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PII: S0958-6946(98)00096-X

Int. Dairy Journal 8 (1998) 599–607

Printed in Great Britain
0958-6946/98/$ – see front matter

Review Paper

Lactobacillus acidophilus and Yogurt in the Prevention and Therapy of Bacterial Vaginosis

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(Received 18 February 1998; accepted 30 June 1998)

ABSTRACT

In the vaginas of women different microorganisms can be found, among others also lactic acid bacteria. These bacteria form an acid milieu that can protect the woman from a vaginal infection. After genital infection the proportion of microorganisms is changed; the numbers of pathogenic organisms such as *Candida*, *Gardnerella* and/or *Trichomonas* increase, the number of lactobacilli decrease. Several studies show that direct application of *Lactobacillus acidophilus* or yogurt in the vagina can be therapeutically useful. There are now some indications that the ingestion of dairy products fermented by *Lactobacillus acidophilus* might also have a therapeutic benefit. © 1998 Elsevier Science Ltd. All rights reserved

Keywords: lactic acid bacteria; yogurt; fermented dairy product; *Lactobacillus acidophilus*; vaginitis; woman

INTRODUCTION

Numerous studies have shown that the vagina of a healthy woman is populated by a variety of microorganisms. The physiological condition of the vagina changes and so do the different microorganisms during a woman's life. The relationship between these organisms is delicately balanced and offers protection against infections of the vagina. When this balance is impaired a woman is at risk of contracting a genital infection. It seems that infection is not only a question of the increasing number of pathological germs but also of the decreasing number of lactobacilli. There is substantiate evidence that a vaginal infection is more likely to be triggered by the decreasing number of lactobacilli leading to relative predominance of pathological organisms.

This article reviews the literature with the emphasis on possibilities of treating vaginal infections with *Lactobacillus* (*L.*) *acidophilus* or with dairy products that are produced with this organism. In an investigation concerning the use of over-the-counter preparations and alternative medicine in women with chronic vaginal symptoms, Nyirjesy *et al.* (1997) showed that 44 of 105 patients had used alternative medications, most frequently acidophilus pills (50% orally, 11.4% vaginally) or yogurt (20.5% orally, 18.2% vaginally).

DEFINITION AND EPIDEMIOLOGY OF BACTERIAL VAGINOSIS

Almost 40 years ago Gardner and Dukes (1955) first described a non specific infection of the vagina, with a fishy smell and discharge. They named this infection after the organism that caused 'Haemophilus vaginalis vaginitis'. Because this organism was not only found in women with the typical signs of this infection but also in women who had neither any symptoms nor were sexually active, controversial discussions about the pathological consequences of this disease took place over years. Due to its unstable gram staining the germ was titled '*Corynebacterium vaginale*' (Zinneman and Turner, 1963) but in 1980 it was renamed in the honor of Gardner '*Gardnerella vaginalis*', because its genus belonged neither to *Haemophilus* nor to *Corynebacterium* (Greenwood and Pickett, 1980). To date, the controversy continues, because numerous (especially anaerobic) microorganisms are involved in the bacterial vaginosis. Names like unspecific colpitis, amincolpitis, Gardnerella vaginitis, Gardners vaginitis, anaerobic vaginosis show the attempt to define this disease in a better way. In this article we will use the name Bacterial vaginosis (BV) (Hoyme and Eschenbach, 1985) which is defined as follows. A thin, homogeneous, greyish-white discharge, an elevated vaginal pH (more than 4.5), the occurrence of 'clue cells' (Gardner and Dukes, 1955) on microscopic examination of vaginal smears and intensified fishy smell after adding 10% KOH (liberating amines) to vaginal fluid specimens.

BV is a very common disease that occurs in about 10–30% of all patients, visiting a sexually transmitted disease clinic (Hallen *et al.*, 1987; Pahlson and Larsson, 1991). In a longitudinal study, BV was found in 87 of 780 pregnant women. After 36 gestational weeks only three of 176 women, that had atypical vaginal flora, developed BV and 32 women with BV recovered from the disease, showing a normal flora at the end of pregnancy (Hay *et al.*, 1994).

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Epidemiologic literature about BV is devoid of a good representative study about the prevalence of BV. All we seem to know so far is that 30–70% of all women suffering from BV show no symptoms. Whether the elevated prevalence in black people is of genetic origin, depends on smoking behavior, sexual behavior or circumcision, is not clear yet. Using an IUD seems to favor the development of BV (Mead, 1993).

