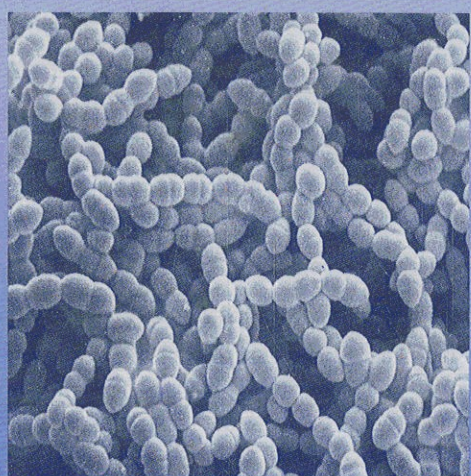




Tamime and Robinson's Yoghurt

Science and technology

Third edition

A. Y. Tamime and R. K. Robinson

Contents

<i>Preface to third edition</i>	xiii
<i>Preface to second edition</i>	xv
<i>Preface to first edition</i>	xvi
1 Historical background	1
1.1 Introduction	1
1.2 Evolution of the process	2
1.3 Diversity of fermented milks	3
1.4 Patterns of consumption	5
1.5 Methods of production and classification	8
1.6 References	10
2 Background to manufacturing practice	13
2.1 Introduction	13
2.2 Preliminary treatment of the milk base	15
2.2.1 Milk as a raw material	15
2.2.2 Separation of cellular material and other contaminants present in milk	17
2.2.3 Milk reception and storage	18
2.3 Standardisation of fat content in milk	19
2.4 Standardisation of the solids-not-fat content in milk	21
2.4.1 Traditional process	23
2.4.2 Addition of milk powder	23
2.4.3 Addition of buttermilk powder	25
2.4.4 Addition of whey powder and/or whey protein concentrates ..	25
2.4.5 Addition of casein powder	29
2.4.6 Concentration by vacuum evaporation (VE)	31
2.4.7 Concentration by membrane filtration	32
2.4.8 Addition of non-milk protein	35
2.4.9 Conclusions	36

2.5	Addition of stabilisers/emulsifiers	39
2.5.1	General background	39
2.5.2	Miscellaneous properties and conditions	42
2.6	Addition of sweetening agents	46
2.6.1	General introduction	46
2.6.2	Types of carbohydrate sweetener	49
2.7	Addition of miscellaneous compounds	54
2.7.1	Penicillinase	54
2.7.2	Preservatives	55
2.7.3	Minerals, vitamins and/or fatty acids	59
2.8	Homogenisation	61
2.8.1	Effects on milk constituents	63
2.8.2	Aspects of processing	65
2.9	Heat treatment	67
2.9.1	Destruction of microorganisms/pathogens	69
2.9.2	Production of stimulatory/inhibitory factors	72
2.9.3	Changes in physicochemical properties of milk	73
2.9.4	Processing effects on the physical properties of the gel	79
2.9.5	Novel or emerging techniques for the processing of the milk base	83
2.10	Fermentation process	85
2.10.1	Introduction	85
2.10.2	Starter organisms	86
2.10.3	Gel formation	91
2.11	Cooling	96
2.11.1	One-phase cooling	97
2.11.2	Two-phase cooling	97
2.12	Addition of fruit/flavouring/colouring ingredients	98
2.12.1	Fruits	98
2.12.2	Flavouring agents	103
2.12.3	Colouring matter	105
2.13	Packaging	106
2.13.1	Introduction	106
2.13.2	Functions of packages	107
2.13.3	Types of packaging materials	108
2.13.4	Comparative studies on the permeability of different yoghurt packages	113
2.13.5	Migration of monomers and other compounds	115
2.13.6	Tamper-evident packages	116
2.13.7	Aluminium foil lids	117
2.13.8	Sterilisation of packaging materials	118
2.13.9	Outer or shipping container	120
2.14	Refrigerated cold storage, transport and distribution	121
2.14.1	The cold store	122
2.14.2	During transport	122
2.14.3	The retail shop and the consumer	123
2.15	Conclusion	123
2.16	References	123

