

## Article

# Antimicrobial Activity of the Circular Bacteriocin AS-48 against Clinical Multidrug-Resistant *Staphylococcus aureus*

Cristina Velázquez-Suárez <sup>1,2</sup>, Rubén Cebrián <sup>3,\*</sup>, Carmen Gasca-Capote <sup>4</sup>, Antonio Sorlózano-Puerto <sup>5,6</sup>, José Gutiérrez-Fernández <sup>5,6</sup>, Manuel Martínez-Bueno <sup>1</sup>, Mercedes Maqueda <sup>1</sup> and Eva Valdivia <sup>1</sup>

<sup>1</sup> Department of Microbiology, Faculty of Sciences, University of Granada, Av. Fuente Nueva s/n, 18071 Granada, Spain; cristina.velazquez@ibvf.csic.es (C.V.-S.); mmartine@ugr.es (M.M.-B.); mmaqueda@ugr.es (M.M.); evavm@ugr.es (E.V.)

<sup>2</sup> Institute of Plant Biochemistry and Photosynthesis, CSIC, Universidad de Sevilla, Av. Américo Vespucio, 49, 41092 Seville, Spain

<sup>3</sup> Department of Molecular Genetics, Groningen Biomolecular Sciences and Biotechnology Institute, University of Groningen, Nijenborgh 7, 9747AG Groningen, The Netherlands

<sup>4</sup> Clinical Unit of Infectious Diseases, Microbiology and Preventive Medicine, Institute of Biomedicine of Seville (IBIS), Virgen del Rocío University Hospital, CSIC, University of Seville, Av. Manuel Siurot, s/n, 41013 Seville, Spain; mcgasca-ibis@us.es

<sup>5</sup> Department of Microbiology, School of Medicine and PhD Program in Clinical Medicine and Public Health, University of Granada, Avda. de la Investigación 11, 18016 Granada, Spain; asp@ugr.es (A.S.-P.); josegf@ugr.es (J.G.-F.)

<sup>6</sup> Laboratory of Microbiology, Virgen de las Nieves University Hospital, Avda. de las Fuerzas Armadas 2, 18012 Granada, Spain

\* Correspondence: r.cebrian.castillo@rug.nl

**Table S1.** Summary table of the different parameters evaluated. Genomic profile aggrupation of the isolated strains indicating the isolation source, antibiotic-resistance profile, biofilm formation capacity, and the antimicrobial activity of AS-48 alone and in combination with lysozyme for selected strains of each group.

Genomic groups	Strains	Isolation source	Antibiotic resistances	AS-48	AS-48 +Lys	Biofilm
G-1	208	Surgery	PEN	4	2	2.25
	97	Unknown	PEN	12	8	0.37
	100	Dermatology	PEN	-	-	0.50
	145	ICU	PEN, AMO/CLA, OXA, CEF	4	2	0.44
	87	Vascular	PEN, AMO/CLA, OXA, CEF, LEV, ERY, JOS	8	8	1.12
G-2	91	Pathology	PEN	-	-	1.09
	78	Vascular	PEN, AMO/CLA, OXA, LEV	6	4	0.87
	79	Respiratory	PEN, GEN, KAN, TOB, TEL, ERY, JOS	-	-	0.80
G-3	101	Vascular	PEN	-	-	0.48
	120	Extra-hospital	PEN	-	-	2.46
	3	Unknown	PEN, TEL	-	-	0.42
	90	Pathology	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, ERY, JOS, CLIN	12	8	0.77
G-4	81	Vascular	PEN	6	8	0.36
G-5	21	ICU	PEN	8	0.5	0.39
	114	Vascular	PEN, ERY, JOS	-	-	0.40
	118	Unknown	PEN, TEL, JOS	-	-	0.44
	153	Miscellaneous	PEN, KAN, TOB, TEL	-	-	1.10
G-6	113	Vascular	PEN, JOS	8	4	0.28
G-7	192	Miscellaneous	PEN, JOS	4	2	0.44

