SENSITIVITY OR RESISTANCE DAIRY STARTER AND ASSOCIATED MICROORGANISMS TO SELECTED ANTIBIOTICS

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Abstract

Forty-two strains of mesophilic lactic streptococci, enterococci, lactobacilli, leuconostoc, staphylococci, and other dairy- and food-related microorganisms were tested for their sensitivity to 30 antibiotic and antimicrobial agents. Elliker's lactic agar served as the growth medium; incubation temperature and times were varied according to individual culture growth requirements. Commercially available multitipped sensitivity discs were used. Almost all the microorganisms investigated, except for *Streptococcus thermophilus*, exhibited definite resistance to eight different sulfonamides. Most of the strains of starter streptococci and *Lactobacillus bulgaricus* were sensitive to all 16 antibiotic or antimicrobial agents (included in this survey) used for mastitis control. Strains of *Leuconostoc dextranicum*, *Streptococcus faecalis*, *Streptococcus durans*, and *Brevibacterium linens* were less affected.

Many antibiotics are used routinely in mastitis therapy, although antibiotic residues are excreted into milk, thus creating problems *(5)*. Also, most residual antibiotics are quite heat resistant *(5)*. If antibiotics are present in milk for cheesemaking, for example, it is more than likely that they will inhibit starter growth, thus affecting product quality *(4)*. Difficuties created by the presence of antibiotics in milk and milk products have been thoroughly discussed *(6)*. Most investigations have used a limited number of antibiotics or microbial strains. Our survey, however, determines the effect of a large number of antibiotics on a considerable number of strains of starter and other microorganisms associated with the dairy and food industry. It is possible that this information also could be of help in classification, differentiation, or speciation of these microorganisms.

Materials and Methods

Bacterial cultures

Five strains were used of each of *Streptococcus lactis*, *Streptococcus cremoris*, *Streptococcus diacetilactis*, *Streptococcus thermophilus*, *Streptococcus durans*, and *Lactobacillus bulgaricus*. Only four strains of *Streptococcus faecalis* were employed. Also included were three strains of *Brevibacterium linens*, two of *Leuconostoc dextranicum*, and one each of *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Micrococcus varians*. Except for the *Brevibacterium linens* (Tryptic soy broth), all cultures were propagated in sterile, reconstituted nonfat dry milk.

Antibiotic sensitivity assays were conducted by using Elliker's lactic agar *(3)* at appropriate incubation temperatures.

Antibiotic agents

Commercially available Multidisks *(2)*, multitipped sensitivity discs manufactured by Colab Laboratories, Inc., Glenwood, Ill., were used.

Sensitivity test procedure. *(a)* Ten to 12 ml of sterile Elliker's lactic agar (pH 7.0) were poured into a level petri dish, solidified, and dried overnight at 37 C. *(b)* Two-tenths milliliter of actively growing bacterial culture was mixed with 7 ml of sterile, 45 C Elliker's agar and was poured onto each dried agar plate. *(c)* Antibiotic-impregnated Multidisks were then placed on each lawn of cells. *(d)* Inoculated agar plates, each with selected antibiotic discs, were incubated for specified periods at the appropriate growth temperature for each test organism: lactic streptococci, 32 C for 16 h; *Leuconostoc*, 32 C for 16 to 24 h; enterococci, lactobacilli, S. *thermophilus, and staphylococci*, 37 C for 16 h; *M. varians*, 28 C for 24 h; and *B. linens*, 21 C for 48 to 72 h. *(e)* Growth inhibition zones were measured from the tips of the antibiotic-impregnated discs to the edge of visible bacterial growth.

Results and Discussion

Interpretation of test results

Growth reactions to antibiotics when applied in two different concentrations were reported as: *sensitive*—a zone around the disc tip with the lower concentrations of antibiotic; *moderately sensitive*—a zone around the disc tip with higher concentration of antibiotic only; *resistant*—no zone around either disc tip.

