

ANNEX (new entries are highlighted in yellow)

PERMITTED ENZYMES

(A) Enzymes derived from animal sources

Enzyme	EC Number	Source
Catalase	1.11.1.6	Bovine liver
Lactoperoxidase	1.11.1.7	Bovine milk
Lipase, triacylglycerol	3.1.1.3	Bovine stomach; salivary glands or forestomach of calf, kid or lamb; porcine or bovine pancreas
Lysozyme	3.2.1.17	Egg whites
Pancreatin (or pancreatic elastase)	3.4.21.36	Pancreas of the hog or ox
Pepsin	3.4.23.1	Bovine or porcine stomach
Phospholipase A2	3.1.1.4	Porcine pancreas
Rennet	3.4.23.4	Aqueous extracts from the fourth stomach of calves, kids, lambs, and adult bovine animals, sheep and goats
Thrombin	3.4.21.5	Bovine or porcine blood
Trypsin	3.4.21.4	Porcine or bovine pancreas

(B) Enzymes derived from plant sources

Enzyme	EC Number	Source
Alpha-amylase	3.2.1.1	Malted cereals
Actinidin	3.4.22.14	Kiwifruit (<i>Actinidia deliciosa</i>)
Beta-Amylase	3.2.1.2	Malted cereals
		Sweet potato (<i>Ipomoea batatas</i>)
Bromelain	3.4.22.4	Pineapple fruit/stem (<i>Ananas comosus</i> and <i>Ananas bracteatus</i> (L))
Ficin	3.4.22.3	<i>Ficus</i> spp.
Lipoxidase	1.13.11.12	Soyabean whey or meal
Papain	3.4.22.2	<i>Carica papaya</i> (L) (Fam. <i>Caricaceae</i>)

(C) Enzymes derived from microbial sources

Enzyme	EC Number	Production organism	Donor organism	Donor gene
1,4-alpha-glucan branching enzyme	2.4.1.18	<i>Bacillus subtilis</i>	<i>Rhodothermus obamensis</i>	1,4-alpha-glucan branching enzyme
Alpha-acetolactate decarboxylase	4.1.1.5	<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus subtilis</i>		
		<i>Bacillus subtilis</i>	<i>Bacillus brevis</i>	Alpha-acetolactate decarboxylase
Alpha-amylase	3.2.1.1	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Alpha-amylase
		<i>Aspergillus niger</i> ¹	<i>Rhizomucor pusillus</i>	Alpha-amylase
		<i>Aspergillus oryzae</i>		
		<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus amyloliquefaciens</i>	<i>Bacillus amyloliquefaciens</i>	Alpha-amylase
		<i>Bacillus licheniformis</i>		
		<i>Bacillus licheniformis</i>	<i>Bacillus amyloliquefaciens</i>	Alpha-amylase
		<i>Bacillus licheniformis</i>	<i>Bacillus licheniformis</i>	Alpha-amylase
		<i>Bacillus licheniformis</i>	<i>Bacillus licheniformis</i> and <i>Bacillus amyloliquefaciens</i>	Alpha-amylase
		<i>Bacillus licheniformis</i>	<i>Geobacillus stearothermophilus</i> ²	Alpha-amylase
		<i>Bacillus licheniformis</i>	<i>Pseudomonas stutzeri</i>	Alpha-amylase
		<i>Bacillus subtilis</i>		
		<i>Bacillus subtilis</i>	<i>Bacillus megaterium</i>	Alpha-amylase
		<i>Bacillus subtilis</i>	<i>Geobacillus stearothermophilus</i> ²	Alpha-amylase
		<i>Geobacillus stearothermophilus</i> ²		
		<i>Geobacillus stearothermophilus</i> ²	<i>Geobacillus stearothermophilus</i> ²	Alpha-amylase
<i>Microbacterium imperiale</i>				
<i>Pseudomonas fluorescens</i>	<i>Thermococcales</i>	Alpha-amylase		
<i>Rhizopus oryzae</i>				
<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus kawachii</i>	Alpha-amylase		
Alpha-arabinofuranosidase	3.2.1.55	<i>Aspergillus niger</i> ¹		
Alpha-galactosidase	3.2.1.22	<i>Aspergillus niger</i> ¹		
Alpha-glucosidase (or maltase)	3.2.1.20	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus oryzae</i>		
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus niger</i> ¹	Alpha-glucosidase (or maltase)