THE PHYSIOLOGICAL AND PATHOLOGICAL VAGINAL ECOSYSTEM

The vaginal microbial flora of a healthy woman

The human vagina is lined by stratified, squamous, nonkeratinized epithelium. The surface is multilayered and the middle and the superficial layers contain glycogen. There are no glands that produce mucus, but the vaginal secretion arises predominantly from transudation of the vaginal epithelium and from the cervical mucus (Paavonen, 1983). The glycogen that is set free by the breakdown of the superficial cells is fermented by enzymes that are secreted by epithelial cells as well as by lactobacilli (Tindall, 1987). This fermentation liberates glucose which is then metabolized to lactic acid. In the last century Döderlein (1894) found the lactobacilli which he described as gram-positive, catalase negative, nonsporing rods. They were named Döderlein-Bacilli and then identified by Thomas (1928) as *L. acidophilus*. Many authors have isolated *L. acidophilus* from the vagina (Butler and Beakley, 1960; Eschenbach *et al.*, 1989; Kohlmeyer *et al.*, 1994; Lachlak *et al.*, 1996; Lock *et al.*, 1948; McGroarty *et al.*, 1992; Reid *et al.*, 1996; Rogosa and Sharpe, 1980; Sautter and Brown, 1980). Besides *L. acidophilus* other strains could be found in the vaginas of healthy women as shown in Table 1.

Eschenbach *et al.* (1989) identified, in 27 of 28 healthy women, populations of lactobacilli that were able to produce hydrogen peroxide (H_2O_2). The ability to produce this substance may contribute to disease prevention by interference with pathogens. Lactobacilli producing H_2O_2 were found in almost 75% of the strains tested (McGroarty *et al.*, 1992) while Reid *et al.* (1996) found 84% positive strains. It seems that women colonized by H_2O_2-producing lactobacilli are protected against acquisition of BV (Hawes *et al.*, 1996; Puapermpoonsiri *et al.*, 1996).

Beside lactobacilli there are a variety of other microorganisms in the vagina. In 107 samples Thomas (1928) found *Staphylococcus, Diphteroides, B. coli, Streptococcus* and *Sarcina*. Sautter and Brown (1980) identified 37 different organisms in sequential vaginal cultures.

The vaginal microbial form of women with bacterial vaginosis

In women suffering from BV many different organisms are found (Hill, 1993; Hillier, 1993) i.e. *Gardnerella vaginalis* (Eschenbach *et al.*, 1989; Fredricsson *et al.*, 1984; Pheifer *et al.*, 1978; Spiegel *et al.*, 1980), *Acteroides* sp. and *Mycoplasma hominis* (Eschenbach *et al.*, 1989; Spiegel *et al.*, 1980), *Gardnerella vaginalis, Bacteroides, Ureaplasma urealyticum* (Roy *et al.*, 1994) and *Candida* (Hurley *et al.*, 1974; Sobel, 1993; Geiger *et al.*, 1995). Döderleinbacilli could be shown in 14 of 44 women with a moniliavaginitis, in nine of 47 women with an unspecific vaginitis, but not in 11 women with *Trichomonas* and in seven women with *Monilia* and *Trichomonas* infection (Butler and Beakley, 1960) and in women with *Gonococcus* infection (Thomas, 1928). Furthermore, *Gardnerella vaginalis* infection did not include lactobacilli (Wood *et al.*, 1985). Only four of 67 patients with *Gardnerella vaginalis* showed H_2O_2 producing lactobacilli, but in 24 of them anaerobic lactobacilli were found (Eschenbach *et al.*, 1989). *Candida albicans* is able to produce an immuno-suppressive mycotoxin called gliotoxin (Shah *et al.*, 1995a).

Table 1. Lactobacillus Species Identified from the Vaginas of Healthy Women

Species	No. of women with indicated species				
N:	100	100	63	100	53
Reference:	A[a]	A[b]	B	C	D
L. acidophilus	42	55	13	24	20
L. jensenii	8	12	22	35	7
L. fermentum	16	17	0	0	7
L. casei	6	13	15	18	0
L. gasseri	0	0	3	13	0
L. brevis	26	0	1	0	2
L. plantarum	1	0	2	1	23
L. rhamnosus	0	0	0	0	2
L. cellobiosus	0	0	0	1	0
L. crispatus	0	0	0	3	0
L. delbrueckii	1	3	0	0	0
None	0	0	2	4	6

[a] Black women.
[b] White women.
References:
A: Kohlmeyer *et al.* (1994).
B: McGroarty *et al.* (1992).
C: Reid *et al.* (1996).
D: Fontaine *et al.* (1996).

