the observation that a 'yogurt' made by direct acidification without microorganisms exhibited similar losses of vitamins (Reddy et al., 1976).

The vitamin contents of milk and yoghurts are shown in Table 6.. These data have been assembled from several reports and are presented as typical for the types of milk and yogurt designated.

Digestibility

Yogurt has been shown by many authors to be more digestible than milk. Breslaw and Kleyn (1973) used a simulated gastric digestion system to assess the protein digestibility of yogurt and of the raw milk mixture at various stages during processing. Their results, summarized in Table 7, show a decrease in protein particle size and an increase in soluble protein, non-protein nitrogen and free amino acids during processing and yogurt manufacture. Use of gelatin as a stabilizer had little effect on the digestibility of the yogurt protein [Table 7(c)]. From a separate digestion experiment these authors concluded that yogurt protein was twice as digestible as milk protein since for yogurt only 3 h were required to attain more than 70% digestion compared with 6 h for milk. Rasic and co-workers (Rasic et al., 1971a & b; Stojslavljevic et al., 1971) showed that yogurts made from different milks had higher digestibility indexes than their parent milks with the yogurt from goat's and sheep's milk having the highest digestibilities. Their results are set out in Table 8. Duitschaever (1978) also reported that goat's milk yogurt had a better digestibility than cow's milk yogurt.

The increased digestibility of yogurt protein compared with protein in milk has been attributed to several factors. These include the softer curd resulting from the high heat treatment (Jay, 1975), high acidity and smaller casein curd (Niv et al., 1963), the increased secretion of digestive enzymes by the salivary glands when stimulated by the curd particles (Halden, 1964), the partially clotted nature of the protein (Pien, 1964) and the increased peptide and free amino acid content resulting from the heat treatment and from proteolysis by the yogurt bacteria.

The carbohydrate in yogurt is also more digestible than that in milk since up to half of lactose is hydrolyzed (Tamime, 1977) during manufacture, a characteristic of yogurt which finds favor with lactose intolerants (Gallagher et al., 1974; Kilara and Shahani, 1974). The latter authors showed that the lactase activity of a medium containing yogurt cells was increased 5-fold when the cells were lysed during incubation under simulated gastric digestion conditions. It can be inferred from this that the lactase activity present in yogurt can greatly facilitate lactose digestion in the human gastrointestinal tract. In experiments with rats, Goodenough and Kleyn (1976) found that a diet of live yogurt over 7 days greatly enhanced the lactase activity of the rats' intestinal mucosa. This effect was probably due to the lactase activity in the yogurt since no comparable increase in lactase activity was noted in rats fed pasteurized yogurt or simulated yogurt containing sucrose or lactose. The results of this study should be applicable to the human situation. In a recently reported trial (Hargrove and Alford, 1978) in which groups of rats were fed unfermented milk, yogurt or other types of fermented and acidified milks, better weight gains and feed efficiency were observed for the yogurt diets than for any of the other diets. The yogurt diet maintained its superiority even after vitamin supplementation of the other diets.

Lactic acid configuration

Yogurt contains both D(-) and L(+) lactic acid with the amount of D(-) increasing with storage and increased

TABLE 6. *Vitamin content of milk and yogurt.*[a]

Vitamin (per 100 g)	Milk (skim)	Yogurt (low fat, plain)
A (IU)	9	70 - 130
Thiamine (μg)	40	37 - 50
Riboflavin (μg)	150 - 200	220 - 260
Pyridoxine (μg)	40	40 - 54
Cyanocobalamine (μg)	0.3 - 0.4	0.1 - 0.35
Ascorbic acid (mg)	0.1 - 2.0	0.1 - 1.0
Tocopherol ($\alpha + \beta + \gamma$) (μg)	Trace	30
Folic acid (μg)	0.25	4
Nicotinic acid (μg)	70 - 90	120 - 130
Pantothenic acid (μg)	360	380
Biotin (μg)	1.6 - 3.0	1.2 - 4.0
Choline (mg)	4.8	0.6

[a]Compiled from:- Anon (1973), Acott & Labuza (loc. cit.), Blanc (loc. cit.), Davis (1975a & b), UK Food Standards Committee (loc. cit.), Formisano et al., (1974), Gorner & Oravcova (1971), Hartman & Dryden (loc. cit.), McCance & Widdowson (loc. cit.) Reddy et al., (1976).