Enzyme	EC Number	Production organism	Donor organism	Donor gene
Aminopeptidase	3.4.11.1	<i>Aspergillus oryzae</i> <i>Lactococcus lactis</i>		
Amylomaltase	2.4.1.25	<i>Bacillus amyloliquefaciens</i>	<i>Thermus thermophilus</i>	Amylomaltase
Asparaginase	3.5.1.1	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Bacillus subtilis</i>	<i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Pyrococcus furiosus</i>	Asparaginase Asparaginase Asparaginase
Aspergillopepsin I	3.4.23.18	<i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Trichoderma longibrachiatum</i> ³	<i>Trichoderma longibrachiatum</i> ³	Aspergillopepsin I
Aspergillopepsin II	3.4.23.19	<i>Aspergillus niger</i> ¹		
Beta-amylase	3.2.1.2	<i>Bacillus amyloliquefaciens</i> <i>Bacillus subtilis</i>		
Beta-fructofuranosidase (invertase or saccharase)	3.2.1.26	<i>Aspergillus japonicus</i> <i>Aspergillus niger</i> ¹ <i>Saccharomyces cerevisiae</i>		
Beta-galactosidase (or lactase)	3.2.1.23	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Bacillus circulans</i> ATCC 31382 <i>Kluyveromyces lactis</i> ⁴ <i>Kluyveromyces marxianus</i> ⁵ <i>Saccharomyces sp.</i>	<i>Aspergillus oryzae</i>	Beta-galactosidase (or lactase)
Beta-glucanase (endo-beta glucanase or endo-1,3-beta-glucanase)	3.2.1.6	<i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Bacillus amyloliquefaciens</i> <i>Bacillus subtilis</i> <i>Bacillus subtilis</i> <i>Disporotrichum dimorphosporum</i> <i>Humicola insolens</i> <i>Rasamsonia emersonii</i> ⁶ <i>Trichoderma longibrachiatum</i> ³	<i>Bacillus amyloliquefaciens</i> <i>Bacillus subtilis</i>	Beta-glucanase (endo-beta glucanase or endo-1,3-beta-glucanase) Beta-glucanase (endo-beta glucanase or endo-1,3-beta-glucanase)
Beta-glucosidase	3.2.1.21	<i>Aspergillus niger</i> ¹		
Carboxylesterase	3.1.1.1	<i>Rhizomucor miehei</i> ⁷		
Carboxypeptidase C	3.4.16.5	<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Carboxypeptidase C
Catalase	1.11.1.6	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> ¹ <i>Micrococcus luteus</i> ⁸	<i>Aspergillus niger</i> ¹	Catalase
Cellulase	3.2.1.4	<i>Aspergillus niger</i> ¹ <i>Penicillium funiculosum</i> <i>Rasamsonia emersonii</i> ⁶ <i>Trichoderma longibrachiatum</i> ³ <i>Trichoderma longibrachiatum</i> ³ <i>Trichoderma viride</i>	<i>Trichoderma longibrachiatum</i> ³	Cellulase
Chymosin	3.4.23.4	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> var. <i>awamori</i> <i>Escherichia coli</i> K-12 strain GE81 <i>Kluyveromyces lactis</i> ⁴	<i>Camelus dromedarius</i>	Chymosin
Cyclodextrin glucanotransferase	2.4.1.19	<i>Bacillus licheniformis</i> <i>Paenibacillus macerans</i> ⁹	<i>Thermoanaerobacter sp.</i>	Cyclodextrin glucanotransferase
Deaminase	3.5.4.6	<i>Aspergillus melleus</i> <i>Chaetomium erraticum</i>		
Dextranase	3.2.1.11	<i>Chaetomium gracile</i> <i>Penicillium lilacinum</i>		
Endo-arabinase	3.2.1.99	<i>Aspergillus niger</i> ¹		
Endo-protease	3.4.21.26	<i>Aspergillus niger</i> ¹		
Glucan 1,3-beta-glucosidase	3.2.1.58	<i>Trichoderma harzianum</i>		
Endo-1,3-beta-xylanase	3.2.1.32	<i>Humicola insolens</i>		
Endo-1,4-beta-xylanase	3.2.1.8	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> ¹ <i>Aspergillus oryzae</i> <i>Aspergillus oryzae</i> <i>Aspergillus oryzae</i> <i>Bacillus amyloliquefaciens</i> <i>Bacillus licheniformis</i> <i>Bacillus subtilis</i>	<i>Aspergillus niger</i> ¹ <i>Aspergillus niger</i> ¹ <i>Aspergillus aculeatus</i> <i>Humicola lanuginosa</i> ¹⁰ <i>Bacillus licheniformis</i>	Endo-1,4-beta-xylanase Endo-1,4-beta-xylanase Endo-1,4-beta-xylanase Endo-1,4-beta-xylanase Endo-1,4-beta-xylanase