Growth reactions to antibiotics applied in only a single concentration were reported as: *sensitive*—a zone around the disc tip; *resistant*—no zone around the disc tip.

Discussion of test results

Overall results are summarized in Tables 1 and 2. In both tables, the abbreviation "mcg" is used according to the manufacturer's designation instead of the more conventional symbol "μg." For full appreciation of the data with regard to mastitis therapy, note that 16 of the 30 agents listed are currently in use and are so designated in each table.

In addition to these antibiotics, sulfa drugs also

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TABLE 1. ANTIBIOTIC AND ANTIMICROBIAL AGENT SENSITIVITY PATTERNS[a, b] OF STRAINS OF LACTIC STREPTOCOCCI, *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, AND *Leuconostoc dextranicum*.

ANTIBIOTIC OR ANTIMICROBIAL AGENT	CONCENTRATION PER DISC	BACTERIAL STRAINS																							
		STREPTOCOCCUS LACTIS					STREPTOCOCCUS CREMORIS					STREPTOCOCCUS DIACETILACTIS					STREPTOCOCCUS THERMOPHILUS					LACTOBACILLUS BULGARICUS					LEUCONOSTOC DEXTRANICUM	LEUCONOSTOC DEXTRANICUM B1165
		7963	7962	C_2F 10		SLE	HP	SC_1	DR_7	ML_4	SC_3	18-16	26-2	31-2	11007	DRC_3	ST_1	ST_2	ST_3	ST_4	ST_5	LB_1	LB_2	LB_3	LB_4	LB_5		
PENICILLIN G[c]	2 units	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	0	0
PENICILLIN G[c]	10 units	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2
POLYMYXIN B[c]	50 units	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	2
POLYMYXIN B[c]	300 units	0	0	0	0	1	1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	2	2	0	0	0	3	3
PHENETHICILLIN	3 units	3	3	2	3	3	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	2	0	0
TETRACYCLINE[c]	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	2	1	2	3	3
TETRACYCLINE[c]	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
VANCOMYCIN	5 mcg	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	3	3	3	2	2	2	0	0
VANCOMYCIN	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
CHLORTETRACYCLINE[c]	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	2	3	3	3	3
CHLORTETRACYCLINE[c]	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
AMPICILLIN[c]	2 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	2	3	1	0	0
AMPICILLIN[c]	10 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	0	1
BACITRACIN[c]	2 units	2	2	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
BACITRACIN[c]	10 units	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
CHLORAMPHENICOL	5 mcg	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	3	3	2	2	2	2	1	2	3	2	2
CHLORAMPHENICOL	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
CEPHALOTHIN	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ERYTHROMYCIN[c]	2 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	1	2	3	3	2	0	0
ERYTHROMYCIN[c]	15 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2
KANAMYCIN	5 mcg	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	2	1	2	2	2
KANAMYCIN	30 mcg	2	2	2	2	3	2	3	3	3	3	3	3	2	2	2	1	1	1	1	1	2	1	3	2	3	3	3
LINCOMYCIN[c]	2 mcg	3	3	1	3	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
METHACYCLINE	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
METHACYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
METHICILLIN	5 mcg	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	0	0	3	3	0	0	0
NAFCILLIN	1 mcg	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	0	0	1	3	1	0	0
COLISTIN	2 mcg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
COLISTIN	10 mcg	0	0	0	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	3	3
CLOXACILLIN[c]	1 mcg	2	2	1	1	2	2	2	2	2	2	2	1	1	1	2	2	2	1	2	2	0	0	2	3	0	0	0
DEMETHYLCHLORTETRACYCLINE	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	1	2	2	3	3	3	3
DEMETHYLCHLORTETRACYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DOXYCYCLINE	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	2	2	3	3	3	3	3
DOXYCYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DIHYDROSTREPTOMYCIN[c]	2 mcg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	0	0	1	1	2	2	1
DIHYDROSTREPTOMYCIN[c]	10 mcg	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	3	3	3	3	3	3	3
NOVOBIOCIN[c]	5 mcg	2	3	2	2	2	2	3	3	3	3	2	2	2	2	2	3	2	2	3	3	1	1	3	3	3	0	2
NOVOBIOCIN[c]	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3
NEOMYCIN[c]	5 mcg	1	0	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1
NEOMYCIN[c]	30 mcg	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
OLEANDOMYCIN[c]	2 mcg	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3	1	0	2	3	3	0	0
OLEANDOMYCIN[c]	15 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0
OXACILLIN[c]	1 mcg	1	1	1	1	1	1	1	2	2	1	1	1	1	1	2	3	3	3	3	3	0	0	2	3	0	0	0
OXYTETRACYCLINE[c]	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	0	2	3	3	3	3
OXYTETRACYCLINE[c]	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
FURADANTIN[c]	50 mcg	0	2	2	0	1	1	1	3	1	1	1	1	1	1	1	3	3	3	3	3	3	3	0	0	3	2	2
FURADANTIN[c]	100 mcg	1	3	3	1	2	1	2	3	2	2	1	1	1	1	2	3	3	3	3	3	3	3	1	1	3	3	3
MANDELAMINE	1.0 mg	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
MANDELAMINE	2.5 mg	1	1	0	1	1	1	1	2	1	1	1	1	1	1	1	2	1	2	2	2	0	0	0	2	1	1	1
NALIDIXIC ACID	30 mcg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
TRIBURON	250 mcg	3	3	3	3	3	2	3	3	3	3	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	1	1
TRIBURON	1 mg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2