TABLE 7. *Distribution of protein in yogurt from various stages in processing after digestion in simulated gastric digestion system.*[a]

Processing Stage/product	Protein particles: 4 Mesh (%)	10 & 20 mesh (%)	40 mesh (%)	Soluble protein (%)	Non protein nitrogen (%)	Free amino acids (μm/ml)
(a)[b]						
Raw mixture before heating	49.5	1.6	3.8	45.1	0.24	6.2
After homogenization, regeneration, heating at 85 C/10 min	36.4	4.4	1.4	57.9	0.31	4.8
After cooling to 44.4-44.5 C and adding culture	31.2	8.2	1.9	58.6	0.31	8.1
Finished yogurt (Natural)	0	0	36.7	63.3	0.37	9.2
(b)						
Finished fruit yogurts (Range for 6 flavors)	0	2.3-5.1	22.8-32.5	63.0-73.9	-[c]	-
(c)						
Non-stabilized yogurt	0	0	28.3	71.7	0.33	8.7
Gelatin stabilized yogurt	0	0	39.3	60.7	0.45	9.2

[a]Adapted from: Breslaw & Kleyn (loc. cit.).
[b]Sections a, b and c are results from 3 different studies.
[c]Values not reported.

TABLE 8. *Biological value of proteins in milks and corresponding yogurts.*[a]

Type of milk	Pepsin pancreaton digest index[b]: Milk	Yogurt after incubation	Yogurt after incubation and refrigeration
Cow's Milk	81.4	84.1, 85.2	85.6, 87.3
Sheep's Milk	83.4	88.9	89.3
Goat's Milk	85.4	89.7	90.5
Reconstituted Spray Dried Milk	77.5	78.6	79.8

[a]After: Rasic et al. (1971a & b), Stojslavljevic et al. (loc. cit.).
[b]Based on release of 8 essential amino acids and compared with whole egg ≡ 100.

TABLE 9. *Lactic acid content of yogurt and other fermented products.*[a]

Fermented product	Lactic acid (%)	%L (+) Lactic acid of total lactic acid
[a]After: Krusch (loc. cit.).		
Yogurt	0.6 - 1.1	47 - 60
Acid milk	c.0.9	88 - 96
Cultured buttermilk	c.0.9	c. 87
Quark	0.6 - 0.8	95 - 96
Cottage cheese	0.2 - 4.0	78 - 92

[a]After: Krusch (loc. cit.).

catabolism by *L. bulgaricus*. The amount of the L(+) isomer in yogurt compared with other fermented foods is given in Table 9 taken from Krusch (1978). Since the D(-) isomer is less actively metabolized in the human body than the L(+) isomer, it could lead to metabolic disturbances in a very unbalanced diet (Krusch, loc. cit.). This is particularly so for babies and a limit of 200 ml per 10 kg body weight per day has been recommended for young children (Davis, 1975b). The L(+) isomer is completely harmless. It should be noted that both isomers improve the digestibility of the casein and aid in retention of calcium in the intestine (Krusch, loc. cit.).

