

**ENZYME PREPARATIONS USED IN FOOD PROCESSING**  
(as compiled by the ETA members)

Following is a list of enzymes used in food processing in North America. Many are also listed in the Food Chemicals Codex IV Edition. The enzymes and the enzyme assays in the Food Chemicals Codex are listed in Appendix V beginning on page 786.

This is an updated version of the list that was compiled by Pariza and Johnson in "Evaluating the Safety of Microbial Enzyme Preparations Used in Food Processing: Update for a New Century", *Regulatory Toxicology and Pharmacology* (2001) 33: 173-186.

TRIVIAL NAME	CLASSIFICATION	SOURCE	SYSTEMATIC NAMES (IUB) <sup>a</sup>	IUB NO. <sup>a</sup>	CAS NO. <sup>b</sup>
<b>α-Amylase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus oryzae</i> var. (3) <i>Rhizopus oryzae</i> var. (4) <i>Bacillus subtilis</i> var. (5) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus subtilis</i> (6) barley malt (7) <i>Bacillus amyloliquefaciens</i> (8) <i>Bacillus amyloliquefaciens</i> <sup>d</sup> d- <i>Bacillus amyloliquefaciens</i> (9) <i>Bacillus licheniformis</i> (10) <i>Bacillus licheniformis</i> <sup>d</sup> d- <i>Bacillus licheniformis</i> (11) <i>Bacillus licheniformis</i> <sup>d</sup> d- <i>Bacillus stearothermophilus</i> (12) <i>Bacillus stearothermophilus</i> (13) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i> (14) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus megaterium</i> (15) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus stearothermophilus</i> (16) <i>Microbacterium imperiale</i>	1,4-α-D-Glucan glucanohydrolase	3.2.1.1	9000-90-2

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<b>Aminopeptidase</b>	Protease	(1) <i>Aspergillus niger</i> (2) <i>Aspergillus oryzae</i> (3) <i>Rhizopus oryzae</i>	$\alpha$ -Aminoacyl-peptide hydrolase	3.4.11.X	
<b>AMP deaminase</b>	Adenosine deaminase	<i>Aspergillus melleus</i>	AMP aminohydrolase	3.5.4.6	9025-10-9
<b>Arabinofuranosidase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> (2) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i>	$\alpha$ -L-arabinofuranoside arabinofuranohydrolase	3.2.1.55	9067-74-7
<b><math>\beta</math>-Amylase</b>	Carbohydrase	(1) barley malt (2) barley (ungerminated)	1,4- $\alpha$ -D-glucan maltohydrolase	3.2.1.2	9000-91-3
<b>Bromelain</b>	Protease	pineapples: <i>Ananas comosus</i> <i>Ananas bracteatus</i>	none	3.4.22.32 3.4.22.33	37189-34-7 9001-00-7
<b>Catalase</b>	Oxidoreductase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i> (3) bovine liver (4) <i>Micrococcus luteus</i>	hydrogen peroxide: hydrogen peroxide oxidoreductase	1.11.1.6	9001-05-2
<b>Cellulase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> ) (3) <i>Trichoderma reesei</i> <sup>d</sup> d- <i>Trichoderma reesei</i> (4) <i>Trichoderma viride</i> (5) <i>Aspergillus aculeatus</i>	1,4-(1,3;1,4)- $\beta$ -D-glucan 4-glucanohydrolase	3.2.1.4	90012-54-8