<b>G-8</b>	77	Dermatology	PEN, JOS	-	-	0.90
	80	ICU	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	4	4	1.21
	96	Respiratory	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	4	3	1.42
	95	Extra-hospital	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, COT	12	4	0.51
<b>G-9</b>	6	Unknown	PEN	-	-	1.50
	12	Dermatology	LEV, JOS	8	4	0.27
	23	Vascular	PEN, ERY	-	-	0.57
	16	Unknown	PEN, ERY, JOS, CLIN	-	-	0.25
	154	Extra-hospital	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, ERY, JOS	4	1	0.96
	171	Extra-hospital	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, ERY, JOS	4	3	0.68
	1	ICU	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	4	1.34
	17	ICU	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	0.5	1.03
<b>G-10</b>	28	Vascular	PEN, LEV, TEL, ERY, JOS, CLIN, COT	8	5	1.78
<b>G-11</b>	110	Unknown	No antibiotic resistance	-	-	1.74
	85	Vascular	PEN	-	-	0.36
	221	Vascular	PEN	-	-	0.49
	191	Miscellaneous	PEN	-	-	0.79
	106	Vascular	PEN	-	-	0.72
	4	Extra-hospital	PEN	-	-	1.80
	147	ICU	PEN	-	-	0.30
	84	Vascular	PEN	-	-	0.81
	24	Extra-hospital	PEN	-	-	0.37
	5	Vascular	PEN	-	-	0.77
	160	Surgery	PEN	-	-	0.75
	207	Respiratory	LEV	-	-	0.80
	193	Unknown	PEN, LEV	-	-	0.66
	170	Vascular	PEN, JOS	-	-	0.74
	190	Extra-hospital	PEN, JOS	-	-	0.75
	122	Vascular	PEN, ERY	-	-	1.12
	220	Extra-hospital	PEN, KAN, TOB	-	-	1.03
	205	Vascular	PEN, KAN, TOB	-	-	0.41
	148	Extra-hospital	PEN, KAN, TOB	-	-	0.60
	142	Extra-hospital	PEN, KAN, TOB	-	-	0.36
	218	Vascular	PEN, LEV, JOS	-	-	1.32
	214	Vascular	PEN, ERY, JOS	-	-	0.32
	175	Miscellaneous	PEN, ERY, JOS	-	-	0.94
	76	Unknown	PEN, ERY, JOS	-	-	1.23
	141	Unknown	PEN, TEL, JOS	-	-	1.09

	203	Respiratory	LEV, ERY, JOS, CLIN	-	-	0.74
	103	Surgery	PEN, TEL, ERY, JOS, CLIN	-	-	0.32
	121	Vascular	PEN, GEN, KAN, TOB, JOS	-	-	1.26
	185	Respiratory	PEN, AMO/CLA, OXA, CEF, LEV, JOS	4	2	0.13
	19	Unknown	PEN, AMO/CLA, OXA, CEF, LEV, JOS	12	0.5	0.82
	135	Surgery	PEN, AMO/CLA, OXA, CEF, LEV, JOS	8	4	0.78
	139	Dermatology	KAN, TOB, LEV, TEL, ERY, JOS, CLIN			0.43
	20	Surgery	PEN, AMO/CLA, OXA, CEF, LEV, ERY, JOS	8	4	1.03
	119	Pathology	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, JOS	7	2	1.22
	204	Respiratory	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, JOS	4	2	0.66
	2	Vascular	PEN, AMO/CLA, OXA, CEF, LEV, TEL, ERY, JOS	12	4	0.68
	174	Pathology	PEN, AMO/CLA, OXA, CEF, LEV, ERY, JOS, CLIN	4	2	1.51
	186	Extra-hospital	PEN, AMO/CLA, OXA, CEF, LEV, ERY, JOS, CLIN	4	4	1.08
	215	Unknown	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, TEL, ERY, JOS	5	4	1.21
	176	Vascular	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, ERY, JOS	12	8	1.24
	152	ICU	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	4	3	1.14
	155	Respiratory	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	6	0.53
	219	Pathology	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	4	3	0.56
	104	Vascular	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	4	1.40
	136	Surgery	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	3	1	0.45
	94	Vascular	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN, COT, RIF	11	12	1.53
<b>G-12</b>	111	ICU	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	16	8	1.48
	112	ICU	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	3	0.50
<b>G-13</b>	13	Vascular	PEN	-	-	0.44
	49	Extra-hospital	PEN, COT	-	-	1.59
	14	ICU	PEN, KAN, TOB	8	4	0.68
<b>G-14</b>	32	Dermatology	No antibiotic resistance	-	-	0.60
	33	Dermatology	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, ERY, JOS	4	0.5	3.11
<b>G-15</b>	29	Vascular	ERY, JOS, COT	-	-	0.23
	30	ICU	PEN, AMO/CLA, OXA, CEF, GEN, KAN, TOB, LEV, TEL, ERY, JOS, CLIN	8	6	0.75

<b>G-16</b>	72	Surgery	No antibiotic resistance	-	-	0.60
	62	ICU	PEN, TEL	-	-	1.04
	53	Vascular	GEN, KAN, TOB, COT	8	4	1.26
	54	Respiratory	PEN, AMO/CLA, OXA, CEF, KAN, TOB, LEV, TEL, ERY, JOS, CLIN, COT	6	0.5	1.06
<b>G-17</b>	68	Miscellaneous	PEN, TEL	6	4	1.01
<b>G-18</b>	55	Unknown	PEN	-	-	0.71
	73	Surgery	PEN	-	-	0.80
	105	Unknown	PEN, TEL	12	8	0.66
<b>G-19</b>	48	Extra-hospital	PEN	8	12	2.79
<b>G-20</b>	35	Unknown	PEN	-	-	0.37
	47	Vascular	PEN	8	0.5	1.51
	52	Vascular	PEN	-	-	1.50
<b>G-21</b>	75	Miscellaneous	PEN, KAN, TOB, TEL, ERY, JOS	9	8	0.64

In shadow, the MRSA strains.