Pasteurized vs. live Yogurt

There is some difference of opinion in the dairy industry on whether yogurt should be pasteurized after manufacture or not. Such a heat treatment would kill the yogurt bacteria and any bacterial contaminants and hence extend the shelf life of the product. This would aid the manufacturers considerably in handling, distribution and marketing. However the yogurt "purists" believe that a heat-treated yogurt should not be called yogurt and that in fact it is a completely different product. This view is espoused by Kroger (1978) who argued that yogurt should not be pasteurized for the following reasons: (*a*) it is unnecessary as a well-made yogurt has a shelf life of up to 60 days and hence pasteurizing is a waste of energy, (*b*) heat destroys the lactase and hence decreases the value of yogurt for lactose intolerants, (*c*) it would lead to problems of labelling and definition and would open the way for acidulated, imitation yogurts, (*d*) a second heat treatment would decrease the vitamin levels and (*e*) it would eliminate the value of yogurt as a source of benign flora which can be of benefit in gastrointestinal problems. Speck (1977) also argued against pasteurizing yogurt on the grounds that lactase is inactivated by heat treatment and therefore one of the nutritive effects of yogurt is destroyed. In contrast to heat treatment, freezing preserves the lactase activity in yogurt and may be a logical alternative method of yogurt preservation to pasteurization.

THERAPEUTIC EFFECTS

Gastrointestinal disorders

Yogurt has been used for and believed to be effective in the prevention and treatment of illness in both man (Steyn, 1969) and animal (Herrick, 1972). Its most common use has been in gastrointestinal disorders such as diarrhea, particularly infantile (Niv et al., loc. cit.), gastroenteritis (Davis and Latto, 1957) and constipation Ferrer and Boyd, 1955). Many reports of beneficial effects of fermented milks concern products containing *Lactobacillus acidophilus,* an organism not normally present in yogurt as defined for this review. Consequently the therapeutic effects of this organism are beyond the scope of this paper and the comments here will be confined to yogurt containing *L. bulgaricus* and *Streptococcus thermophilus.*

Considerable controversy has surrounded the efficacy of yogurt as a therapeutic agent. The central issues in this debate are whether or not the yogurt organisms can survive gastric (acid) and duodenal (bile salt) conditions and whether or not they can implant in the intestine. The influence of deoxycholate on the yogurt organisms and *L. acidophilus* was reported by Lembke (1964). His results are reproduced in Table 10. *S. thermophilus* was very susceptible, whereas some of the *Lactobacillus* organisms survived a short time in the lowest concentration of bile salt. Acott and Labuza (loc. cit.) investigated the effect of acid conditions over a period of 3.5 h on the yogurt organisms. Figure 1 taken from their paper shows that the *Streptococcus* was rapidly destroyed, whereas a small proportion of the *Lactobacillus* survived after 3.5 h. Rocchietta (1975), Salvadori and Salvadori (1974) and Goodenough and Kleyn (loc. cit.) have found that significant numbers of yogurt organisms can survive passage through the gastrointestinal tract. Hargrove and Alford (loc. cit.) reported that in rats fed yogurt, *L. bulgaricus* was frequently found in the lower intestine but *S. thermophilus* was never isolated below the upper small intestine. With regard to implantation of these organisms in the intestine, it is now generally agreed that *L. bulgaricus* cannot implant whereas *L. acidophilus* can. The latter is a normal inhabitant of the human intestine (as well as the mouth and vagina), whereas *L. bulgaricus* is not (Sandine, 1979). It is therefore unlikely that *L. bulgaricus* can inhibit intestinal putrefaction and be effective in treating gastro-intestinal disorders (Mitsuoka, 1972). It is interesting to note that a study into adhesion of bacteria to surfaces led to the suggestion that the lactobacilli currently used in yogurt manufacture are non-adhering strains, the implication being that it may be possible to use adhering strains which would implant in the intestine and confer beneficial effects similar to those of *L. acidophilus* (Mabbit, 1977).

Nonetheless yogurt has been used effectively in treating several disorders. Niv et al. (loc. cit.) reported beneficial effects of yogurt ingestion by children with infantile diarrhea and attributed the effect of initiation of normal, functional flora in the gut by the easily digestible nutrients of yogurt. In an investigation into the effects of yoghurt cultures on the intestinal flora of infants (6-9 months old), Gotti (1977) found that yogurt cultures passed through unchanged but caused significant increases in *Bifidobacterium* species in the intestine. Use of yogurt in aiding the regeneration of gut flora after destruction by antibiotics therapy has been reported (Halden, loc. cit.).