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<b>Chymosin</b>	Protease	(1) <i>Aspergillus niger</i> var. <i>awamori</i> <sup>d</sup> d-calf prochymosin gene (2) <i>Escherichia coli</i> K-12 <sup>d</sup> d-calf prochymosin gene (3) <i>Kluyveromyces marxianus</i> var. <i>lactis</i> <sup>d</sup> d-calf prochymosin gene	none	3.4.23.4	9001-98-3
<b>Chymotrypsin</b>	Protease	bovine or porcine pancreatic extract	none	3.4.21.1	9004-07-3
<b>Dextranase</b>	Carbohydrase	(1) <i>Chaetomium erraticum</i> (2) <i>Chaetomium gracile</i>	1,6- $\alpha$ -D-glucan 6-glucohydrolase	3.2.1.11	9025-70-1
<b>Ficin</b>	Protease	figs: <i>Ficus</i> sp.	none	3.4.22.3	9001-33-6
<b>Fructosyl transferase</b>	Transferase	(1) <i>Aspergillus japonicus</i>	1,2- $\beta$ -D-fructan:1,2- $\beta$ -D-fructan 1 <sup>F</sup> - $\beta$ -D-fructosyltransferase	2.4.1.100	73379-55-2
<b><math>\alpha</math>-Galactosidase</b>	Carbohydrase	(1) <i>Mortierella vinacea</i> var. <i>raffinoseutilizer</i> (2) <i>Aspergillus niger</i> (3) <i>Saccharomyces cerevisiae</i> <sup>d</sup> d-Guar seed	$\alpha$ -D-galactoside galactohydrolase	3.2.1.22	90025-35-8
<b><math>\beta</math>-Glucanase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Bacillus subtilis</i> var. (3) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> ) (4) <i>Talaromyces emersonii</i> (formerly <i>Penicillium emersonii</i> ) (5) <i>Bacillus amyloliquefaciens</i> (6) <i>Aspergillus aculeatus</i> (7) <i>Bacillus amyloliquefaciens</i> <sup>d</sup> d- <i>Bacillus amyloliquefaciens</i> (8) <i>Disporotrichum dimorphosporum</i>	1,3-(1,3; 1,4)- $\beta$ -D-glucan 3(4)-glucohydrolase	3.2.1.6	62213-14-3

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<b>Glucoamylase</b> (Amyloglucosidase)	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus oryzae</i> var. (3) <i>Rhizopus oryzae</i> var. (4) <i>Rhizopus niveus</i> (5) <i>Rhizopus delemar</i> (6) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i> (7) <i>Penicillium funiculosum</i>	1-4- $\alpha$ -D-glucan-glucohydrolase	3.2.1.3	9032-08-0
<b>Glucose Isomerase</b>	Isomerase	(1) <i>Actinoplanes missouriensis</i> (2) <i>Bacillus coagulans</i> (3) <i>Streptomyces olivaceus</i> (4) <i>Streptomyces olivochromogenes</i> (5) <i>Streptomyces rubiginosus</i> (6) <i>Streptomyces rubiginosus</i> <sup>d</sup> d- <i>Streptomyces rubiginosus</i> (7) <i>Streptomyces murinus</i> (8) <i>Microbacterium arborescens</i>	D-xylose ketol-isomerase	5.3.1.5	9023-82-9
<b>Glucose Oxidase</b>	Oxidoreductase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i>	$\beta$ -D-glucose: oxygen 1-oxidoreductase	1.1.3.4	9001-37-0
<b>Glutaminase</b>	Glutaminase	<i>Bacillus subtilis</i>	L-glutamine amidohydrolase	3.5.1.2	9001-47-2

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<b>β-D-Glucosidase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> )	β-D-glucoside glucohydrolase	3.2.1.21	9001-22-3
<b>Hemicellulase<sup>c</sup></b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> ) (3) <i>Aspergillus aculeatus</i> (4) <i>Aspergillus foetidus</i>	(1) α-L-arabinofuranoside arabinofuranohydrolase (2) 1,4-β -D-mannan mannanohydrolase (3) 1,3-β-D-xylan xylanohydrolase (4) 1,5-α-L-arabinan 1,5-α-L arabinofuranohydrolase (5) 1,4-β-D-Xylan xylanohydrolase (6) 1,4-β-D-xylan xylohydrolase	3.2.1.55 3.2.1.78 3.2.1.32 3.2.1.99 3.2.1.8 3.2.1.37	9067-74-7 37288-54-3 9025-55-2 75432-96-1 9025-57-4 9025-53-0
<b>Hesperdinase</b>	Carbohydrase	<i>Penicillium decumbens</i>	α-L-Rhamnoside rhamnohydrolase	3.2.1.40	37288-35-0
<b>Invertase</b>	Carbohydrase	<i>Saccharomyces</i> sp. ( <i>Kluyveromyces</i> )	β-D-fructofuranoside fructohydrolase	3.2.1.26	9001-57-4
<b>Lactase</b>	Carbohydrase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus oryzae</i> var. (3) <i>Saccharomyces</i> sp. (4) <i>Candida pseudotropicalis</i> (5) <i>Kluyveromyces marxianus</i> var. <i>lactis</i> (6) <i>Kluyveromyces marxianus</i> var. <i>lactis</i> <sup>d</sup> d- <i>Kluyveromyces marxianus</i> var. <i>lactis</i> (7) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Aspergillus oryzae</i>	β-D-galactoside galactohydrolase	3.2.1.23	9031-11-2