In pregnant women with vaginal infection Westney *et al.* (1994) found *Gardnerella vaginalis* (50%), *Streptococcus* B (43.7%), *Candida albicans* (37.4%), *Trichomonas vaginalis* (13.4%), *E. coli* (6.2%); Hay *et al.* (1994) identified *Mycoplasma hominis* (43.6%) and *Gardnerella vaginalis* (44.9%) and Thorsen *et al.* (1998) described *Gardnerella vaginalis* and anaerobic bacteria and/or *Mycoplasma hominis* (59.6%). Hillier *et al.* (1992) isolated H_2O_2 producing lactobacilli in 10 out of 67 pregnant women with a BV and in 177 of 199 without a BV.

It seems that a BV is almost always an infection with *Gardnerella vaginalis* and a variety of different anaerobic bacteria. Most probably there is an unknown synergism between different microorganisms that is responsible for the increasing number of these specific bacteria. Chen *et al.* (1982) found that the succinate produced by *Gardnerella vaginalis* might increase the number of these other bacteria.

THERAPY OF BV WITH *LACTOBACILLUS ACIDOPHILUS*

Metchnikoff (1907) was the first to propose the use of lactobacilli for the restoration of a physiological

microbial flora in the gastrointestinal tract. There are studies showing that urinary infections and diarrhea can be treated with lactobacilli (Reid *et al.*, 1990). *L. casei* var. *rhamnosus* was able to prevent urinary infections in rats that had uropathogenic bacteria applied into the bladder (Reid *et al.*, 1985). Also, in women with recurrent urinary infections, *L. casei* GR-1 proved effective after vaginal and perineal implantation (Bruce and Reid, 1988). The effect of *L. casei* GR-1 and *L. acidophilus* 76 on *E. coli* is not due to lactic acid or H_2O_2 but to an unknown substance with a molecular weight between 12,000 and 14,000 (McGroarty and Reid, 1988; Reid *et al.*, 1988).

There are two different methods in the treatment with lactobacilli: The vaginal application and the oral intake of dairy products containing *L. acidophilus.*

STUDIES WITH VAGINAL APPLICATION OF LACTOBACILLI OR FERMENTED DAIRY PRODUCTS

Löser (1920) tried to restore a normal vaginal flora by the application of lactobacilli. Oliveira (1956) reported that in 49 infections with BV the symptoms disappeared and the pH changed from 5 to 6 to less than 4, after *L. acidophilus* application. Similar results were published by Rindi (1955). Twenty patients with chronic moniliasis showed an improvement of their symptoms after treatment with *L. acidophilus* (Will, 1979). Sandler (1979) also noticed improvement in women suffering from moniliasis after they were treated with lyophilized *L. acidophilus* products together with yogurt.

Mohler and Brown (1933) published a study where six of 21 women improved and nine women fully recovered after application of *L. acidophilus.* Exogenous application of Döderlein-bacilli was successful in 18 of 19 cases with unspecific vaginitis, in 22 of 25 cases with *Monilia* vaginitis, in seven of eight *Trichomonas* infections and in six with a combined *Trichomonas* and *Moniliasis* infection (Butler and Beakley, 1960). Comparable results were achieved by Ostrzenski (1974). More than 80% of 239 patients studied by Kanne *et al.* (1986) recovered from a *Moniliasis* vaginitis and stayed free of the disease when using vaginal tablets containing 50 mg lyophilisate of *L. acidophilus* (10^7–7×10^8), 0.03 mg estriol and 600 mg lactose. In two double blind, placebo-controlled clinal trials 28 women (Hallen *et al.*, 1992) and 32 nonmenopausal women with BV (Parent *et al.*, 1996) were treated with lyophilized H_2O_2-producing *L.acidophilus.* Immediately after completion of the treatment, 16 had normal vaginal wet smear results, compared to none of the 29 women treated with placebo (Hallen *et al.*, 1992). Four weeks after the start of therapy with vaginal tablets (Gynoflor), the cure rate was 88% in the verum group and 22% in the placebo group (Parent *et al.*, 1996). In a further double-blind, randomized, placebo-controlled trial with 167 patients, the vaccination with Gynatren, a *L. acidophilus* vaccine, was significantly better than the placebo (Siboulet, 1991) confirming the results of former studies (Karkut, 1984; Müller and Salzer, 1983). In a female with multiple vaginal infections a pessary containing freeze-dried *L.casei* var. *rhamnosus* GR-1 was inserted in the vagina. The patient came vaginitis symptom-free (Reid *et al.*, 1994).

