(12) STANDARD PATENT (11) Application No. **AU 2012210565 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Human lactoferrin derived peptides and there use

(51) International Patent Classification(s)
C07K 14/79 (2006.01) ***A61K 38/40*** (2006.01)

(21) Application No: **2012210565** (22) Date of Filing: **2012.01.25**

(87) WIPO No: **WO12/101157**

(30) Priority Data

(31) Number	(32) Date	(33) Country
11152213.2	**2011.01.26**	**EP**

(43) Publication Date: **2012.08.02**
(44) Accepted Journal Date: **2017.03.30**

(71) Applicant(s)
Pergamum AB

(72) Inventor(s)
Mahlapuu, Margit;Bjorn, Camilla;Sjostrand, Veronika;Walse, Bjorn;Svensson, Bo

(74) Agent / Attorney
Griffith Hack, GPO Box 4164, Sydney, NSW, 2001, AU

(56) Related Art
WO 2010/081800 A2
WO 2009/062898 A1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 August 2012 (02.08.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/101157 A1

(51) International Patent Classification:
C07K 14/79 (2006.01) *A61K 38/40* (2006.01)

(21) International Application Number:
PCT/EP2012/051112

(22) International Filing Date:
25 January 2012 (25.01.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11152213.2 26 January 2011 (26.01.2011) EP

(71) Applicant *(for all designated States except US)*: **PharmaSurgics in Sweden AB** [SE/SE]; Arvid Wallgrens Backe 20, S-413 46 Göteborg (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MAHLAPUU, Margit** [SE/SE]; Jakobshöjdsvägen 8, S-412 70 Göteborg (SE). **BJÖRN, Camilla** [SE/SE]; Guldringen 7, S-426 52 Västra Frölunda (SE). **SJÖSTRAND, Veronika** [SE/SE]; Alfhemsgatan 4, S-413 10 Göteborg (SE). **WALSE, Björn** [SE/SE]; Skyttelinjen 130, S-226 49 Lund (SE). **SVENSSON, Bo** [SE/SE]; Sandby 144, S-247 91 Södra Sandby (SE).

(74) Agent: **BRANN AB**; P.O. Box 12246, Fleminggatan 7, S-102 26 Stockholm (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,

[Continued on next page]

(54) Title: HUMAN LACTOFERRIN DERIVED PEPTIDES AND THERE USE

(57) Abstract: The present invention relates to new peptides and to use thereof, in particular for treatment and/or prevention of infections, inflammations, pain, wounds, scar and/or tumours.

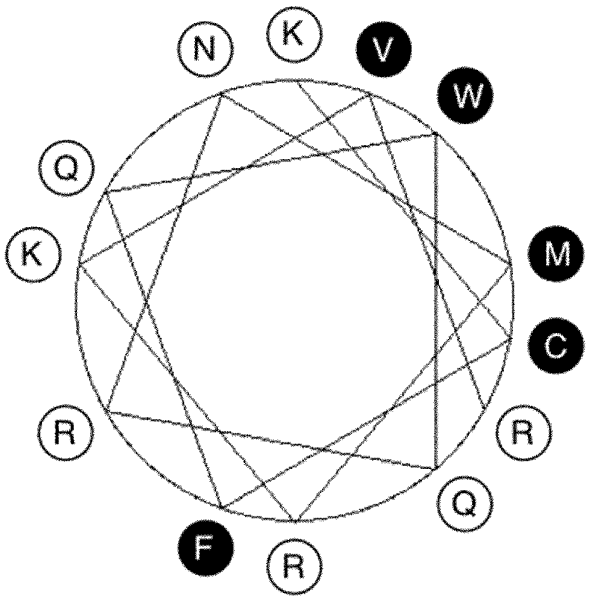

Figure 2

WO 2012/101157 A1

DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

HUMAN LACTOFERRIN DERIVED PEPTIDES AND THERE USE

Field of the invention

The present invention relates to new peptides and to use thereof, in particular for treatment and/or prevention of infections, inflammations, pain, wounds, scar and/or tumours.