Enzyme	EC Number	Production organism	Donor organism	Donor gene
		<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	Endo-1,4-beta-xylanase
		<i>Disporotrichum dimorphosporum</i>		
		<i>Humicola insolens</i>		
		<i>Rasamsonia emersonii</i> ⁶		
		<i>Trichoderma longibrachiatum</i> ³		
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus niger</i> ¹	Endo-1,4-beta-xylanase
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus tubingensis</i>	Endo-1,4-beta-xylanase
		<i>Trichoderma longibrachiatum</i> ³	<i>Thermopolyspora flexuosa</i> ¹¹	Endo-1,4-beta-xylanase
Glucoamylase (or amyloglucosidase)	3.2.1.3	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Glucoamylase (or amyloglucosidase)
		<i>Aspergillus niger</i> ¹	<i>Penicillium oxalicum</i>	Glucoamylase (or amyloglucosidase)
		<i>Aspergillus niger</i> ¹	<i>Talaromyces emersonii</i>	Glucoamylase (or amyloglucosidase)
		<i>Aspergillus niger</i> ¹	<i>Trametes cingulata</i>	Glucoamylase (or amyloglucosidase)
		<i>Aspergillus oryzae</i>		
		<i>Rhizopus delemar</i>		
		<i>Rhizopus niveus</i>		
		<i>Rhizopus oryzae</i>		
		<i>Trichoderma longibrachiatum</i> ³	<i>Trichoderma longibrachiatum</i> ³	Glucoamylase (or amyloglucosidase)
Glucose isomerase (or xylose isomerase)	5.3.1.5	<i>Actinoplanes missouriensis</i>		
		<i>Bacillus coagulans</i>		
		<i>Microbacterium arborescens</i>		
		<i>Streptomyces olivaceus</i>		
		<i>Streptomyces olivochromogenes</i>		
		<i>Streptomyces murinus</i>		
		<i>Streptomyces rubiginosus</i>		
		<i>Streptomyces rubiginosus</i>	<i>Streptomyces rubiginosus</i>	Glucose isomerase (or xylose isomerase)
Glucose oxidase	1.1.3.4	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Glucose oxidase
		<i>Aspergillus niger</i> ¹	<i>Penicillium chrysogenum</i>	Glucose oxidase
		<i>Aspergillus oryzae</i>	<i>Aspergillus niger</i> ¹	Glucose oxidase
Glutaminase	3.5.1.2	<i>Bacillus amyloliquefaciens</i>		
Glycerophospholipid cholesterol acyltransferase	2.3.1.43	<i>Bacillus licheniformis</i>	<i>Aeromonas salmonicida subsp. salmonicida</i>	Glycerophospholipid cholesterol acyltransferase
Hexose oxidase	1.1.3.5	<i>Hansenula polymorpha</i> ¹²	<i>Chondrus crispus</i>	Hexose oxidase
Inulinase	3.2.1.7	<i>Aspergillus niger</i> ¹		
Lipase, monoacylglycerol	3.1.1.23	<i>Penicillium camembertii</i>		
Lipase, triacylglycerol	3.1.1.3	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Candida antarctica</i>	Lipase, triacylglycerol
		<i>Aspergillus niger</i> ¹	<i>Fusarium culmorum</i>	Lipase, triacylglycerol
		<i>Aspergillus oryzae</i>		
		<i>Aspergillus oryzae</i>	<i>Fusarium oxysporum</i>	Lipase, triacylglycerol
		<i>Aspergillus oryzae</i>	<i>Humicola lanuginosa</i> ¹⁰	Lipase, triacylglycerol
		<i>Aspergillus oryzae</i>	<i>Rhizomucor miehei</i> ⁷	Lipase, triacylglycerol
		<i>Aspergillus oryzae</i>	<i>Humicola lanuginosa</i> ¹⁰ and <i>Fusarium oxysporum</i>	Lipase, triacylglycerol
		<i>Candida rugosa</i>		
		<i>Hansenula polymorpha</i> ¹²	<i>Fusarium heterosporum</i>	Lipase, triacylglycerol
		<i>Mucor javanicus</i> ¹³		
		<i>Penicillium roquefortii</i> ¹⁴		
		<i>Rhizomucor miehei</i> ⁷		
		<i>Rhizopus arrhizus</i>		
<i>Rhizopus niveus</i>				
<i>Rhizopus oryzae</i>				
Lysophospholipase	3.1.1.5	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Lysophospholipase
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus nishimurae</i>	Lysophospholipase
Maltogenic alpha-amylase	3.2.1.133	<i>Bacillus licheniformis</i>	<i>Geobacillus stearothermophilus</i> ²	Maltogenic alpha-amylase
		<i>Bacillus subtilis</i>	<i>Geobacillus stearothermophilus</i> ²	Maltogenic alpha-amylase
Maltotetrahydrolase	3.2.1.60	<i>Bacillus licheniformis</i>	<i>Pseudomonas stutzeri</i>	Maltotetrahydrolase
Mannan endo-1,4-beta-mannosidase	3.2.1.78	<i>Aspergillus niger</i> ¹		
		<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus subtilis</i>		
		<i>Trichoderma longibrachiatum</i> ³		
Metalloproteinase ¹⁵	3.4.24.4	<i>Aspergillus oryzae</i>		
		<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus coagulans</i>		
		<i>Bacillus subtilis</i>		

