

Supplementary Data

Table 1. The classification halophiles on the basis of optimum salt concentrations for growth

Sl. No.	Categories	NaCl Concentration
1	Extreme halophiles	2.5-5.2 M
2	Borderline extreme halophiles	1.5-4.0 M
2	Moderate halophiles	0.5-2.5 M
3	Slight halophiles	0.2-0.5 M
4	Non-halophiles/Halo-tolerant	less than 0.2 M

Table 2. Hypersaline environments on the basis of brines

Sl. No.	Hypersaline Environments	Origin	Chemistry	Example
1.	Athalassohaline halobacterial environments	Evaporation of water bodies	Brines have sodium and chloride, but magnesium and calcium as the main ions. Alkaline pH	Salt Lakes Dead Sea
2.	Thalassohaline halobacterial environments	Evaporation of water bodies (especially Sea)	Brines have sodium and chloride as the main ions. A neutral to slightly alkaline pH	Solar Salterns Deep lake (Antarctica)
3.	Hypersaline soils	Rhizosphere of halophilic plants	Brines have chloride as the main ion.	Some places in Spain and USSR

Table 3. The classifications of halophilic archea

Genus and Species	Morphology	Source	References
Genus <i>Halobacterium</i>			
<i>Halobacterium vallismortis</i>	Rod – shaped/ pleomorphic	Salt pool	(43)
<i>Halobacterium jilantaiense</i>	Rod – shaped or pleomorphic	Salt Lake	(44)
<i>Halobacterium rubrum</i>	Rod – shaped or pleomorphic	Saltern	(45)
<i>Halobacterium noricense</i>	Rod – shaped or pleomorphic	<i>Halobacterium noricense</i>	(46)
<i>Halobacterium salinarum</i>	Rod – shaped or pleomorphic	Salted hides, salted fish	(40)
Genus <i>Halorussus</i>			
<i>Halorus susrarus</i>	Rod shaped and motile	Marine solar saltern	(42)
<i>Halorus susruber</i>	Rod shaped and motile	Salt Lake	(43)
<i>Halorus susamylolyticus</i>	Rod shaped and motile	Salt Lake	(44)
Genus <i>Haladaptatus</i>			
<i>Haladaptatus pauchihalophilus</i>	Coccus – shaped and non-motile	Low salt spring	(44)
<i>Haladaptatus litoreus</i>	Coccus – shaped and non-motile	Solar Saltern	(46)
<i>Haladaptatus pallidirubidus</i>	Coccus – shaped and non-motile	Saline soil	(41)

Genus <i>Halalkalicoccus</i>			
<i>Halalkalicoccus tibetensis</i>	Coccus – shaped and non-motile	Saline lake	(44)
Genus <i>Halarchaeum</i>			
<i>Halarchaeum salinum</i>	Non – motile and pleomorphic	Commercial salt	(45)
Genus <i>Halarchaeobius</i>			
<i>Halarchaeobius salinus</i>	-	Salt Lake	(45)
<i>Halarchaeobius amylolyticus</i>	square	Solar salt	(46)
Genus <i>Halococcus</i>			
<i>Halococcus morrhuae</i>	coccus	Salt Lake, sea water, salterns	(44)
<i>Halococcus salifodinae</i>	coccus	Salt deposit	(43)
<i>Halococcus qingdaonensis</i>	coccus	Sea salt	(43)
Genus <i>Halorhabdus</i>			
<i>Halorhabdus tiamaeta</i>	pleomorphic	Red Sea	(46)
<i>Halorhabdus utahensis</i>	pleomorphic	Salt Lake	(46)
<i>Halorhabdus rudnickae</i>	pleomorphic	Salt- mining area	
Genus <i>Haloquadratum</i>			