Background art

Lactoferrin is a single chain metal-binding glycoprotein with a molecular weight of 77 kDa. It has been found that the structural domain of lactoferrin responsible for the bactericidal properties is a pepsin-cleaved fragment called lactoferricin (see e.g. Bellamy W., et al., Identification of the bactericidal domain of lactoferrin, Biochim. Biophys. Acta 1121: 130-136, 1992, and Bellamy W., et al., Antibacterial spectrum of lactoferricin B, a potent bactericidal peptide derived from the N-terminal region of bovine lactoferrin, J. Appl. Bact. 73: 472-479, 1992).

Lactoferrin receptors are found on many types of cells including monocytes and macrophages, lectin-stimulated human peripheral blood lymphocytes, brushborder cells, and tumour cell lines.

Several patent publications describe the possible use of lactoferrin for treatment of infections or inflammations. In WO 98/06425, e.g., it is disclosed that lactoferrin and lactoferricin can be used for treatment and prevention of infections, inflammations and tumours.

EP 629 347 describes an antimicrobial agent containing (A) lactoferrin hydrolysate and/or one or more of antimicrobial peptides derived from lactoferrins, and (B) one or more compounds selected from the group consisting of metal-chelating protein, tocopherol, cyclodextrin, glycerine-fatty acid ester, alcohol, EDTA or a salt thereof, ascorbic acid or a salt thereof, citric acid or a salt thereof, polyphosphoric acid or a salt thereof, chitosan, cysteine, and cholic acid as the effective components thereof. This antimicrobial agent is intended for treatment of products, and especially for safely treating e.g. food and medicines. The agent according to this publication is thus a new preservative. In the publication several peptide sequences are given and some of them resemble the peptides according to the invention, although there are several important differences described further below.

US 5,304,633 disclose antimicrobial peptides isolated from hydrolysates of human and bovine lactoferrin. Isolation of peptides corresponding to amino acids 12 to 47, and 17 to 41 of human lactoferrin are specifically disclosed.

JP 7145196 describes the preparation of antibiotic peptides by hydrolysis of lactoferrin. The preparation of a peptide corresponding to amino acids 17 to 41 of human lactoferrin is specifically described.

JP 8040925 discloses pharmaceutical compositions containing lactoferrin derived peptides and their use in the treatment of cornea damages, especially keratitis. Peptides corresponding to amino acids 17 to 41, 12 to 58, and 19 to 38, of human lactoferrin are specifically disclosed.

JP 7274970 describes the recombinant production of antibacterial lactoferricin derived peptides, specifically a peptides corresponding to amino acids 18 to 42 of human lactoferrin is disclosed.

JP 8143468 describes lactoferrin derived peptides and their use as antiulcer drugs, a peptide corresponding to amino acids 19 to 33 of human lactoferrin is specifically disclosed.

WO 00/01730 describes peptides derived from human lactoferrin and their use for treatment of infections and inflammations.

EP 1 228 097 describes peptides derived from the immediate N-terminal end of human lactoferrin and their use as microbial agents.

EP 1151009 describes peptides comprising a sequence corresponding to amino acids 35 to 50 of human lactoferrin having antimicrobial and/or endotoxin neutralizing activity.

WO 2006/047744 describes immunomodulatory peptides derived from the N-terminal part of human lactoferrin comprising at least 33 amino acids and being substituted in both the N- and C-terminus with four positively charged amino acids.

WO 2009/050279 describes mutated lactoferrin peptides and their antimicrobial activity.

WO 2009/062898 describes arginine substituted lactoferrin peptides and their antimicrobial and anti-inflammatory activity.

