## ENZYMES IN FOOD TECHNOLOGY



Edited by Robert J. Whitehurst and Barry A. Law

## **Contents**

1	The nature of enzymes and their action in foods BARRY A. LAW	1
	BARKI A. LAW	1
	1.1 Introduction	2
	1.2 Enzymes in food	2
	1.2.1 Enzyme nomenclature	3
	1.2.2 Enzyme kinetics	6
	1.3.2 Enzyme (in)stability	. 8
	1.2.4 Composition and activity of commercial enzyme preparations	9
	1.3 Sources and range of enzymes for food technology	14
	1.4 Food enzyme legislation	16
	1.5 Modification of food enzyme activity by protein engineering	18
	1.6 Summary and conclusions	18
	References	10
	- c. L	19
2	Enzymes for bread, pasta and noodle products JOAN QI SI and CORNELIA DROST-LUSTENBERGER	
		19
	2.1 Introduction	19
	2.2 Bread	20
	2.2.1 Fungal alpha-amylases 2.2.2 Amylases to extend shelf life	21
	2.2.2 Amylases to extend short inc 2.2.3 Xylanases/pentosanases/hemicellulases	28
		31
	2.2.4 Lipase 2.2.5 Oxidases	33
	2.2.6 Synergistic effects of enzymes	34
	2.2.7 Enzymes for frozen dough and part-baked bead	39
	2.2.7 Enzymes for Asian noodles and non-durum pasta	46
	2.3.1 Reducing speckiness	46
	2.3.2 Increasing brightness and colour stability	46
	2.3.3 Improving texture	48
	2.3.4 Mechanisms for the effect of lipase ,	<b>5</b> 1
	Acknowledgement	54
	References	54
,	3 Enzymes in brewing	5'
•	DIEDERIK J. M. SCHMEDDING and MARI J. M. C.	
	van GESTEL	
	3.1 Introduction	5
	3.1.1 History of brewing	5
	3.2 Raw materials	2

	3.2.1 Malt and adjuncts		58
	3.2.2 Hops		59
	3.2.3 Yeast		59
	3.2.4 Water		59
	3.2.5 Exogenous enzymes as processing aids		59
3.3	The processes of malting and brewing		60
	3.3.1 The malting process		61
	3.3.2 Malt specification	,	61
	3.3.3 The brewing process		62
3.4	Enzymes in the brewing process		64
	3.4.1 Enzymes in malting		64
	3.4.2 Enzymes in mashing		66
	3.4.3 Enzymes in adjunct cooking		70
	3.4.4 Enzymes in lautering/mash filtration		70
	3.4.5 Enzymes in fermentation		71
	3.4.6 Enzymes in maturation		73
	3.4.7 Chill proofing enzymes		73
	3.4.8 Future developments		74
	knowledgements		75
Fur	ther reading		75
	AARTEN van OORT and ROSE-MA ANAL-LLÁUBÈRES	RIE	
4.1	Introduction		76
	Legal aspects of the use of enzymes in winemakin	ø	76
	4.2.1 Recommendations from international organ	<del>-</del>	77
4.3	Enzymes in winemaking: history and definitions		77
	Enzyme properties and composition		78
	Applications of enzymes		79
	4.5.1 Enzymes for pressing and maceration		80
4.6	Enzyme applications for white and pink wine grap	e varieties	81
4.7	Enzyme applications for red wine grape varieties		83
4.8	Enzyme applications for must and press wines: cla	arification enzymes	83
4.9	Enzyme applications for young wines: maturation	and filtration enzymes	84
4.10	O Enzyme preparations for aroma liberation		85
4.1	1 Enzymes for colour extraction		87
4.1	2 Other enzymes used in winemaking		87
	4.12.1 Urease		, 87
	4.12.2 Lysozyme		88
4.1	3 New developments		8,8
	4.13.1 Cork cleaning		′ 88
	4.13.2 Colour stabilisation		88
	4.13.3 Health issues		89
	4 Conclusions		89
Ket	recernies		7.5