Yogurt itself has been reported to have antibacterial effects on pathogens resistant to standard antibiotics (Yazicioglu and Yilmaz, 1966). *L. bulgaricus* has been shown to have antibacterial activity (Singh and Laxminarayana, 1973) and to contain a broad spectrum antibiotic 'bulgarican' (Reddy and Shahani, 1971; Shahani et al., 1976). Other workers have however been unable to observe significant antibacterial activity in cultures of *L. bulgaricus*. Spillman et al. (1978) surveyed ten *L. bulgaricus* strains isolated from commercial yogurt and some collection strains of this organism and concluded that lactic acid was the only antimicrobial agent active against the test pathogens. A similar conclusion was reached by Rubin (1977). Todorov (1962) and Mel'nikova and Koreleva (1975) reported that both *S. thermophilus* and *L. bulgaricus* produced substances which were inhibitory to *Salmonella* and *Escherichia coli* with *L. bulgaricus* being considerably stronger than *S. thermophilus*. These reports suggested the involvement of lactic acid in the antimicrobial action. However, Shahani et al. (1976) found that lactic acid used singly or in combination with other metabolites did not exhibit any inhibitory activity against ten test pathogenic bacteria.

Pulusani et al. (1979) observed antimicrobial activity in skim milk cultures of both *L. bulgaricus* and *S. thermophilus*. Methanolacetone extracts of the *S. thermophilus* cultures showed activity against a range of

TABLE 10. *Influence of deoxycholic acid on yogurt bacteria.*[a]

Organism	Initial cell count	Viable cell count after incubation at 37 C for 1 min. .5	1 min. .1	1 min. .01[b]	60 min. .5	60 min. .1	60 min. .01[b]
S. thermophilus	5.3×10^8	-[c]	(-)[d]		-	-	
L. bulgaricus	8.0×10^8		-	(-)		-	-
L. acidophilus	4.9×10^8		-	(-)		-	-

[a]After: Lembke (1964).
[b]Concentration (%) of deoxycholic acid.
[c]- No growth.
[d](-) Weak growth.

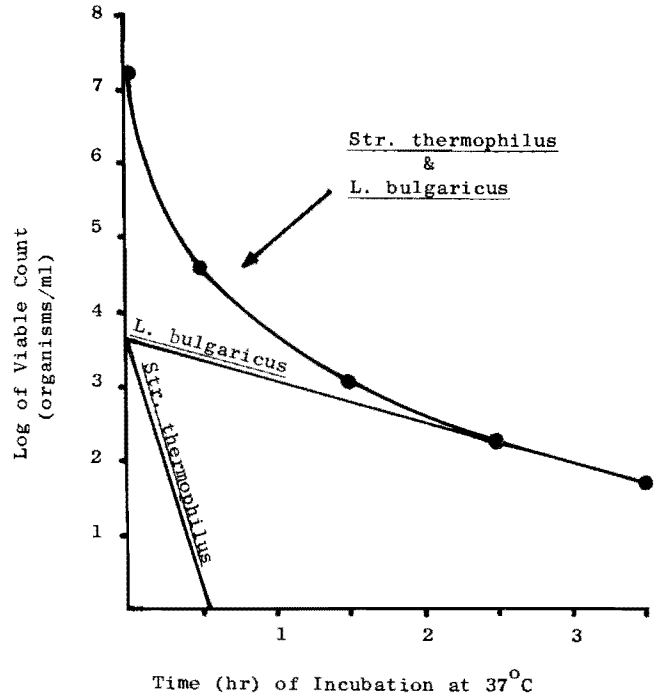

Figure 1. *Relationship between log of viable count and time of incubation of the starter culture in yogurt at pH 2. After: Acott and & Labuza [loc. cit.]*

test organisms including *Salmonella, Shigella, E. coli* and *Pseudomonas* species. Gel chromatography of the extracts on Sephadex G-10 yielded three partially purified fractions of molecular weights around 700 daltons. The authors concluded that the active substances were most likely heat-stable, low molecular weight amines. Further studies need to be carried out in this area to elucidate the structure of these antimicrobial agents.