[a] NO INHIBITION 0

[b] INHIBITION { 1 INHIBITORY ZONE ≤ 2 mm. / 2 INHIBITORY ZONE > 2 mm. BUT < 5 mm. / 3 INHIBITORY ZONE ≥ 5 mm.

[c] CURRENTLY USED IN MASTITIS THERAPY.

TABLE 2. ANTIBIOTIC AND ANTIMICROBIAL AGENT SENSITIVITY PATTERNS[a, b] OF STRAINS OF ENTEROCOCCI, *Brevibacterium linens*, STAPHYLOCOCCI, AND MICROCOCCI.

ANTIBIOTIC OR ANTIMICROBIAL AGENT	CONCENTRATION PER DISC	BACTERIAL STRAINS														
		STREPTOCOCCUS DURANS					STREPTOCOCCUS FAECALIS				BREVIBACTERIUM LINENS			STAPHYLOCOCCUS AUREUS	STAPHYLOCOCCUS EPIDERMIDIS	MICROCOCCUS VARIANS
		15-20	9-20	36-11	52-13	38-2	51-2	22-23	24-23	47-13	1	2	3			
PENICILLIN G[c]	2 units	3	3	3	3	3	2	2	2	2	0	2	0	3	3	1
PENICILLIN G[c]	10 units	3	3	3	3	3	3	3	3	3	0	3	0	3	3	2
POLYMYXIN B[c]	50 units	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0
POLYMYXIN B[c]	300 units	0	0	0	0	0	0	0	0	0	2	3	2	0	1	0
PHENETHICILLIN	3 units	2	2	3	3	2	2	2	2	2	0	0	0	3	3	3
TETRACYCLINE[c]	5 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
TETRACYCLINE[c]	30 mgc	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
VANCOMYCIN	5 mcg	2	2	2	2	2	2	2	2	2	3	3	1	2	2	2
VANCOMYCIN	30 mcg	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CHLORTETRACYCLINE[c]	5 mcg	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3
CHLORTETRACYCLINE[c]	30 mcg	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3
AMPICILLIN[c]	2 mcg	3	3	3	3	3	3	3	3	3	0	0	0	3	3	3
AMPICILLIN[c]	10 mcg	3	3	3	3	3	3	3	3	3	0	1	0	3	3	3
BACITRACIN[c]	2 units	3	2	2	2	3	1	2	1	1	3	3	2	1	2	1
BACITRACIN[c]	10 units	3	3	3	3	3	2	3	2	2	3	3	3	3	3	3
CHLORAMPHENICOL	5 mcg	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3
CHLORAMPHENICOL	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CEPHALOTHIN	30 mcg	2	2	3	3	3	2	2	2	2	2	3	1	3	3	3
ERYTHROMYCIN[c]	2 mcg	3	3	2	2	2	2	2	2	2	3	2	3	3	3	3
ERYTHROMYCIN[c]	15 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
KANAMYCIN	5 mcg	1	1	0	0	0	0	0	0	0	1	1	1	2	2	3
KANAMYCIN	30 mcg	2	2	1	1	1	1	1	1	1	3	3	2	3	3	3