Beside the application of lactobacilli, fermented dairy products were also used. Orlowa and Tomashewitch (1933) used skim milk with *Bacillus bulgaricus.* Treating 25 women who suffered from vaginal discharge with 3 mL yogurt, Gunston and Fairbrother (1975) achieved good results in women with unspecific vaginitis, but had no success when treating *Trichomonas* vaginitis. No effect was observed in women suffering from *Trichomonas* and *Candida,* but in 29 of 38 women with BV the vaginal flora was restored (Friedlander *et al.*, 1986). Collins and Hardt (1980) studied 30 patients with *Candida* infection, comparing vaginal implantation of yogurt, low-fat milk and non-fermented acidophilus milk. They obtained conflicting results: there were three reinfections within three months with no milk product, one with yogurt, one with non-fermented acidophilus milk and 0 with low-fat milk. In a study of 84 women, in their first trimester of pregnancy and suffering from BV, 32 were treated with *L. acidophilus,* 32 with 5% acetic acid and 20 served as a control group. 28 women of the *L. acidophilus* group and 12 of the acetic acid group returned to normal flora, whereas only one of the control group showed no evidence of disease after two months of treatment (Neri *et al.*, 1993). In another study three days after administration of yogurt in 11 women with BV all strains of Gram-negative bacteria disappeared (Chimura *et al.*, 1995). However, Fredricsson *et al.* (1987, 1989) had found only one out of 14 women showing a normal vaginal flora after treatment with a *L. acidophilus* fermented dairy product.

STUDIES WITH ORAL APPLICATION OF YOGURT CONTAINING *L. ACIDOPHILUS*

Hilton *et al.* (1992) studied the efficacy of yogurt containing *L. acidophilus* for the treatment of *Candida* infection. They chose 33 women suffering from *Candida* vaginitis and divided them into two groups. The first group received 240 grams of yogurt daily for six months followed by six months of no treatment. The second group started with no treatment and continued with the yogurt for the other half of the year; thus each woman served as her own control. Eight of the 13 patients finishing the study suffered from a chronic vaginitis, three women had five *Candida* infections and two women had between six and eight infections per year. The colonization of the vagina with lactobacilli and *Candida* was measured and the *Candida* infection was evaluated clinically. As can be seen in Table 2, the control group had significantly more infections and it had less *L. acidophilus* in the faeces and in the vagina than the control group. Unfortunately, the study was not double-blinded. Drutz (1992) pointed out that in future studies an appropriate control would be the pasteurized version of the same yogurt. He tried to explain the results of Hilton's study as follows. *L. acidophilus* may have displaced *Candida* ssp. normally residing in the gastrointestinal tract and may have colonized the vagina from there, subsequently inhibiting colonization of *Candida* ssp. by its competing presence in the vagina.

In a crossover trial Shalev *et al.* (1996) compared daily ingestion of 150 mL of yogurt containing live *Lactobacillus acidophilus* with 150 mL of pasteurized yogurt in 46 women with recurrent BV and candidal vaginitis. At least 28 patients participated during the first four months of

Table 2. Effect of Yogurt Containing *Lactobacillus acidophilus* on *Candida* Infections and Colonizations in Women with Vaginitis (Hilton *et al.*, 1992)

	Yogurt ($N = 6$)	Control ($N = 11$)	P value[a]
Mean number of infections per six months[b]	0.38 ± 0.51	2.54 ± 1.66	<0.001
Mean number of positive *Candida* colonizations per six months[c]	0.84 ± 0.90	3.23 ± 2.17	0.001

[a] Paired t-test.
[b] Defined by the presence of clinical vaginitis: Gram stain positive for yeast, pseudohyphae, an acidic vaginal pH, a positive culture for *Candida* species.
[c] Defined by vaginal culture positive for *Candida* species with no clicincal evidence of vaginitis.

the study and seven patients completed the entire study protocol. An increased prevalence of colonization of the rectum and vagina by the bacteria and reduced episodes of BV were found after the ingestion of yogurt enriched with live *L. acidophilus*. Lidbeck *et al.* (1987) suggested that *L. acidophilus* in fermented dairy product should be taken continuously in order to maintain high levels of lactobacilli in the intestine.