Coronary heart disease

In view of the current interest in the relationship between diet, blood cholesterol levels and coronary heart disease, reports of the hypocholesterolemic effects of yogurt are noteworthy (Mann and Spoerry, 1974; Mann, 1977; Hepner et al., 1979). Mann and Spoerry (loc. cit.), in a study on cholesterolemia in the Maasai, observed a hypocholesterolemic effect in tribesmen who consumed large quantities (up to 8.33 1/man/day) of milk fermented with a wild *Lactobacillus* culture. Hypocholesterolemic effects have also been reported for unfermented milk in man (Howard and Marks, 1977) and rats (Nair and Mann, 1977; Malinow and McLachlin, 1975). A recent review was devoted to this topic (Richardson, 1978). However, in the report by Hepner et al., (loc. cit.), yogurt was shown to have a greater hypocholesterolemic effect than 2% fat milk.

There have been several suggestions regarding the reason for the hypocholesterolemic effect of yogurt. Mann (loc. cit.) showed that conversion of acetate to cholesterol was inhibited and suggested that the presence of hydroxymethylglutarate in yogurt may inhibit cholesterol synthesis. Calcium (Howard, 1977), orotic acid (Bernstein et al., 1976), lactose (Marks and Howard, 1977) and casein (Carroll and Hamilton, 1975; Hepner et al., loc. cit.) have all been suggested as possible hypocholesterolemic factors. Speck (1976) suggested that the large numbers of *Lactobacillus* organisms in fermented milks could cause deconjugation of bile salts in the small intestine with consequent fecal excretion of bile acids and a lowering of the body sterol pool. In the work of Hepner et al. (loc. cit.), heat-treated yogurt and 'live yogurt' were found to exert similar effects. It therefore appears that yogurt contains either a heat-stable enzyme system or a bacterial metabolite which is not present or present in lower amounts in milk which causes this hypocholesterolemic effect.

Other therapeutic uses

Yogurt has been reported to be useful for individuals with allergies to milk proteins since yogurt proteins have a reduced allergenicity (Niv et al., loc. cit.; Davis, 1975a and b). Other interesting therapeutic uses of yogurt include its use in the treatment of non-specific vaginal discharge (Gunston and Fairbrother, 1975) and its inhibitory effect on proliferation of some tumor cells (Reddy et al., 1973; Farmer et al., 1974 and 1975). *L. bulgaricus* was found to be more inhibitory than *S. thermophilus*, and heating was found to destroy the inhibitory properties of the cells. The nature of the inhibitory compound is not known.

Yogurt is a particularly rich source of calcium. Sufferers of lactose intolerance who cannot drink milk often develop osteoporosis as a result of a deficiency of dietary calcium. Since lactose intolerants can tolerate yogurt, this product is useful for alleviating calcium deficiency (Kroger, loc. cit.). It is also a useful source of calcium for middle-aged women who often suffer bone deformity during and after menopause due to calcium deficiency. Dupuis (1964) studied the efficiency of absorbance and retention of calcium in rats fed yogurt and rats fed normal balanced diets containing calcium in other forms. She found that the calcium supplied by the yogurt was better absorbed and utilized than the calcium in the normal balanced diets.

Possible detrimental effects

A few detrimental effects of yogurt have been noted. Richter and Duke (1970) observed that rats fed an exclusive diet of yogurt developed cataracts, an effect they attributed to the galactose content of the yogurt. It was subsequently pointed out (Anon, 1970) that the results were not applicable to humans as the rats consumed abnormally large amounts of yogurt and yogurt was their sole food. It has been suggested that the galactose may cause a small number of people to develop galactosemia though the effect is considered of minor importance. Galactosemia occurs in children with a rare congenital condition characterized by the absence of galactose uridyltransferase but these children do not usually live to maturity (Macdonald, 1978).