3	Processing plants and equipment	162
3.1	Home or small-scale production	162
3.1.1	Miscellaneous systems	163
3.1.2	Packaging system	165
3.2	Medium-scale production	167
3.2.1	Hand-operated vat	167
3.2.2	Multi-purpose vat	167
3.2.3	Mini dairy science and technology	168
3.2.4	Small-scale packaging machines	169
3.3	Large-scale production	174
3.3.1	Milk reception, handling and storage	174
3.3.2	Standardisation of fat content in milk	177
3.3.3	Fortification of milk solids	181
3.3.4	Homogenisation	194
3.3.5	Heat treatment	197
3.3.6	Fermentation/incubation of the milk	206
3.3.7	Cooling	214
3.3.8	Pumps	218
3.3.9	Miscellaneous fittings	227
3.3.10	Fruit handling and mixing units	230
3.3.11	Filling machines	236
3.3.12	Miscellaneous handling, chill cooking and refrigerated cold storage	249
3.4	Mechanisation of yoghurt production and plant design	254
3.5	Continuous yoghurt production	256
3.5.1	Background	256
3.5.2	The NIZO process	257
3.5.3	Recent developments	258
3.6	Automation/process control	260
3.6.1	Levels of automation	260
3.6.2	Area/department 1	262
3.6.3	Area/department 2	263
3.6.4	Area/department 3	264
3.6.5	Area/department 4	264
3.6.6	Area/department 5	265
3.6.7	Area/department 6	267
3.6.8	Management information system	267
3.6.9	System architecture	268
3.6.10	System security	269
3.6.11	Traceability	269
3.6.12	In-line monitoring	272
3.7	Building design, maintenance and services	273
3.7.1	General background and introduction	273
3.7.2	Location of a dairy plant	273
3.7.3	Layour of a dairy plant	275
3.7.4	Design and construction of dairy buildings	275
3.8	Conclusion	277
3.9	References	277

4	Plant cleaning, hygiene and effluent treatment	284
	Cleaning aspects	284
4.1	Primary aspects	284
4.2	Principles of the cleaning process	285
4.3	Factors involved in the selection and performance of a detergent	293
4.3.1	Type/range of detergents used in the yoghurt industry	293
4.3.2	Type of soiling matter	293
4.3.3	Water hardness and quality	294
4.3.4	Miscellaneous factors	295
4.4	Cleaning methods	296
4.4.1	Manual checking	296
4.4.2	Cleaning-in-place (CIP)	297
4.4.3	Miscellaneous cleaning methods	301
4.5	Factors influencing the efficiency of cleaning	302
4.5.1	Type of soil	302
4.5.2	Method of cleaning adopted	302
4.5.3	Contact time	303
4.5.4	Concentration of detergent solution	303
4.5.5	Temperature	303
4.5.6	Flow rate or velocity	303
4.5.7	Acid wash	305
4.5.8	Plant design	305
4.5.9	Chemical composition of a detergent	306
4.6	Specific cleaning and sterilisation operations of yoghurt processing equipment and utensils	308
	Sterilisation aspects	321
4.7	Fundamentals of the sterilisation process	321
4.8	Methods of sterilisation and/or sanitation	321
4.8.1	Heat	322
4.8.2	Chemical agents	322
4.8.3	Filtration	326
4.8.4	Irradiation	326
4.8.5	Spraying, fogging or fumigation	326
4.8.6	Hand hygiene	327
4.8.7	Foot-bath	327
4.8.8	Conclusion	327
4.9	Kinetics and mechanisms of microbial destruction	329
4.10	Means of assessing the sanitary condition of the processing plant	331
4.10.1	Physical examination	331
4.10.2	Chemical examination	332
4.10.3	Bacteriological examination	332
	Effluent treatment	333
4.11	Background	333
4.12	Nature of pollution	334
4.13	Methods of effluent treatment	335
4.14	References	337

5	Traditional and recent developments in yoghurt production and related products	348
5.1	Introduction	348
5.2	Standard commercial yoghurt	349
5.3	Yoghurt made from different mammalian milks	351
5.3.1	Goat's milk yoghurt	352
5.3.2	Sheep's milk yoghurt	354
5.3.3	Buffalo's milk yoghurt	357
5.3.4	Camel's milk yoghurt	359
5.3.5	Mare's milk yoghurt	361
5.3.6	Ass's fermented milk	361
5.4	Pasteurised/UHT/long-life/heat shock yoghurt	361
5.4.1	Technology of manufacture	362
5.4.2	Processing effects on the properties of the product	364
5.5	Drinking yoghurt	365
5.5.1	Background	365
5.5.2	Processing aspects	366
5.5.3	Other beverage products	369
5.5.4	Carbonated yoghurt	370
5.6	Lactose hydrolysed yoghurt (LHY)	371
5.7	Concentrated/strained yoghurt	373
5.7.1	Introduction and nomenclature	373
5.7.2	Processing methods	374
5.7.3	Miscellaneous properties	381
5.7.4	Microstructure	384
5.7.5	Related products	388
5.8	Frozen yoghurt	392
5.8.1	Background, standards and marketing	392
5.8.2	Technology of manufacture	393
5.8.3	Related products	397
5.9	Dried yoghurt	399
5.9.1	Introduction	399
5.9.2	Processing methods	399
5.9.3	Kishk and related products	403
5.10	Health-promoting yoghurt	409
5.11	Fat-substitutes yoghurt	412
5.12	Vegetable oil yoghurt	417
5.13	ω -3 Enriched oil yoghurt	419
5.14	Chemically acidified yoghurt	419
5.15	Soy-milk yoghurt	421
5.16	Transglutaminase (Tg-ase) yoghurt	425
5.17	Miscellaneous yoghurt products	427
5.18	Future developments and conclusion	429
5.19	References	429
6	Microbiology of yoghurt and related starter cultures	468
6.1	Introduction	468
6.1.1	Historical background and classification	469
6.1.2	Modification of starter cultures	481