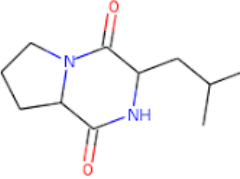
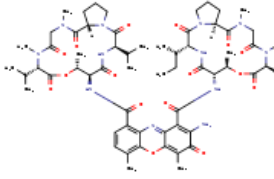
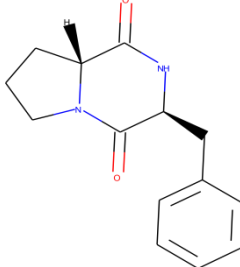
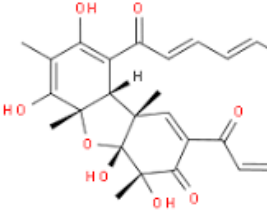
<i>Haloquadratum walsbyi</i>	Square-shaped and non-motile	Salterns	(46)
Genus <i>Natronococcus</i>			
<i>Natronococcus roseus</i>	coccus	Hypersaline lake	(46)
Genus <i>Halostagnicola</i>			
<i>Halostagnicola hispanica</i>	Coccus and oval shaped	Salt Lake	(45)
Genus <i>Halorubrum</i>			
<i>Halorubrum ejinorensense</i>	Rod	Lake	(45)
<i>Halorubrum tibetense</i>	Irregular rod	Lake	(46)
<i>Halorubrum orientale</i>	Pleomorphic cells	Saline lake	(46)
<i>Halorubrum sodomense</i>	Rods	Dead Sea	(44)
Genus <i>Natronobacterium</i>			
<i>Natronobacterium vacuolatum</i>	Rod or spherical shaped	Lake Magadi	(46)
<i>Natronobacterium gregoryi</i>	cocci, bacillus, spirochetes	Lake Magadi	(46)
<i>Natronobacterium pharaonis</i>	Circular shaped	Saline soda lakes Egypt and Kenya	(46)
Genus <i>Haloferax</i>			
<i>Haloferax mediterranei</i>	Pleomorphic	Marine saltern	(45)
<i>Haloferax volcanii</i>	No cell wall and uses layer for structure	Dead Sea, Great Salt Lake	(45)
Genus <i>Haloarcula</i>			

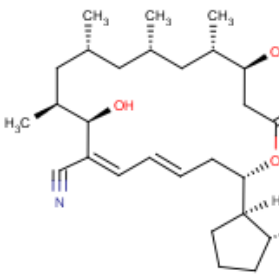
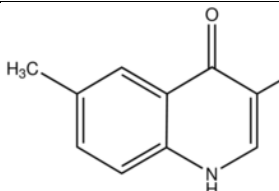
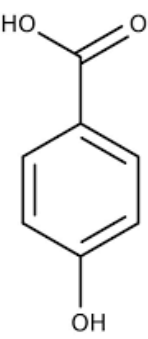
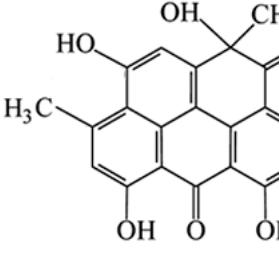
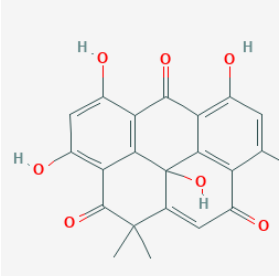
<i>Haloarcula japonica</i>	Non-vaculated flat triangular shape	Japan	(46)
<i>Haloarculacaliforniae</i>	Non-vaculated rod	California	(45)
<i>Haloarculasinaiensis</i>	Box shaped	Sinai	(45)

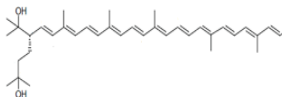
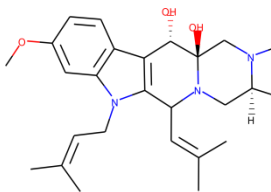
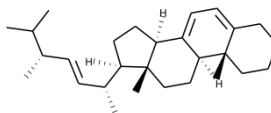
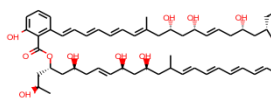
Table 4. Some potential compounds produced by the archaea (6, 46)