LINCOMYCIN[c]	2 mcg	3	3	1	1	1	1	1	1	1	2	1	2	3	1	3
METHACYCLINE	5 mcg	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
METHACYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
METHICILLIN	5 mcg	1	0	3	3	0	1	1	1	2	0	0	0	3	3	3
NAFCILLIN	1 mcg	1	0	3	3	0	1	1	1	2	0	0	0	3	3	3
COLISTIN	2 mcg	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
COLISTIN	10 mcg	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0
CLOXACILLIN[c]	1 mcg	0	0	2	2	1	0	0	0	0	0	0	0	3	3	3
DEMETHYLCHLORTETRACYCLINE	5 mcg	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3
DEMETHYLCHLORTETRACYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DOXYCYCLINE	5 mcg	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3
DOXYCYCLINE	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DIHYDROSTREPTOMYCIN[c]	2 mcg	0	0	0	0	0	0	0	0	0	2	1	1	0	0	0
DIHYDROSTREPTOMYCIN[c]	10 mcg	0	0	0	1	1	0	0	0	0	3	3	2	2	2	1
NOVOBIOCIN[c]	5 mcg	3	3	3	3	3	2	1	1	2	3	3	2	3	1	3
NOVOBIOCIN[c]	30 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
NEOMYCIN[c]	5 mcg	1	1	1	1	1	0	0	0	0	2	2	2	2	3	3
NEOMYCIN[c]	30 mcg	2	2	2	2	2	0	0	0	0	3	3	2	3	3	3
OLEANDOMYCIN[c]	2 mcg	2	2	2	2	1	2	2	2	2	3	3	3	2	2	3
OLEANDOMYCIN[c]	15 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
OXACILLIN[c]	1 mcg	0	0	3	3	1	0	0	0	0	0	0	0	2	2	3
OXYTETRACYCLINE[c]	5 mcg	3	3	3	3	3	1	3	3	3	3	3	2	3	3	3
OXYTETRACYCLINE[c]	30 mcg	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3
FURADANTIN[c]	50 mcg	3	2	1	2	1	3	3	3	3	0	0	0	3	3	3
FURADANTIN[c]	100 mcg	3	3	2	3	2	3	3	3	3	0	0	0	3	3	3
MANDELAMINE	1.0 ma	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
MANDELAMINE	2.5 mg	0	0	0	0	0	0	0	0	0	1	2	1	2	2	1
NALIDIXIC ACID	30 mcg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIBURON	250 mcg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
TRIBURON	1 mg	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

[a] NO INHIBITION 0

[b] INHIBITION
- 1 INHIBITORY ZONE ≤ 2mm.
- 2 INHIBITORY ZONE > 2mm. BUT < 5mm.
- 3 INHIBITORY ZONE ≥ 5mm.