Summary of the invention

The present invention relates to new peptides with improved antimicrobial and/or anti-inflammatory activity. The peptides according to the present invention are designed based on the amino acid sequence SEQ ID NO:1 corresponding to amino acids 13 to 30 of mature human lactoferrin.

Q-P-E-A-T-K-C-F-Q-W-Q-R-N-M-R-K-V-R (SEQ ID NO:1)

The present invention as claimed herein is described in the following items 1 to 9:

1. A peptide selected from any one of the peptides

R-Q-W-K-R-R-M-R-K-V-F-H-S-Y-R-R-M-G	(SEQ ID NO: 21);
K-Q-W-K-R-W-M-R-K-V-F-V-S-L-R-R-V-G	(SEQ ID NO: 22);
R-Q-W-K-R-V-M-R-K-V-F-G-S-R-W-W-R-G	(SEQ ID NO: 23);
K-Q-W-K-R-M-M-R-K-V-F-S-V-R-R-W-F-L	(SEQ ID NO: 24);
F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27);
F-Q-W-K-R-R-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 6);
W-F-Q-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 7);
F-W-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 8);
F-Q-W-K-R-R-M-R-K-V-R-G-S-K-K-K-K-G	(SEQ ID NO: 19);
F-Q-W-K-R-R-M-R-K-V-R-G-S-L-R-R-W-G	(SEQ ID NO: 20);
F-R-W-K-R-R-M-R-K-V-R-G-S-R-R-R-Q-G	(SEQ ID NO: 25);
F-W-W-K-R-A-M-R-K-V-R-L-S-R-R-R-R-G	(SEQ ID NO: 31);
F-W-W-K-R-A-M-R-K-V-R-N-S-R-R-R-R-G	(SEQ ID NO: 32); and
F-W-W-K-K-A-M-K-K-V-K-G-T-R-R-R-R-G	(SEQ ID NO: 34).

2. A peptide according to item 1, which peptide is

F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27).

3. A peptide according to item 1 or 2, wherein a free COOH at the carboxy terminal end has been transformed into $CONH_2$.

4. A peptide according to any one of items 1 to 3, wherein a free NH_2 group at the amino terminal end has been transformed into the amide CH_3CONH.

5. A peptide according to any one of items 1 to 4 for use as a medicament.

6. A peptide according to any one of items 1 to 4, for use in the treatment and/or prevention of infections or inflammations.

7. Use of a peptide according to any one of items 1 to 4, for the manufacture of a medicament for the treatment and/or prevention of infections or inflammations.

8. A method for the treatment and/or prevention of infections or inflammations, whereby a peptide according to any one of items 1 to 4, is administered to a subject in need of such treatment and/or prevention.

9. A pharmaceutical composition comprising a peptide according to any of items 1 to 4.

The first embodiment of the invention relates to peptides comprising at least the amino acid sequence

X1-X2-W-X4-X5-X6-M-X8-K-V-X11-X12-X13-X14-X15-X16-X17 (SEQ ID NO: 2)

wherein

X1 is F, K or R

X2 is Q, W or R

X4 is K or R

X5 is R or K

X6 is N, A, V, W or R

X8 is R or K

X11 is R, F or K

X12 is G, S, N, V, L or H

X13 is S, G, T or V

X14 is R, L, Y, W or K

X15 is R, K or W

X16 is R, K or W, and

X17 is R, G, Q, V, M, F, W or K,

and functional equivalent variants of these peptides.

The peptides can preferably further comprise the amino acids F, W or C at the N-terminal end.

The peptides can preferably further comprise the amino acids G, R or L at the C-terminal end.

Preferably the peptides according to the first embodiment of the invention comprise at least the amino acid sequence

X1-X2-W-K-X5-X6-M-X8-K-V-X11-X12-X13-X14-X15-X16-X17 (SEQ ID NO: 3)

wherein

X1 is F, K or R

X2 is Q, or W

X5 is R or K

X6 is N, A, V, or W

X8 is R or K

X11 is R, F or K

X12 is V, L or N

X13 is S, G, T or V

X14 is R, L, Y, W or K

X15 is R, K or W

X16 is R, K or W, and

X17 is R, F, W or K;

and functional equivalent variants of these peptides.