CONTENTS
CONTRACTO

хi

T	nzymes in the manufacture of dairy products	90
E B	ARRY A. LAW	
		90
	1 Introduction	90
5	2 Milk-clotting enzymes	91
	5.2.1 The nature and identity of rennets and coagulants	92
	5.2.1 The nature and identity of remets and coagulants from different sources 5.2.2 Main characteristics of remets and coagulants from different sources	95
	5.2.3 Production of rennets and coagulants	96
	5.2.4 Formulation and standardisation of rennets and coagulants	96
5	.3 Lactoperoxidase	97
5	4 Cheese ripening enzymes	97
	5.4.1 Types of enzymes available commercially	99
	5.4.2 Enzyme addition technology	101
	5.4.3 Enzyme-modified cheese (EMC) technology	103
	5.5 Lysozyme	104
	5.6 Transglutaminase	104
:	5.7 Lipase	104
	5.7.1 Lipolysed milk fat (LMF)	105
	5.7.1 Lipotysed links like (Lam) 5.7.2 Lipase-catalysed intra- and intermolecular modification of milk fat	105
	5.8 Lactase	107
	5.8.1 Commercial dairy products of lactase technology	107
	References	
		109
6	Enzymic modification of food protein	
	PER MUNK NIELSEN and HANS SEJR OLSEN	
		109
	6.1 Introduction	109
	6.2 Industrial proteases	110
	6.3 Protein hydrolysis in enzyme applications	111
	6.2.1 Control of hydrolysis reaction	11.
	6.3.2 Calculation of the degree of hydrolysis of proteins using the	112
	pH-stat technique	*
	6.3.3 Calculation of the degree of hydrolysis of proteins using the	114
	osmometry technique	114
	6.3.4 Some kinetic aspects of protein hydrolysis	116
	6.3.5 The effect of proteolysis	117
	6.4 The bitterness problem	118
	6.4.1 Other off-flavour problems related to bitterness	119
	6.5 Protein hydrolysis for food processing	120
	6.5.1 Inactivation of enzyme activity and downstream processing	122
	6.6 Functional protein hydrolysates	124
	6.7 Low allergenic peptides for baby food formulae	125
	6.8 Meat extracts	127
	6.9 Bone cleaning	127
	6.9.1 Hydrolysis of meat protein in relation to bone cleaning	129
	6.10 Enzymatic tenderisation of meat	130
	6.11 Modification of wheat gluten	131
	6.12 Use of membranes in protein hydrolysis processes	131
	6.12.1 Functional protein hydrolysates	132
	6.12.2 Low molecular weight hydrolysates	133
	6.12.3 The membrane reactor	

## CONTENTS

хü

	6.13 Flavour enhancers	134
	6.13.1 Production of flavour enhancers	134
	6.13.2 Enzymatically hydrolysed vegetable proteins (e-HVP)	135
	6.13.3 Hydrolysed animal proteins (e-HVP)	135
	6.14 Yeast extracts	136
	6.15 Fish processes	137
	6.16 Protein cross-linking in food processing	138
	6.16.1 Applications of transglutaminase	139
	References	140
7	Enzymes in fruit and vegetable juice extraction	144
	REINHOLD URLAUB	
	7.1 Introduction	144
	7.1 Introduction 7.2 The legal situation	145
	7.2 The legal situation 7.3 Definitions and characteristics	146
	7.4 Pectins	147
	7.4.1 Smooth-region pectinases	148
	7.4.1 Smooth-legion pectinases 7.4.2 Hairy-region pectinases	149
	7.4.2 Hany-region pecuniases 7.5 Cellulose and hemicellulose	150
	7.6 Starch	151
	7.7 Protein	153
	7.8 Application of technical enzyme products	154
	7.9 Pome fruit processing	155
	7.9.1 Enzymatic treatment of the mash	157
	7.9.2 Pomace extraction	158
	7.9.3 Maceration	159
	7.9.4 Pomace maceration	160
	7.9.5 Juice treatment	161
	7.9.6 Traditional clarification and filtration	165
	7.9.7 Ultrafiltration of apple juice	166
	7.9.8 Cloudy apple juice or apple juice concentrate	167
	7.10 Grapes	168
	7.10 Grapes 7.10.1 Processing of Concord grapes	168
	7.10.2 Manufacturing white grape juice and grape juice concentrate	169
	7.11 Berries	170
	7.12 Stone fruit	172
	7.13 Citrus fruit	172
	7.13.1 WESOS	173
	7.13.2 Citrus juice concentrates	175
	7.13.2 Clear and semi-cloudy citrus concentrates	, 176
	7.13.4 Extraction of citrus oil	177
	7.13.5 Cloudifier	178
	7.14 Tropical fruit	179
	7.15 Vegetables	181
	7.16 Membrane cleaning	182
	References	182