THE ORIGIN OF VAGINAL LACTOBACILLI

In a study to determine the origin of vaginal lactobacilli, Thomas (1928) fed *L. acidophilus* to two children in whom the organism was not present in the vagina or in the faeces before the study. After ingestion he could identify *L. acidophilus* in both places. The survival of lactobacilli in the gastrointestinal tract is dependent on the strain. *L. acidophilus* is most probably part of the physiological gastrointestinal flora (Bertazzoni Minelli *et al.*, 1993) and seems to survive better in the gastrointestinal tract than does *L. delbrueckii* ssp. *bulgaricus* (Bouhnik, 1993; Conway *et al.*, 1987; Gilliland *et al.*, 1978; Marteau *et al.*, 1992; Patel *et al.*, 1992). There is also a different behavior of *L. acidophilus* strains in the presence of acids and bile acids (Lankaputhra and Shah, 1995).

Lactobacilli must have a certain affinity to the intestinal mucosa to successfully colonize the gastrointestinal tract as it was shown for bifidobacteria (Bernet *et al.*, 1993), *L. acidophilus* (Bernet *et al.*, 1994; Chauvière *et al.*, 1992; Coconnier *et al.*, 1992; Conway *et al.*, 1987), *L. casei* GG (Elo *et al.*, 1991) and possibly *L. delbrueckii* ssp. *bulgaricus* (Conway *et al.*, 1987). The same ability to attach to vaginal epithelial cells was shown by Wood *et al.* (1985). The ability of *Candida* ssp. to attach to vaginal cells is better at pH 6 than at pH 3–4. When vaginal cells were first incubated with lactobacilli and later with *Candida* ssp. far less *Candida* ssp. were able to attach to the cells (Sobel *et al.*, 1981). The mechanisms for this attachment are not yet clearly understood, but proteins, lipoteichoic acid or carbohydrates might be responsible (Andreu *et al.*, 1995).

THE ROLE OF MAINTENANCE OF A PHYSIOLOGICAL VAGINAL FLORA BY LACTOBACILLI

The vagina is protected by lactobacilli because they maintain an acidic environment or because they produce substances that inhibit the activity of other microorganisms. This inhibition is ascribed to lactic acid (Tramer, 1966), hydrogen peroxide (Wheather *et al.*, 1952) and bacteriocins (Pheifer *et al.*, 1978; Piard *et al.*, 1992; Tramer, 1966). After a treatment of the vagina with a low-pH lactate gel a *Lactobacillus*-dominated flora reappeared in 10 pregnant women with BV (Holst and Brandberg, 1990).

It seems that not only the pH but also the lactobacilli are responsible for a protective milieu in the vagina. Neri *et al.* (1993) described a higher success rate in pregnant women treated with yogurt than with acetic acid. A low pH is due to lactobacilli producing lactid acid by metabolizing glycogen (Wylie *et al.*, 1969). The glycogen is converted by enzymes as well as by lactobacilli liberating glucose which is then metabolized to lactic acid (Spiegel *et al.*, 1980). The treatment of bacterial vaginosis by local application of lactobacilli reduced the symptoms in only 12 of 32 cases, compared with metronidazol® and placebo, which led to an improvement in 29 of 37 and in 11 of 32 cases respectively (Boeke *et al.*, 1993).

Besides a low pH, the hydrogen peroxide production of lactobacilli seems to be an additional mechanism that regulates the growth and composition of the vaginal flora (Eschenbach *et al.*, 1989). Together with flavoproteins, the oxygen is converted to hydrogen peroxide that is able to inhibit the growth of other microorganisms (Dahiya and Speck, 1968). It is of great importance to note that not all *L. acidophilus* strains are able to produce hydrogen peroxide. In a study by Fitzsimmons and Berry (1994), only nine of 12 strains were able to do so. This is congruent with observations made by Eschenbach *et al.* (1989), who found strains that produced hydrogen peroxide in 6% of affected women and in 96% of healthy women. In a study performed with 275 pregnant women the incidence of H_2O_2-producing lactobacilli was 60% (Hillier *et al.*, 1992). These strains are able to inhibit the growth of *Gardnerella* ssp. and *Bacteroides bivius*. That the hydrogen peroxide is responsible for this inhibition was shown by in vitro studies that also investigated the influence of inhibitors (Table 3).