The peptides can preferably further comprise the amino acids F, W or C at the N-terminal end.

The peptides can preferably further comprise the amino acids G, R or L at the C-terminal end.

More preferably, the peptides according to the first embodiment of the invention are selected from peptides comprising an amino acid sequence selected from the amino acid sequences

R-Q-W-K-R-R-M-R-K-V-F-H-S-Y-R-R-M-G	(SEQ ID NO: 21)
K-Q-W-K-R-W-M-R-K-V-F-V-S-L-R-R-V-G	(SEQ ID NO: 22
R-Q-W-K-R-V-M-R-K-V-F-G-S-R-W-W-R-G	(SEQ ID NO: 23)
K-Q-W-K-R-M-M-R-K-V-F-S-V-R-R-W-F-L	(SEQ ID NO: 24)
F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27)
F-Q-W-K-R-R-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 6)
W-F-Q-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 7)
F-W-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 8)
F-Q-W-K-R-R-M-R-K-V-R-G-S-K-K-K-K-G	(SEQ ID NO: 19)
F-Q-W-K-R-R-M-R-K-V-R-G-S-L-R-R-W-G	(SEQ ID NO: 20)
F-R-W-K-R-R-M-R-K-V-R-G-S-R-R-R-Q-G	(SEQ ID NO: 25)
F-W-W-K-R-A-M-R-K-V-R-L-S-R-R-R-R-G	(SEQ ID NO: 31)
F-W-W-K-R-A-M-R-K-V-R-N-S-R-R-R-R-G	(SEQ ID NO: 32)
F-W-W-K-K-A-M-K-K-V-K-G-T-R-R-R-R-G	(SEQ ID NO: 34)

and functional equivalent variants of these peptides.

Most preferably the peptides according to the first embodiment of the invention are selected from the peptides

R-Q-W-K-R-R-M-R-K-V-F-H-S-Y-R-R-M-G	(SEQ ID NO: 21)
K-Q-W-K-R-W-M-R-K-V-F-V-S-L-R-R-V-G	(SEQ ID NO: 22
R-Q-W-K-R-V-M-R-K-V-F-G-S-R-W-W-R-G	(SEQ ID NO: 23)
K-Q-W-K-R-M-M-R-K-V-F-S-V-R-R-W-F-L	(SEQ ID NO: 24)
F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27)

F-Q-W-K-R-R-M-R-K-V-R-G-S-R-R-R-R-G (SEQ ID NO: 6)
W-F-Q-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G (SEQ ID NO: 7)
F-W-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G (SEQ ID NO: 8)
F-Q-W-K-R-R-M-R-K-V-R-G-S-K-K-K-K-G (SEQ ID NO: 19)
F-Q-W-K-R-R-M-R-K-V-R-G-S-L-R-R-W-G (SEQ ID NO: 20)
F-R-W-K-R-R-M-R-K-V-R-G-S-R-R-R-Q-G (SEQ ID NO: 25)
F-W-W-K-R-A-M-R-K-V-R-L-S-R-R-R-R-G (SEQ ID NO: 31)
F-W-W-K-R-A-M-R-K-V-R-N-S-R-R-R-R-G (SEQ ID NO: 32)
F-W-W-K-K-A-M-K-K-V-K-G-T-R-R-R-R-G (SEQ ID NO: 34)

and functional equivalent variants of these peptides.

The peptides according to the invention preferably have a length of from 12 to 100 amino acid residues, such as preferably a length of from 12 to 50 amino acid residues, or a length of from 12 to 30 amino acid residues, such as more preferably a length of from 12 to about 25 amino acid residues, such as most preferably a length of from 12 to 20 amino acid residues, such as 12, 13, 14, 15, 16, 17, 18 , 19 or 20 amino acid residues.