Enzyme	EC Number	Production organism	Donor organism	Donor gene
		<i>Geobacillus stearothermophilus</i> ²		
Mucorpepsin (or aspartic proteinase)	3.4.23.23	<i>Aspergillus oryzae</i>		
		<i>Aspergillus oryzae</i>	<i>Rhizomucor miehei</i> ⁷	Aspartic proteinase
		<i>Cryphonectria parasitica</i>		
		<i>Rhizomucor miehei</i> ⁷		
Pectin esterase	3.1.1.11	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Pectin esterase
		<i>Aspergillus oryzae</i>	<i>Aspergillus aculeatus</i>	Pectin esterase
Pectin lyase	4.2.2.10	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Pectin lyase
		<i>Aspergillus niger</i> ¹	<i>Trichoderma longibrachiatum</i> ³	Pectin lyase
Peroxidase	1.11.1.7	<i>Aspergillus niger</i> ¹	<i>Marasmius scorodonius</i>	Peroxidase
Phosphodiesterase I	3.1.4.1	<i>Leptographium procerum</i>		
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus nishimurae</i>	Phospholipase A2
Phospholipase A1	3.1.1.32	<i>Aspergillus oryzae</i>	<i>Fusarium venenatum</i>	Phospholipase A1
Phospholipase A2	3.1.1.4	<i>Aspergillus niger</i> ¹	Porcine pancreas	Phospholipase A2
		<i>Streptomyces violaceoruber</i>		
Phospholipase C	3.1.4.3	<i>Pichia pastoris</i>	Isolated from soil	Phospholipase C
3-Phytase	3.1.3.8	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	3-phytase
4-Phytase	3.1.3.26	<i>Aspergillus oryzae</i>	<i>Peniophora lycii</i>	4-Phytase
Polygalacturonase (pectinase)	3.2.1.15	<i>Aspergillus niger</i> ¹		
		<i>Aspergillus niger</i> ¹	<i>Aspergillus niger</i> ¹	Polygalacturonase (pectinase)
		<i>Aspergillus oryzae</i>		
		<i>Aspergillus oryzae</i>	<i>Aspergillus aculeatus</i>	Polygalacturonase (pectinase)
		<i>Rhizopus oryzae</i>		
		<i>Trichoderma longibrachiatum</i> ³		
Pullulanase	3.2.1.41	<i>Bacillus acidopullulyticus</i>		
		<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus licheniformis</i>		
		<i>Bacillus licheniformis</i>	<i>Bacillus deramificans</i>	Pullulanase
		<i>Bacillus subtilis</i>		
		<i>Bacillus subtilis</i>	<i>Bacillus acidopullulyticus</i>	Pullulanase
		<i>Bacillus subtilis</i>	<i>Bacillus deramificans</i>	Pullulanase
		<i>Bacillus subtilis</i>	<i>Bacillus naganensis</i>	Pullulanase
		<i>Klebsiella pneumoniae</i> ¹⁶		
		<i>Pullulanibacillus sp.</i>		
Ribonuclease	3.1.26.5	<i>Penicillium citrinum</i>		
Serine proteinase ¹⁷	3.4.21.14	<i>Aspergillus melleus</i>		
		<i>Aspergillus oryzae</i>		
		<i>Bacillus amyloliquefaciens</i>		
		<i>Bacillus halodurans</i>		
		<i>Bacillus licheniformis</i>		
		<i>Bacillus subtilis</i>		
Serine protease (Chymotrypsin)	3.4.21.1	<i>Bacillus licheniformis</i>	<i>Nocardioopsis prasina</i>	Serine protease (Chymotrypsin)
Serine protease with trypsin specificity	3.4.21.4	<i>Fusarium venenatum</i>	<i>Fusarium oxysporum</i>	Serine protease with trypsin specificity
Tannase	3.1.1.20	<i>Aspergillus oryzae</i>		
Transglucosidase	2.4.1.24	<i>Aspergillus niger</i> ¹		
		<i>Trichoderma longibrachiatum</i> ³	<i>Aspergillus niger</i> ¹	Transglucosidase
Transglutaminase	2.3.2.13	<i>Streptomyces mobaraensis</i> ¹⁸		
Urease	3.5.1.5	<i>Lactobacillus fermentum</i>		