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<b>Lipase<sup>f</sup></b>	Lipase	(1) edible forestomach tissue of calves, kids, and lambs (2) animal pancreatic tissues (3) <i>Aspergillus oryzae</i> var. (4) <i>Aspergillus niger</i> var. (5) <i>Rhizomucor miehei</i> (6) <i>Candida rugosa</i> (7) <i>Rhizopus delemar</i> (8) <i>Rhizopus oryzae</i> (9) <i>Rhizopus niveus</i> (10) <i>Penicillium roqueforti</i> (11) <i>Penicillium camembertii</i> (12) <i>Mucor javanicus</i> (13) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Rhizomucor miehei</i> (14) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Thermomyces lanuginosus</i>	triacylglycerol acylhydrolase	3.1.1.3	9001-62-1
<b>Lysozyme</b>	Hydrolase	Hen egg white	peptidoglycan N-acetylmuramoylhydrolase	3.2.1.17	9001-63-2
<b>Maltogenic Amylase</b>	Carbohydrase	<i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus stearothermophilus</i>	1,4- $\alpha$ -D-glucan a-maltohydrolase	3.2.1.133	160611-47-2
<b>Naringinase</b>	Carbohydrase	<i>Penicillium decumbens</i>	$\alpha$ -L-Rhamnoside rhamnohydrolase	3.2.1.40	37288-35-0
<b>Pancreatin</b>	Mixture of carbohydrase, lipase, and protease	bovine and porcine pancreatic tissue	(1) 1,4- $\alpha$ -D-glucan glucanohydrolase (2) triacylglycerol acylhydrolase (3) protease	3.2.1.1 3.1.1.3 3.4.21.4	9000-90-2 9001-62-1 9002-07-7
<b>Papain</b>	Protease	papaya: <i>Carica papaya</i> (L)	none	3.4.22.2	9001-73-4

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<b>Pectinase<sup>c</sup></b>	Carbohydrase	(1) <i>Aspergillus niger</i> var.	(1) poly(1,4- $\alpha$ -D-galacturonide) glycanohydrolase	3.2.1.15	9032-75-1
		(2) <i>Rhizopus oryzae</i> var.	(2) pectin pectylhydrolase	3.1.1.11	9025-98-3
		(3) <i>Aspergillus aculeatus</i>			
		(4) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Aspergillus aculeatus</i>			
		(5) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i>			
			(3) (1 $\rightarrow$ 4)-6-O-methyl- $\alpha$ -D-galacturonan lyase	4.2.2.2	9015-75-2
			(4) (1 $\rightarrow$ 4)-6-O-methyl- $\alpha$ -D-galacturonan lyase	4.2.2.10	9033-35-6
			(5) $\alpha$ -L-arabinofuranoside arabinofuranohydrolase	3.2.1.55	9067-74-7
			(6) 1,5- $\alpha$ -L-arabinan 1,5- $\alpha$ -L-arabinanohydrolase	3.2.1.99	75432-96-1
			(7) poly(1,4- $\alpha$ -D-galacturonide) galacturonohydrolase	3.2.1.67	9045-35-6
	(8) arabinogalactan 4- $\beta$ -D-galactanohydrolase	3.2.1.89	58182-40-4		
	(9) acetic-ester acetylhydrolase	3.1.1.6	9000-82-2		
	(10) (1 $\rightarrow$ 4)- $\alpha$ -D-galacturonan reducing-end-disaccharide-lyase	4.2.2.9	37290-87-2		
<b>Pepsin</b>	Protease	porcine or other animal stomach tissue	none	3.4.23.1 3.4.23.2	9001-75-6 9025-48-3
<b>Phosphodiesterase</b>	Nuclease	(1) <i>Penicillium citrinum</i> (2) <i>Leptographium procerum</i> (formerly <i>Verticicladiella procera</i> )	Oligonucleate 5'-nucleotidohydrolase	3.1.4.1	9025-82-5