The peptides according to the invention comprise the standard twenty genetically-encoded amino acids. They may also comprise one or more of the amino acids in their corresponding stereoisomers in the 'D' form, as compared to the natural 'L' form.

In the description single-letter or three-letter symbols are used to denote the amino acids. These symbols, which are well known to man skilled in the art, have the following meaning: A = Ala = alanine, C = Cys = cysteine, D = Asp = aspartic acid, E = Glu = glutamic acid, F = Phe = phenylalanine, G= Gly = glycine, I- Ile = isoleucine, K = Lys = lysine, M= Met = methionine, N = Asn = asparagine, P = Pro = proline, Q = Gln = glutamine, R = Arg = arginine, S = Ser = serine, T = Thr = threonine, V = Val = valine, W = Trp = tryptophan.

Lower case letters are used to designate the corresponding D-amino acids.

Functional equivalent variants of the peptides according to the invention can include insertions or deletions of one or more amino acids, such as 1-5 insertions or deletions, 1,2 ,3, 4 or 5 insertions or deletions.

Functional equivalent variants of the peptides according to the invention can also include substitutions. Substitutions can be either conservative or non-conservative. Conservative substitutions are substitution of an amino acid within the same general class (e.g. an acidic amino acid, a basic amino acid, etc.) by another amino acid within the same class. E.g. a hydrophobic amino acid can be substituted with another hydrophobic amino acid, e.g. Trp can be substituted for Leu. A positively charged amino acid can be substituted with another

positively charged amino acid, e.g. Arg can be substituted for Lys, such as 1-5 substitutions, 1, 2 ,3 ,4 or 5 substitutions.

Figure 1 illustrates the different classes of amino acids.

The functional equivalent variants of the peptides according to the invention can also comprise other unnatural amino acids, as long as the desired functional property is retained by the polypeptide. Such unnatural amino acids can include α,α-disubstituted amino acids, N-alkyl amino acids or other variants mimicking a specific natural amino acid.

E.g. in the functional equivalent variants of the peptides according to the invention lysine (K/Lys) can preferably be substituted by Dap (diaminopropionic acid), Dab (2,4-diaminobutanoic acid), Orn (ornithine) or Hyl (5-Hydroxylysine), arginine (R/Arg) can preferably be substituted by Har (homoarginine), alanine (A/Ala) can preferably be substituted by Aib (α-Aminoisobutyric acid) or Abu (2-Aminobutanoic acid), valine (V/Val) can preferably be substituted by Nva (norvaline) or Iva (isovaline), leucine (L/Leu) can preferably be substituted by Nle (norleucine) or Cha (3-Cyclohexylalanine), serine (S/Ser) can preferably be substituted by Hse (Homoserine), cysteine (C/Cys) can preferably be substituted by Hcy (Homocysteine), histidine (H/His) can preferably be substituted by Hhs (Homohistidine) or 3-MH (3-methylhistidine), phenylalanine (F/Phe) can preferably be substituted with Phg (2-Phenylglycine), proline (P/Pro) can preferably be substituted with Hyp (4-hydroxyproline).

Accordingly, functionally equivalent variants of the peptides are peptides that have more than 70% sequence identity, such as more than 75% sequence identity, preferably more than 80% sequence identity such as more than 85% sequence identity, most preferably more than 90% sequence identity such as more than 93, 94, 95, 96, 97, 98, or 99 % sequence identity, compared to a peptide selected from the peptides