¹ *Aspergillus niger* group includes *A. aculeatus*, *A. awamori*, *A. ficuum*, *A. foetidus*, *A. japonicus*, *A. phoenicis*, *A. saitoi* and *A. usarii*.

² *Geobacillus stearothermophilus* – former name *Bacillus stearothermophilus*.

³ *Trichoderma longibrachiatum* also known as *Trichoderma reesei*.

⁴ *Kluyveromyces lactis* – former name *Saccharomyces lactis*.

⁵ *Kluyveromyces marxianus* – former names *Saccharomyces fragilis* and *Kluyveromyces fragilis*.

⁶ *Rasamsonia emersonii* – former name *Talaromyces emersonii*.

⁷ *Rhizomucor miehei* – former name *Mucor miehei*.

⁸ *Micrococcus luteus* – former name *Micrococcus lysodeikticus*.

⁹ *Paenibacillus macerans* – former name *Bacillus macerans*.

¹⁰ *Humicola lanuginosa* also known as *Thermomyces lanuginosus*.

¹¹ *Thermopolyspora flexuosa* – former name *Nonomuraea flexuosa*.

¹² *Hansenula polymorpha* also known as *Pichia angusta*.

¹³ *Mucor javanicus* also known as *Mucor circinelloides* f. *circinelloides*.

¹⁴ *Penicillium roquefortii* also known as *Penicillium roqueforti*.

¹⁵ Metalloproteinase (EC 3.4.24.4) includes vibriolysin (EC 3.4.24.25), pseudolysin (EC 3.4.24.26), thermolysin (3.4.24.27), bacillolysin (EC 3.4.24.28), aureolysin (EC 3.4.24.29), coccolysin (EC 3.4.24.30), mycolysin (EC 3.4.24.31), beta-lytic metalloendopeptidase (EC 3.4.24.32), deuterolysin (EC 3.4.24.39), serralysin (EC 3.4.24.40).

¹⁶ *Klebsiella pneumoniae* – former name *Klebsiella aerogenes*.

¹⁷ Serine proteinase (EC 3.4.21.14) includes oryzin (EC 3.4.21.63).

¹⁸ *Streptomyces mobaraensis* – former name *Streptovercillium mobaraense*.