Other *in vitro* studies showed that *L. acidophilus* or *L. casei* ssp. *casei* inhibited the growth of *E. coli* (Kotz *et al.*, 1990; Tramer, 1966), *Mobiluncus mulieris* and *Gardnerella* ssp. (Mardh and Soltesz, 1983; Skarin and Sylwan, 1986) or the growth of *Mobiluncus mulieris* and *Gardnerella* ssp. (Skarin and Sylwan, 1986). *Candida albicans* was not inhibited by coagulase-negative staphylococcus (Nezdarilova, 1992) or by a substance in the filtrates of *L. acidophilus* (Guillot, 1958; Collins and Hardt, 1980) or by *L. acidophilus*. Further, when additional thiocyanate was given, *L. acidophilus* was able to inhibit *Candida albicans* (Fitzsimmons and Berry, 1994). *L. acidophilus* shows an antibacterial activity (Vincent *et al.*, 1959), can produce superoxide dismutase (Gonzalez *et al.*, 1991), hydrogen peroxide (Collins and Aramaki, 1980) as well as different bacteriocins as acidocin (Brink *et al.*, 1994; Shahani *et al.*, 1977; Tahara *et al.*, 1992, 1996), acidophillin (Shahani *et al.*, 1977), acidophilucin A (Toba *et al.*, 1991),

Table 3. Growth Inhibition of *Gardnerella vaginalis* and *Bacteroides bivius* by H_2O_2-producing *L. acidophilus*: Influence of Inhibitors (Klebanoff *et al.*, 1991)

Supplement	*Gardnerella vaginalis* viable cell count cfu $\times 10^6$ mL^{-1}	P^a	*Bacteroides bivius* viable cell count cfu $\times 10^6$ mL^{-1}	P^a
Control	2.31		8.3	
LB^+ (4×10^6 resp. 7×10^5)	0.015	<0.01	0.0002	<0.001
+ Catalase	1.82	ns	3.7	ns
+ Heated catalase	0.013	<0.05	0.0	<0.001
+ SOD	0.006	<0.02	0.0	<0.001
LB^-(4×10^6)	1.52	ns	2.8	ns
LB^+(2×10^5) + MPO + Cl^-	0.0006	<0.001		
− LB^+	2.58	ns		
− MPO	1.36	ns		
− Cl^-	1.74	ns		
+ Catalase	1.02	ns		
+ Heated catalase	0.005	<0.002		
+ SOD	0.005	<0.002		
− LB^+, + LB^-	1.33	ns		
− LB^+, + H_2O_2	0.0	<0.001		

LB^+ = H_2O_2-generating *L. acidophilus*.
LB^- = non-H_2O_2-generating *L. acidophilus*.
+ = added; − = omitted.
SOD = superoxide dismutase.
MPO = myeloperoxidase.
ns = not significant.
[a] Difference from control.

Table 4. Microbiology of Different Lactobacillus Products Found on the American Market (Hughes and Hillier, 1990)