Yogurt may have a cariogenic effect if the residence time in the mouth is prolonged. However this is considered unlikely as the flow of alkaline saliva quickly

removes the lactic acid from the teeth. Furthermore, since yogurt does not adhere to the teeth it does not induce formation of plaques which harbor cariogenic bacteria (Newman, 1974). Frostell (1970) examined the effects of milk, sour milk and other beverages on the pH of dental plaques and concluded that milk and sour milk are only slightly or not at all cariogenic with sour milk being marginally better than milk. These and other results have suggested that yogurt may in fact inhibit lactic acid production by these bacteria. No work has been reported on the cariogenic effect of sweetened yogurt though this product could be expected to have an effect similar to other foods containing sugar.

CONCLUSION

Traditional yogurt is expected to maintain its place in the food market for its nutritive, organoleptic and possibly therapeutic qualities. In addition, certain dietary yogurts may be introduced. These may have reduced lactose levels (Tamime, loc. cit.) low energy values (low total solids levels and added stabilizers) (Buchanan, 1968), added *L. acidophilus* (Davis, 1970) of bifidobacteria (Kisza et al., 1978), low lactic acid, highly digested protein, added minerals, e.g. iron and fluoride and vitamins (Davis, 1970) or added polyunsaturated vegetable oils (Pokrovskii et al., 1974; Davis, 1973).

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Calendar

Feb. 2-4---LAW AND THE FOOD INDUSTRY. Three-day class sponsored by Extension Service, University of California-Davis. Contact: University Extension, University of California, Davis, CA 95616, 916-752-0880.

Feb. 3-4---FOOD PROCESSORS-SANITATION WORKSHOP. Mission De Oro, Santa Nella, CA. Contact: Paulette De Jong, Food Science and Technology, University of California, Davis, CA 95616, 916-752-1478.

Feb. 10-11---70th ANNUAL OREGON DAIRY INDUSTRIES CONFERENCE. Valley River Inn, Eugene, OR. Contact: Mary K. Moran, ODI Secretary, Dept. of Food Science Room 100, Wiegland Hall, Oregon State University, Corvallis, OR 97331, 503-754-3131.

February 11-12--DAIRY AND FOOD INDUSTRY CONFERENCE. The Ohio State University. Contact: John Lindamood, Dept. of Food Science and Nutrition, 2121 Fyffe Road, The Ohio State University, Columbus, OH 43210.

Feb. 15-18---NATIONAL MASTITIS COUNCIL MEETING. Executive Inn, Louisville, KY. Contact: John Adams, NMC, 30 F Street NW, Washington, DC 20001.

Feb. 23-25---1981 EDUCATIONAL CONFERENCE FOR FIELDMEN AND SANITARIANS. Ramada Inn, Hurstborne Lane, Louisville, KY. Contact: W. Dale Marcum, 239 Woodhill Lane, Frankfort, KY 40601.

Feb. 23-25--SENSORY EVALUATION METHODS. Atlanta, GA. Shortcourse sponsored by IFT. Fee: $200. Hotel Reservations: Hyatt Regency Hotel, 265 Peachtree St. NE, Atlanta, GA 30303. Registration: Institute of Food Technologists, 221 N. LaSalle St., Chicago, IL 60601.

Feb. 24-25---DAIRY INDUSTRY WORKSHOP, sponsored by Virginia Association of Sanitarians and Dairy Fieldmen. Donaldson Brown Continuing Education Center, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, Contact: W. J. Farley, Secretary-Treasurer, AVSDF, Rt. 1, Box 247, Staunton, VA 24401.

Feb. 23-March 6---ADVANCED MICRO-ANALYTICAL SANITATION. Two-week course, sponsored by American Association of Cereal Chemists. Course will be held at O'D . Kurtz Associates, Inc., Melbourne, FL. Fee: $1000. Contact: Ruth Nelson, Short Course Coordinator, AACC, 3340 Pilot Knob Road, St. Paul, MN 55121, 612-454-7250; or James W. Gentry, O'D. Kurtz Associates, Inc., 2411 S. Harbor City Blvd., Melbourne, FL 32901, 305-723-0151.