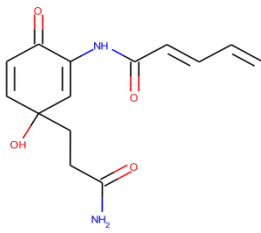
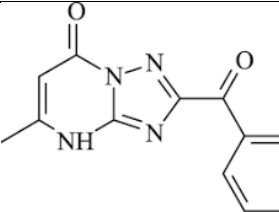
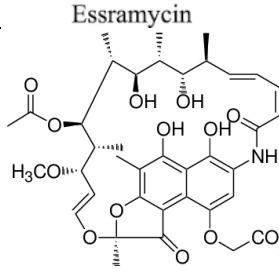
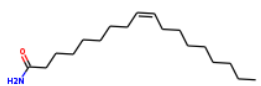
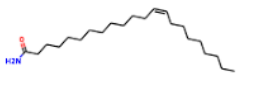
Species	Molecule
<i>Haloferax alexandrines</i>	Canthaxanthin
<i>Natrialba magadii</i>	2-sulfotrehalose
<i>Halo salifodinae</i> MPM-TC	Perfluorotributylamine Cyclopentane, 1-butyl-2-ethyl- 1,10-Biphenyl]-3-amine Pyridine, 4-(phenylmethyl)- Hexadecane, 2-methyl- Nonadecane Phytol
<i>Nocardiopsis</i> sp. AJ1	Pyrrolo (1,2-A (pyrazine-1,4-dione, hexahydro- 3[2methyl propyl]-) Actinomycin C2
<i>Nocardiopsis</i> sp. HR-4	Angucyclines Angucyclinones
<i>Nocardiopsis</i> sp. HYJ128	Borrelidin C and D
<i>Nocardiopsisisterrae</i> YIM 90022	Quinoline alkaloid (4-oxo-1,4 dihydroquinoline-3- carboxamide) N-acetyl-anthranilic acid Indole-3-carboxylic acid
<i>Nocardiopsis gilva</i> YIM90087	4,7-bis(4-methoxyphenyl)-6-hydroxy- 5methoxybenzo[d] thiazole Novobiocin
<i>Haloterrigena hispanica</i>	Cyclo(D-prolyl-L-tyrosine) cyclo(L-prolyl-L- tyrosine) cyclo(L-prolyl-L-phenylalanine) cyclo(L-prolyl-L-isoleucine) cyclo(L-prolyl-L-valine)

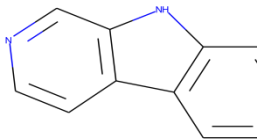
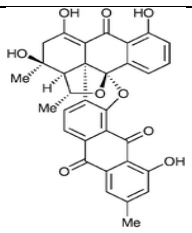
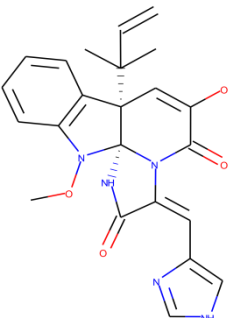
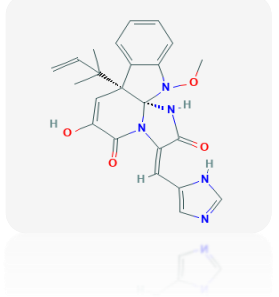
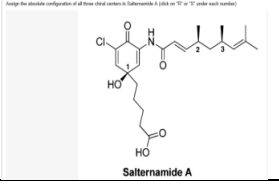
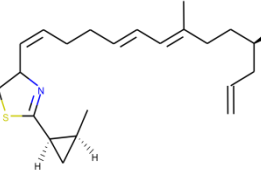
Table 5. Some bioactive compounds and their structure

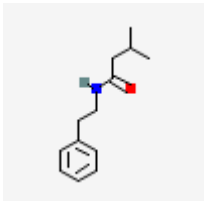
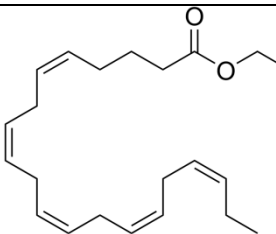
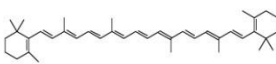
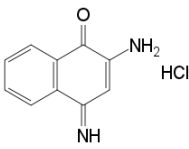
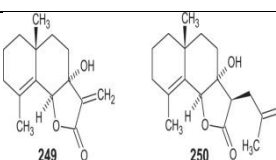
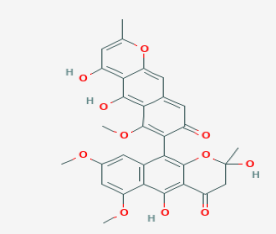
S. No.	Compound	Structure	Bioactivity	Source Microbe	Reference
1.	Pyrrolo (1,2-A(pyrazine-1,4-dione,hexahydro-3-[2-methylpropyl]-)		Antimicrobial activity	Nocardiopsis sp. A JI	(41)
2.	Actinomycin C2		Antimicrobial activity	Nocardiopsis sp. A JI	(41)
3.	Cyclo-(L-Pro-L-Phe)		Antimicrobial activity	Alcaligenes faecalis A72	(42)
4.	Bisvertinolone		Antimicrobial activity	Fungi	(43)