Product	Advertised content	Lactobacilli isolated			Other bacteria isolated	
		Species	H_2O_2 prod.	Quantity (cfu g^{-1})	Species	Quantity (cfu g^{-1})
Yogurt	Not applicable	*L. delbrueckii* ssp. *bulgaricus*	+	ND	None	ND
	Not applicable	*L. delbrueckii* ssp. *bulgaricus*	+	ND	None	ND
	Not applicable	*L. delbrueckii* ssp. *bulgaricus*	+	ND	None	ND
Acidophilus milk	*L. acidophilus*	*L. acidophilus*	−	ND	None	ND
	L. acidophilus	*L. acidophilus*	+	ND	*Str. mitis*, *Pseudomonas*	ND
Acidophilus powder	*L. acidophilus*	*L. casei* ssp. *rhamnosus*	+	10^6	*Clostridium sporogenes*, *E. faecium*	10^2, 10^5
	L. acidophilus, *L. bulgaricus*, *L. bifidum*, *L. thermophilus*, *L. salivarius*	*L. casei* ssp. *rhamnosus*	+	10^4	*E. faecium*	10^5
	L. acidophilus, *L. bifidum*, *Str. faecium*	*L. casei* ssp. *rhamnosus*	−	10^6	*E. faecium*	10^6
	L. acidophilus	*L. casei* ssp. *rhamnosus*	−	10^6	*E. faecium*	10^5
Acidophilus capsules	*L. acidophilus*, *L. bulgaricus*, *Str. thermophilus*	*L. acidophilus*	−	10^2	None	10^1
	L. acidophilus	*L. casei* ssp. *rhamnosus*	+	10^4	*E. faecium*	10^3
	L. acidophilus, *L. bulgaricus*, *Str. thermophilus*	*L. casei* ssp. *rhamnosus*	+	10^6	*E. faecium*	10^1
	L. acidophilus	*L. casei* ssp. *rhamnosus*	+	10^3	*E. faecium*	10^2
	L. acidophilus	*L. casei* ssp. *rhamnosus*	−	10^7	*E. faecium*	10^2
	L. acidophilus	*L. casei* ssp. *rhamnosus*	−	10^7	*E. faecium*	10^1
Acidophilus-tablets	*L. acidophilus*, *L. bulgaricus*	*L. acidophilus*	+	10^4	*E. faecium*	10^2

ND = Not done.

lactacin B and F (Barefoot and Klaenhammer, 1984; Muriana and Klaenhammer, 1991).

ABOUT THE MICROBIOLOGICAL COMPOSITION OF FERMENTED DAIRY PRODUCTS AND OTHER LACTOBACILLI PREPARATIONS

Sour dairy products introduced in world markets recently, may contain not only *L. delbrueckii* ssp. *bulgaricus* and *Str. thermophilus* but also *L. acidophilus* and/or bifidobacteria. Whether these products contain sufficient concentration of *L. acidophilus* at the time of consumption is not clear. A significant decrease of *L. acidophilus* in products stored for seven days at 5°C was shown (Gilliland and Speck, 1977b). In yogurt, only 50% of *L. acidophilus* survived a storage of 14 days at 5°C (Hull *et al.*, 1984). When the concentration was between 10^7 and 10^8 cfu mL^{-1}, there was no decrease within 30 days at 4°C. However, when the concentration was less than 10^5 cfu mL^{-1} there was a significant reduction in *L. acidophilus* in the same time (Shah *et al.*, 1995b).

Besides fermented dairy products many other *L. acidophilus* preparations are being marketed. In the US these are referred to as Megadophilus, Richidophilus, Mega Potency Acidophilus, Sensidophilus, etc. (Hughes and Hillier, 1990). Similar preparations can be found also in Europe, e.g. Gynophilus in Finland and Gynoflor E in Germany, Austria and Switzerland. These formulae contain not only *L. acidophilus*, but also estriol (0.03 mg) and lactose (600 mg).

Astounding results were published by Hughes and Hillier (1990) who were able to detect *L. acidophilus* in only two of 16 preparations. Only 10 preparations contained lactobacilli that were able to produce hydrogen peroxidase (Table 4). Similar observations were made by Gilliland and Speck (1977a) as well as by Hamilton-Miller *et al.* (1996). These results can be explained by the fact that 90% of the *L. acidophilus* lose their activity when the production is not carefully controlled (Klaenhammer, 1982).

CONCLUSION

The difficulties in the diagnosis and treatment of the bacterial vaginosis arise because the definition of the disease is still not clear and there are multitudes of different tests that are not validated. Therefore more effort should be made to define the disease and to standardize the tests.

Different case reports showed evidence that the therapy of bacterial vaginosis with lactobacilli and specially *L. acidophilus* might be effective. This therapy is already widely used (Drutz, 1992). Besides the topical application the ingestion of fermented dairy products with *L. acidophilus* also seems to be effective (Hilton *et al.*, 1992; Shalev *et al.*, 1996). The results of these investigations indicate that the dairy industry should produce fermented dairy products with *L. acidophilus* in sufficient concentrations (i.e. between 10^7–10^8 cfu mL^{-1}) and that these products should not be pasteurized after production. Studies have to be carried out to answer the question if every strain of *L. acidophilus* or other probiotic bacteria are advantageous and if H_2O_2-producing *L. acidophilus* are essential for the treatment of BV.

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