CONTENTS	Xiii
CONTENTS	ХШ

8		zymes in fruit processing	184
	CA	THERINE GRASSIN and PIERRE FAUQUEMBERGUE	
		Citrus peeling	184
		Citrus peel processing	186
	8.3	Fruit firming	187
		8.3.1 Strawberries	194
		8.3.2 Tomato	196
	Ref	erences ,	199
9	En	zymes in starch modification	200
	HANS SEJR OLSEN		
		Introduction	200
	9.2	Processing and enzymology	201
		9.2.1 Starch liquefaction	201
		9.2.2 alpha-Amylases	204
		9.2.3 Saccharification of liquefied starch	210
		9.2.4 Tailor-made glucose syrups	210
		9.2.5 Use of syrups	211
		9.2.6 Production of maltose syrups	213
		9.2.7 DX, DE and reducing value	213
		9.2.8 High conversion syrup	214
		9.2.9 Production of high dextrose syrups	215
		9.2.10 Amyloglucosidase/pullulanus combination in the production of	
		high dextrose syrup	216
		9.2.11 Continuous saccharification	217
	0.3	9.2.12 Continuous saccharification in a membrane reactor	218
	9.3	Enzymes as processing aids in the purification of saccharified wheat starch Glucose isomerisation	218
	9.4	9.4.1 The isomerisation reaction	219
		9.4.2 Isomerisation conditions	219
		9.4.3 Isomerisation temperature	220
		9.4.4 Isomerisation pH	220
		9.4.5 Isomerisation glucose (dextrose-DX) and fructose concentration	220 221
		9.4.6 The immobilised enzyme system	221
		9.4.7 Process lay-out	221
		9.4.8 Enzyme decay	224
		9.4.9 Controlling isomerisation costs	224
	9.5	Use of high-fructose corn syrups (HFCS)	225
		Cyclodextrins	226
		The future	227
		Conclusion	227
	Ref	erences	228
10	Commercial enzyme production and genetic modification of		
		irce organisms	229
		CHIE PIGGOTT	/
	10 1	Brief history	229
		2 Sources of commercial enzymes	229
	20.2		227

xiv CONTENTS

Index

10.2.1 Animal-derived enzymes	230
10.2.2 Plant-derived enzymes	230
10.3 Microbial enzyme fermentation	232
10.4 Preservation of industrial microorganisms	233
10.4.1 Freezing	234
10.4.2 Freeze-drying	234
10.4.3 Subculturing	234
10.5 Inoculum development	234
10.6 Submerged fermentation	235
10.7 Separation of broth	236
10.7.1 Filtration with filter aid	236
10.7.2 Microfiltration	237
10.7.3 Centrifugation	237
10.8 Concentration	237
10.9 Drying	238
10.10 Enzyme formulation	239
10.10.1 Powder blending	239
10.10.2 Liquid blending	240
10.10.2 Eliquid blending 10.11 Surface culture (Koji) fermentation	240
10.12 Intracellular enzyme production	241
	242
10.13 Genetics of producer organisms	244
Acknowledgements	244
References	

245