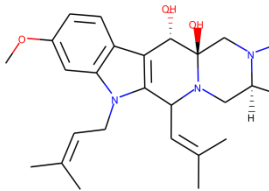
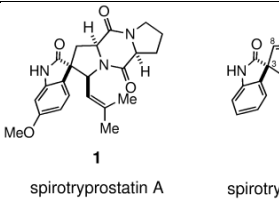
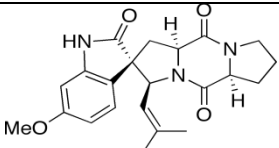
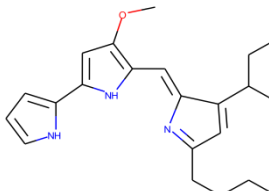
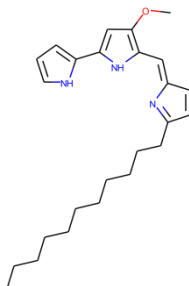
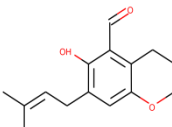
5.	Borrelidin C		Antimicrobial activity	Nocardiopsis sp. HYJ128	(44)
6.	4-oxo-1,4-dihydroquinoline-3-carboxamide		Antibacterial activity, antifungal activity	Its chemically synthesized	(44)
7.	p-hydroxybenzoic acid		Antimicrobial activity	Actinomycetes	(35)
8.	1-hydroxy-1-norresistomycin		Antioxidant activity	Actinomycetes	(34)
9.	Resistoflavine		Antibacterial activity, anticancerous	Actinomycetes	(32)

10.	Nonadecane		Antimicrobial activity	Archea	(38)
11.	Bacterioruberin		Anticancerous activity	Archea	(44)
12.	Fumitremorgin B		Cytotoxic activity	<i>Aspergillus fumigates</i>	(46)
13.	Ergosterols		Cytotoxic activity	Rhizopus sp.	(32)
14.	Marinomycin A		Antibiotic, Antitumour	Actinomycetes	(31)

15.	Daryamide C		Antitumour	Actinomycetes	(33)
16.	Essramycin		Antibiotic activity	Actinomycetes	(22)
17.	Rifamycin B	 18, Rifamycin B	Antibiotic	Actinobacteria	(24)
18.	9-octadecanamide		Anti-oxidant property	Bacteria	(46)
19.	13-cis-docosenamide		Antibacterial and cytotoxic activity	Bacteria	(44)

20.	Norharman		Antimicrobial activity	<i>Pseudoalteromonas piscicida</i>	(25)
21.	BE-43472B	 6: BE-43472B	Bactericidal activity	<i>Ecteinascidia turbinata</i>	(28)
22.	Oxaline		Antitumour	<i>Penicillium oxalicum</i>	(41)
23.	Meleagrins		Antitumour, Antibacterial	Fungi	(42)
24.	Salternamide A	 Salternamide A		Actinobacteria	(46)
25.	Curacin A		Antimicrotubule	Cyanobacteria	(44)

26.	3-Methyl-N-(2-phenylethyl) butanamide (11)		Antifouling	Letendreaehelmi nthicola	(45)
27.	Eicosapentanoic acid (EPA)		Heart disease treatment, anti-inflammatory agent	Algae	(23)
28.	B- carotene		Antioxidant activity	Dunaliellasalina	(27)
29.	Naphthoquinoneimine		Antifungal activity	<i>Aspergillus niger</i> EN-13	(34)
30.	Asperamides A		Antifungal activity	<i>Aspergillus niger</i> EN-13	(42)
31.	Nigerasperone C		Antifungal activity	<i>Aspergillus niger</i> EN-13	(44)

32.	Fumitremorgin B		Cytotoxic activity	<i>Aspergillus fumigatus</i>	(45)
33.	Spirotryprostatins	 1 spirotryprostatin A spirotry	Cytotoxic activity	<i>Aspergillus fumigates</i>	(46)
34.	Spirotryprostatins		Cytotoxic activity	<i>Aspergillus fumigates</i>	(45)
35.	Metacycloprodigiosin		Cytotoxic activity	<i>Saccharopolyspora</i> sp. nov.	(46)
36.	Undecylprodigiosin		Cytotoxic activity	<i>Saccharopolyspora</i> sp. nov.	(45)
37.	Chaetopyranin		Cytotoxic activity	<i>Chaetomium globosum</i>	(46)