[c] CURRENTLY USED IN MASTITIS THERAPY

are added to therapeutic preparations. We attempted to include some of the commonly used sulfa drugs in this survey, but found that Elliker's lactic agar could not be used as a test medium. Mueller-Hinton agar does not contain the protective factor(s) found in Elliker's lactic agar. Because many of the starter microorganisms used in our study are nutritionally fastidious, Mueller-Hinton agar, however, would be inadequate. Almost all the microorganisms investigated, except for S. *thermophilus,* exhibited definite resistance to eight different sulfonamides when grown on lactic agar. Strains of S. *thermophilus* were inhibited by several sulfa drugs. This might indicate severe sensitivity when tested by using more appropriate procedures.

Most of the strains of starter streptococci (S. *lactis,* S. *cremoris,* S. *diacetilactis,* and S. *thermophilus*) and *L. bulgaricus* were sensitive to all 16 antibiotic or antimicrobial agents (included in this survey) used for mastitis control. Strains of *L. dextranicum,* S. *faecalis, B. linens,* and S. *durans* exhibited resistance, in the same order, to 5, 5, 3, and 1 of the designated antimastitis agents.

The results presented in Tables 1 and 2 show that *L. dextranicum* may be more resistant to antibiotics than most other starter bacteria. On the basis of their resistance to the number of antibiotics included in this survey, starter and associated bacteria could be listed in this order of decreasing resistance: *L. dextranicum, B. linens,* S. *faecalis,* S. *durans, L. bulgaricus,* S. *lactis,* S. *diacetilactis,* S. *thermophilus,* and S. *cremoris.* Four of the 5 strains of S. *lactis* showed complete resistance to polymyxin B; the remaining strain was only moderately sensitive to this antibiotic. All 5 strains of S. *diacetilactis* were moderately sensitive to polymyxin B. Three of the 5 S. *cremoris* strains were completely sensitive to polymyxin B; the other strains were moderately sensitive.

Table 3 presents a list of antibiotics without effect (at use levels) on specific test organisms. For example, Furadantin, at 50 μg, does not inhibit *B. linens.* This inhibitory agent, therefore, might add selectivity to Cheese agar *(1)* used to isolate *B. linens.* From other data in Table 3, it seems that a combination of mandelamine plus polymyxin B, at some concentration, could be used to develop a selective medium for enterococci. Neomycin at 30 μg was inhibitory to the 5 test strains of S. *durans* investigated. Strains of S. *faecalis,* on the other hand, exhibited resistance to this use level. This observation might be exploited to develop a differential test for these enterococci.

From data presented, it should be possible to compare the pharmacological action of different antibiotics on the basis of their degree of inhibitory effect

TABLE 3. ANTIBIOTIC RESISTANCE OF TEST MICROORGANISMS[a]

Leuconostoc dextranicum	*Brevibacterium linens*	*Streptococcus faecalis*	*Streptococcus durans*	*Lactobacillus bulgaricus*	*Streptococcus lactis*	*Streptococcus diacetilactis*	*Streptococcus thermophilus*	*Streptococcus cremoris*	*Staphylococcus aureus*	*Staphylococcus epidermidis*	*Micrococcus varians*
Phenethicillin	Methicillin	Polymyxin B	Polymyxin B	Nalidixic acid	Colistin	Colistin	Colistin	Nalidixic acid	Polymyxin B	Nafcillin	Polymyxin B
Vancomycin	Nafcillin	Colistin	Colistin		Nalidixic acid	Nalidixic acid	Nalidixic acid		Nafcillin	Colistin	Nafcillin
Bacitracin	Cloxacillin	Cloxacillin	Mandelamine						Colistin	Nalidixic acid	Colistin
Lincomycin	Oxacillin	Dihydrostreptomycin	Nalidixic acid						Nalidixic acid		Nalidixic acid
Methicillin	Furadantin	Oxacillin									
Nafcillin	Nalidixic acid	Mandelamine									
Cloxacillin		Nalidixic acid									
Oleandomycin		Neomycin									
Oxacillin											

[a]The highest concentration of these antibiotics used is given in Tables 1 and 2.

on the several strains and species of bacteria used in this investigation.

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