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<b>Phospholipase A<sub>2</sub></b>	Lipase	(1) animal pancreatic tissue (2) <i>Streptomyces violaceoruber</i> (3) <i>Aspergillus niger</i> <sup>d</sup> d- porcine pancreas (4) <i>Streptomyces chromofuscus</i>	phosphatidylcholine 2-acylhydrolase	3.1.1.4	9001-84-7
<b>Phytase</b>	Phosphatase	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i>	(1) myo-inositol-hexakisphosphate-3-phosphohydrolase (2) orthophosphoric-monoester phosphohydrolase	3.1.3.8 3.1.3.2	37288-11-2 9001-77-8
<b>Protease (general)</b>	Protease	(1) <i>Aspergillus niger</i> var. (2) <i>Aspergillus oryzae</i> var. (3) <i>Aspergillus melleus</i> (4) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus amyloliquefaciens</i> (5) <i>Bacillus subtilis</i> (6) <i>Bacillus amyloliquefaciens</i> <sup>d</sup> d- <i>Bacillus amyloliquefaciens</i> (7) <i>Bacillus licheniformis</i> var. (8) <i>Bacillus stearothermophilus</i> (9) <i>Rhizopus niveus</i> (10) <i>Rhizopus oryzae</i> (11) <i>Bacillus amyloliquefaciens</i> (12) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Rhizomucor miehei</i>	none	3.4.23.18  3.4.21.62 3.4.24.28   3.4.11.1	9025-49-4  9014-01-1 76774-43-1 9068-59-1  9073-79-4 9001-61-0 90119-07-6

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<b>Pullulanase</b>	Carbohydrase	(1) <i>Bacillus acidopullulyticus</i> (2) <i>Bacillus licheniformis</i> <sup>d</sup> d- <i>Bacillus deramificans</i> (3) <i>Bacillus naganoensis</i> (4) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus naganoensis</i> (5) <i>Bacillus circulans</i> (6) <i>Klebsiella planticola</i> <sup>d</sup> d- <i>Klebsiella planticola</i>	pullulan $\alpha$ -1,6-glucanohydrolase	3.2.1.41	9075-68-7
<b>Rennet</b>	Protease	(1) fourth stomach of ruminant animals (2) <i>Cryphonectria parasitica</i> (formerly <i>Endothia parasitica</i> ) (3) <i>Cryphonectria parasitica</i> <sup>d</sup> d- <i>Cryphonectria parasitica</i> (4) <i>Rhizomucor miehei</i> (5) <i>Rhizomucor pusillus</i> (Lindt) (6) <i>Bacillus cereus</i> (7) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Rhizomucor miehei</i>	none	3.4.23.4 3.4.23.22 3.4.23.23	9001-98-3 37205-60-0 148465-73-0
<b>Transglucosidase</b>	Glucanotransferase	<i>Aspergillus niger</i>	1,4- $\alpha$ -D-glucan 4- $\alpha$ -D-glycosyltransferase	2.4.1.25	9032-09-1
<b>Transglutaminase</b>	Acyltransferase	<i>Streptoverticillium mobaraensis</i> var.	protein-glutamine:amine $\gamma$ -glutamyltransferase	2.3.2.13	80146-85-6
<b>Trypsin</b>	Protease	animal pancreas	None	3.4.21.4	9002-07-7
<b>Urease</b>	Urease	<i>Lactobacillus fermentum</i>	urea amidohydrolase	3.5.1.5	9002-13-5

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<b>Xylanase</b>	Carbohydrase	(1) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> ) <sup>d</sup> d- <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> )	1,4-β-D-xylan xylanohydrolase	3.2.1.8	9025-57-4
		(2) <i>Aspergillus niger</i> var. <i>awamori</i> <sup>d</sup> d- <i>Aspergillus</i> var.	1,3-β-D-xylan xylanohydrolase	3.2.1.32	9025-55-2
		(3) <i>Bacillus licheniformis</i> <sup>d</sup> d- <i>Bacillus licheniformis</i>			
		(4) <i>Aspergillus oryzae</i> <sup>d</sup> d- <i>Thermomyces lanuginosus</i>			
		(5) <i>Disporotrichum dimorphosporum</i>			
		(6) <i>Aspergillus niger</i> <sup>d</sup> d- <i>Aspergillus niger</i>			
		(7) <i>Trichoderma reesei</i> (formerly <i>T. longibrachiatum</i> )			
		(8) <i>Bacillus subtilis</i> <sup>d</sup> d- <i>Bacillus subtilis</i>			

<sup>a</sup>Enzyme Nomenclature: Recommendations of the Nomenclature Committee of the International Union of Biochemistry (available at [www.chem.qmul.ac.uk/iubmb/enzyme/](http://www.chem.qmul.ac.uk/iubmb/enzyme/))

<sup>b</sup>Chemical Abstract Service Registry Number

<sup>c</sup>Usually a mixture of polygalacturonate hydrolase, arabinosidase, mannosidase, and xylanase.

<sup>d</sup> A genetically modified organism. The donor organism is listed after “d-”.

<sup>e</sup>Usually a mixture of the activities listed under the systematic name (common names include pectin depolymerase, pectin methylesterase, pectate lyase, and pectin lyase).

<sup>f</sup> Lipase includes esterase and lysophospholipase.