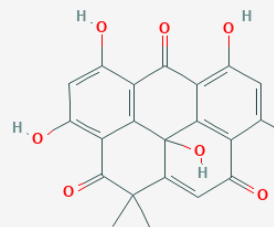
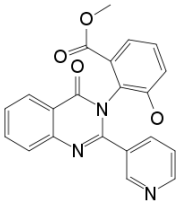
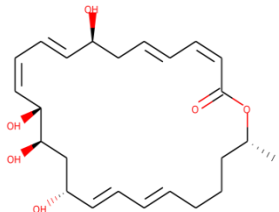
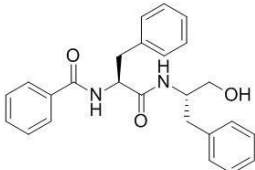
38.	Resistoflavine		Antibacterial activity, anticancerous	Actinomycetes	(46)
39.	Terrelactone A		Antimicrobial activity	<i>Aspergillus terrea</i> PT06- 02	(28)
40.	Pyrone I and II		Antibacterial activity	Bacteria	(28)
41.	Aurantiomides B and C		Cytotoxic activity	<i>Penicillium aurantiogriseum</i> SP0-19	(44)

Table 6. Species and their secondary metabolites along with the conditions in which they grow

S.No	Species	Enzymes/Secondary metabolite	Condition to grow	References
1	<i>Hbt. salinarum (halobium)</i> ATCC 43214	glycine-containing peptides	4 M NaCl for optimum catalytic activity	(46)
2	<i>Haloarcula sp. S-1</i>	α -amylase	chloroform at low salt concentrations	(44)
3	<i>Hbt.salinarum</i>	Bacteriorhodopsin	salted fish	(46)
4	<i>Hfx. mediterranei.</i>	Cyclodextrin glycosyltransferases	1.5 M NaCl, 55 °C and pH 7.5	(44)
5	<i>Halococcus sp. 197A</i>	β -agarase known as Aga-HC	3.5 M NaCl, pH 6 and	(42)

			a temperature of 70 °C	
6	<i>Haloarcula sp. LLSG7</i>	cellulase	40–80 °C, pH 7–11 and 3–5 M NaCl	(46)
7	<i>Hfx. volcanii.</i>	Laccases	45 °C and 200 mM NaCl,	(44)
8	<i>Halobacterium strain AS7092</i>	Halocin C8	culture supernatant at 4 °C or in dH ₂ O at –20 °C	(42)
9	<i>Haloarcula sp. G41</i>	extracellular lipase	70 °C, pH 8 and 2.6 M NaCl	(46)
10	<i>Hfx.volcanii H1209</i>	Alcohol dehydrogenases	alkaline pH values and KCl or NaCl	(45)
11	<i>Hrd. Utahensis</i>	extracellular β xylanase and β -xylosidase	β -xylanase was at pH ~6.5, 0.15–0.43 M NaCl, and 55 and 70 °C, β xylosidase activity 0.15 M NaCl, 65 °C and pH 7.6	(45)
12	<i>Hbt. salinarum CECT 395</i>	recombinant halophilic chitinase (ChiN1)	pH 7.3 and 40 °C, with high stability over broad pH (6–8.5) and temperature (25–45 °C)	(46)
13	<i>Hbt.halobium</i>	catalase	pH 7 without any addition of NaCl	(46)
14	<i>haloarchaeon, strain A235</i>	Catechol 2, 3-dioxygenase	pH 8, 2 M KCl and 42 °C	(27)
15	<i>Har. hispanica ATCC 33960</i>	Glutathione S-transferases	pH 9 and 25 °C	(27)
16	<i>Hfx. alicantei</i>	β -galactosidase	4 M NaCl; in absences of salt but in presences of sorbitol	(27)
17	<i>Dunaliella salina</i>	carotenoids	Salt condition 0.5 % to saturation (around 35 %), (pH 0–1)	(44)
18	<i>Halobacterium sp. NRC-1</i>	esterase	5 M NaCl and 80 °C	(32)
19	<i>Hfx. mediterranei</i>	NADP-glutamate dehydrogenase	60 °C, pH 8.5 and 1–1.5 M NaCl or KCl	(44)

20	<i>Har. japonica</i> .	2-deoxy-D-ribose-5-phosphate aldolase (carbon metabolism)	1 M NaCl and 60 °C.	(44)
21	<i>methanogenic Archaea</i>	Phenazines	carbon monoxide as a growth substrate	(32)
22	<i>Hcc. acetoinfaciens FERM BP-942</i>	Intracellular restriction enzyme	pH 7.1–7.5,	(44)