6.1.3	Potential genetic modifications	483
6.2	Characteristics of growth	484
6.2.1	Milk as a medium for microbial growth	484
6.2.2	Associative growth	485
6.3	Factors causing slow growth of starter cultures	489
6.3.1	Compounds that are naturally present in milk	489
6.3.2	Effect of incubation temperature and inoculation rate	490
6.3.3	Mastitis milk and somatic cell count	490
6.3.4	Hydrogen peroxide (H ₂ O ₂)	491
6.3.5	Antibiotic residues	492
6.3.6	Detergent and disinfectant residues	496
6.3.7	Environmental pollution	497
6.3.8	Bacteriophages	498
6.3.9	Bacteriocins	505
6.3.10	Miscellaneous factors	508
6.4	Conclusion	511
6.5	References	511
7	Biochemistry of fermentation	535
7.1	Introduction	535
7.2	Carbohydrate metabolism	535
7.2.1	Homolactic fermentation	536
7.2.2	Heterolactic fermentation	538
7.2.3	Lactase activity	539
7.2.4	Production of lactic acid	540
7.2.5	Production of exopolysaccharides (EPS)	543
7.2.6	Production of flavour compounds	551
7.3	Protein metabolism	559
7.3.1	Constituent compounds of the milk protein molecule	560
7.3.2	Proteolytic enzymes	561
7.3.3	Proteolysis by the yoghurt and related organisms	561
7.3.4	Products of proteolysis	570
7.4	Lipid/fat metabolism	574
7.4.1	Introduction	574
7.4.2	Changes in the level of free and esterified fatty acids	576
7.4.3	Changes in the level of volatile fatty acids	577
7.5	Vitamin metabolism	579
7.5.1	General background	579
7.5.2	Biosynthesis of folic acid	582
7.5.3	Biosynthesis of niacin	583
7.5.4	Biosynthesis of vitamin B ₆	584
7.6	Miscellaneous changes	585
7.7	References	587
8	Preservation and production of starter cultures	608
8.1	Introduction	608
8.2	Methods of starter culture preservation	609
8.2.1	Liquid starters	610
8.2.2	Dried starters	611

8.2.3	Frozen starters	618
8.3	Technology of cell biomass production	622
8.3.1	Growth characteristics	622
8.3.2	Concentration of the cell biomass	623
8.4	Production systems of starter cultures	626
8.4.1	Introductory remarks	626
8.4.2	Simple microbiological techniques	627
8.4.3	Mechanically protected systems	628
8.4.4	pH control systems	633
8.4.5	Bacteriophage resistant/inhibitory medium (BRM/BIM)	633
8.5	Developments in inoculation systems	634
8.5.1	Automatic inoculation system (AISY)	634
8.5.2	In-line inoculation with freeze-dried or frozen concentrated culture	635
8.6	Conclusion	638
8.7	References	639
9	Nutritional value of yoghurt	646
9.1	Introduction	646
9.2	Carbohydrates	647
9.2.1	Available carbohydrates	647
9.2.2	Unavailable carbohydrates	649
9.2.3	Exopolysaccharides (EPS)	650
9.3	Protein	651
9.4	Lipids	652
9.5	Vitamins and minerals	653
9.5.1	Yoghurt cultures	653
9.5.2	Probiotic yoghurts	655
9.6	Nutritional additives	655
9.7	Yoghurt and health	657
9.7.1	Background	657
9.7.2	Therapeutic properties of yoghurt	658
9.7.3	Therapeutic properties of probiotic yoghurts	663
9.8	Conclusion	667
9.8.1	Overall reactions	667
9.8.2	Current situation	668
9.8.3	Future considerations	669
9.9	References	670
10	Quality control in yoghurt manufacture	685
10.1	Introduction	685
10.2	Principles of HACCP	687
10.2.1	Brief introduction	687
10.2.2	Implementation of a HACCP system	688
10.3	Aspects of verification	691
10.4	Monitoring the process plant	693
10.5	Examination of raw materials	694
10.5.1	Sampling	694
10.5.2	Liquid milk	695

10.5.3	Milk powder	698
10.5.4	Starter cultures for standard yoghurt	700
10.5.5	Starter cultures for probiotic yoghurts	704
10.6	Quality appraisal of the retail product	704
10.6.1	Analysis of chemical composition	705
10.6.2	Assessment of physical characteristics	707
10.6.3	Microbiological analysis	717
10.6.4	Assessment of organoleptic characteristics	725
10.7	Conclusion	733
10.8	References	733
Appendix I	Different ways in which titratable activity is expressed and their relative values to % lactic acid	754
Appendix II	Temperature conversion	756
Appendix III	Volume units	759
Appendix IV	Weight/mass units	761
Appendix V	Miscellaneous units	762
Appendix VI	Work/energy and other related units	763
Appendix VII	Force and pressure units	765
Appendix VIII	Length and area units	766
Appendix IX	Pearson square and algebraic methods	767
<i>Index</i>		772