March 4---SOUTHERN CALIFORNIA FOOD PROCESSORS SANITATION WORKSHOP. Inn at the Park, Anaheim, CA. Contact: Paulette De Jong, Food Science and Technology, University of California, Davis, CA 95616, 916-752-1478.

March 10-11---NEW YORK STATE CHEESE MANUFACTURERS' ASSOCIATION, ANNUAL CONFERENCE. Hotel Syracuse, Syracuse, NY. Contact: D. K. Bandler, 11 Stocking Hall, Cornell University, Ithaca, NY 14853.

March 11-13---PRACTICAL STATISTICAL METHODS FOR THE FOOD, DRUG AND COSMETIC INDUSTRIES. Holiday Inn, Mundelien, IL. Sponsored by Northeastern Illinois Section and the Food, Drug and Cosmetic Division, American Society for Quality Control. Contact: Keith Bitzinger, Abbott Laboratories, Dept. 916, Abbott Park, North Chicago, IL 60064, 312-937-4975.

March 23-27---MOLDS AND MYCOTOXINS IN FOODS. Short course sponsored by American Association of Cereal Chemists and the University of Minnesota. Course will be held at Coffey Hall, 1420 Eckles Ave., Univesity of Minnesota, St. Paul, MN 55108. Course fee: $375. Contact: Ruth Nelson, Short Course Coordinator, AACC, 3340 Pilot Knob Road, St. Paul, MN 55121, 612-454-7250, or Office of Special Programs, 405 Coffey Hall, 1420 Eckles Ave., University of Minnesota, St. Paul, MN 55108, 612-373-0725.

March 23-25 AMERICAN CULTURED DAIRY PRODUCTS INSTITUTE ANNUAL TRAINING SCHOOL AND JUDGING CONTEST. El Tropicano Hotel, San Antonio, TX. Contact: C. Bronson Lane, ACDPI. PO Box 7813, Orlando, FL 32854.

March 25-27---SOUTHEASTERN REGIONAL LABORATORY DESIGN SEMINAR. Atlanta, GA. Fee: $400. Contact: Norman V. Steere & Associates, Inc., 140 Melbourne Ave., SE, Minneapolis, MN 55414, 612-378-2711.

May 13-15---3A SANITARY STANDARDS COMMITTEE MEETINGS. Galt House, Louisville, KY. Contact: Harold Thompson, DFISA, 5530 Wisconsin Ave., Room 1050, Washington, DC 20015.

May 18-21---INTERSTATE MILK SHIPPERS CONFERENCE. Hot Springs, AK. Contact: Herb Vaux, Indiana State Board of Health, 1330 W. Michigan St., Indianapolis, IN 46206.

June 7-10---IFT 81, 41st ANNUAL MEETING AND FOOD EXPO. Institute of Food Technologists. World Congress Center, Atlanta, GA. Contact: IFT, Suite 2120, 221 North LaSalle St., Chicago, IL 60601, 312-783-8424.

June 21-24---24th ANNUAL CANADIAN INSTITUTE OF FOOD SCIENCE AND TECHNOLOGY. Theme: "Research: Whose Business?" Winnipeg Convention Centre/ Holiday Inn, Winnipeg, Manitoba, Canada. Contact: Barry McConnell, Conference Chairman, Dept. of Food Science, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2.

Aug. 17-21---21st ANNUAL MEETING, HOSPITAL, INSTITUTION & EDUCATIONAL FOOD SERVICE SOCIETY. Houston, TX. Contact: HIEFSS, 4410 West Roosevelt Road, Hillside, IL 60162.

Nov. 15-19---FOOD AND DAIRY EXPO '81, Dairy and Food Industries Supply Association. World Congress Center, Atlanta, GA Contact: Fred Greiner, DFISA, 5530 Wisconsin Ave., Room 1050, Washington, DC 20015.