Table 7. List of compounds obtained from different species and their application

S. No.	Compound	Species	Application	Reference
1.	α -amylase (alpha-1,4-glucan-4 glucanohydrolases)	<i>Haloarcula</i> sp. S-1, <i>Har. hispanica</i> <i>Haloferax</i> sp. HA10	food, extracellular detergent-stable, paper, textile and pharmaceutical industries	(44)
2.	Amylopullulanase	<i>Halorubrum</i> sp. strain Ha25	starch processing enzymes	(42)
3.	Glucoamylase (amyloglucosidases)	<i>Halobacterium sodomense</i>	Produce high glucose syrup and dextrose for confectionary and pharmaceutical industries	(41)
4.	Pullulanases (pullulan 6-glucanohydrolase)	<i>Klebsiella</i> .sp	Degrade pullulan, amylopectin and starch	(45)
5.	Esterases	<i>Har. marismortui</i>	Recombinant DNA technology	(41)
6.	Alcohol dehydrogenase	<i>Hfx. volcanii</i>	Enzyme stability	(45)
7.	Esterases and Lipase	<i>Haloarcula</i> sp. G41 <i>Natronococcus</i> sp. strain TC6 <i>Halobacterium</i> sp. NRC-1	Biodiesel, detergent, paper, dairy, leather, pharmaceutical industries, and biotechnological applications	(41)
8.	Amylopullulanase	<i>Halorubrum</i> sp. strain Ha25	Starch processing industry	(45)
9.	Protease	<i>Hfx. lucentensis</i> VKMM 007 <i>Nmn. pharaonis</i> <i>Nab. magadii</i>	Leather, food processing biotechnological fields, detergent industries, pharmaceutical and bioremediation processes	(41)

10.	Serine protease	<i>Hbt. salinarum</i> (halobium)	agrochemical products	(45)
11.	Endopeptidase	<i>Halobacterium</i> <i>halobium</i>	Biomedical applications and food processing industry	(41)
12.	β -xylanase β -xylosidase	<i>Hrd. Utahensis</i>	Production of bioethanol and biodiesel from biomass, the clarification of fruit juices, bleaching of paper pulp, the processing of animal food	(41)
13.	β -galactosidases	<i>Hfx. alicantei</i> <i>Hrr.</i> <i>lacusprofundi</i>	Used in probiotic foodstuffs [24] and hydrolysis of lactose in milk	(41)
14.	Cellulose (endoglucanase, Exoglucanases, β - glucosidase)	<i>Haloarcula</i> sp. G10	Detergent, textile, paper, bioremediation and food industries	(41)
15.	Chitinase	<i>Hbt. salinarum</i> strain NRC-1	Catalyze the hydrolytic degradation of chitin, pharmaceutical industry	(41)
16.	Agarases (α -agarases, β -agarases)	<i>Halococcus</i> sp. 197A <i>Hcc. agarilyticus</i>	Agarolytic activity on agar medium	(41)
17.	Restriction enzyme (endonucleases)	<i>Hcc.</i> <i>acetoinfaciens</i> FERM BP-942	Recombinant DNA Technology	(44)
18.	NADP-glutamate dehydrogenase	<i>Hfx. mediterranei</i>	Role in ammonia assimilation	(41)
19.	Glucose dehydrogenase	<i>Haloferax</i> <i>mediterranei</i>	Used in biotechnological applications in non- aqueous media	(44)
20.	xylose dehydrogenase	<i>Har. marismortui</i>	Xylose degradation	(41)
21.	Nitrate reductase	<i>Hfx. mediterranei</i> <i>Hfx. denitrificans</i> <i>Hfx. volcanii</i> <i>Har. marismortui</i>	Denitrifying micro-organisms	(44)
22.	Laccases	<i>Hfx. volcanii</i>	Food, paper, textile industry	(44)
23.	Catalases	<i>Hbt. Halobium</i>	Food industry	(41)
24.	Histamine dehydrogenases	<i>Nnm. gari</i> BCC 24369	Food industries	(41)
25.	Alcohol dehydrogenases	<i>Hfx. volcanii</i> H1209	Biofuel production and biosensor technologies	(41)
26.	Glutathione S-transferases	<i>Har. hispanica</i> ATCC 33960	Detoxification	(41)