R-Q-W-K-R-R-M-R-K-V-F-H-S-Y-R-R-M-G	(SEQ ID NO: 21)
K-Q-W-K-R-W-M-R-K-V-F-V-S-L-R-R-V-G	(SEQ ID NO: 22)
R-Q-W-K-R-V-M-R-K-V-F-G-S-R-W-W-R-G	(SEQ ID NO: 23)
K-Q-W-K-R-M-M-R-K-V-F-S-V-R-R-W-F-L	(SEQ ID NO: 24)
F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27)
F-Q-W-K-R-R-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 6)
W-F-Q-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 7)
F-W-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 8)
F-Q-W-K-R-R-M-R-K-V-R-G-S-K-K-K-K-G	(SEQ ID NO: 19)
F-Q-W-K-R-R-M-R-K-V-R-G-S-L-R-R-W-G	(SEQ ID NO: 20)

F-R-W-K-R-R-M-R-K-V-R-G-S-R-R-R-Q-G (SEQ ID NO: 25)
F-W-W-K-R-A-M-R-K-V-R-L-S-R-R-R-R-G (SEQ ID NO: 31)
F-W-W-K-R-A-M-R-K-V-R-N-S-R-R-R-R-G (SEQ ID NO: 32)
F-W-W-K-K-A-M-K-K-V-K-G-T-R-R-R-R-G (SEQ ID NO: 34)

The percent identity between two amino acid sequences is determined as follows. First, an amino acid sequence is compared to, for example, SEQ ID NO:1 using the BLAST 2 Sequences (Bl2seq) program from the stand-alone version of BLASTZ containing BLASTN version 2.0.14 and BLASTP version 2.0.14. This stand-alone version of BLASTZ can be obtained from the U.S. government's National Center for Biotechnology Information web site at ncbi.nlm.nih.gov. Instructions explaining how to use the Bl2seq program can be found in the readme file accompanying BLASTZ. Bl2seq performs a comparison between two amino acid sequences using the BLASTP algorithm.To compare two amino acid sequences, the options of Bl2seq are set as follows: -i is set to a file containing the first amino acid sequence to be compared (e.g., C:\seq1.txt); -j is set to a file containing the second amino acid sequence to be compared (e.g., C:\seq2.txt); -p is set to blastp; -o is set to any desired file name (e.g., C:\output.txt); and all other options are left at their default setting. For example, the following command can be used to generate an output file containing a comparison between two amino acid sequences: C:\Bl2seq –i c:\seq1.txt –j c:\seq2.txt –p blastp –o c:\output.txt. If the two compared sequences share homology, then the designated output file will present those regions of homology as aligned sequences. If the two compared sequences do not share homology, then the designated output file will not present aligned sequences. Once aligned, the number of matches is determined by counting the number of positions where an identical nucleotide or amino acid residue is presented in both sequences.

The percent identity is determined by dividing the number of matches by the length of the sequence set forth in an identified sequence followed by multiplying the resulting value by 100. For example, if a sequence is compared to the sequence set forth in SEQ ID NO:1 (the length of the sequence set forth in SEQ ID NO:1 is 18) and the number of matches is 16, then the sequence has a percent identity of 89 % (i.e., 16 ÷ 18 * 100 = 89) to the sequence set forth in SEQ ID NO:1.

Furthermore, fusions of the peptides according to the invention to other polypeptides, e.g. glutathione-S-transferase, protein A, oligo-histidine tag to simplify purification, or to an epitope recognised by an antibody such as the Myc tag epitope are also included in the present invention.

Fusions that include other desirable features that are, for example, useful in detecting or isolating the peptide, or promoting cellular uptake of the peptide are also included in the invention. Examples of such fusion partners are a biotin moiety, a streptavidin moiety, a radioactive moiety, a fluorescent moiety like a small fluorophore or a green fluorescent protein GFP fluorophore, an immunogenic tag, a lipophilic molecule or polypeptide domain that is capable of promoting cellular uptake of the peptide.

Functional equivalent variants of the peptides according to the invention can also comprise chemically modified or derivatised amino acids, for example by PEGylation, amidation, esterification, acylation, acetylation and/or alkylation.

Different attachments strategies for PEG exist and should be included. For example, PEG can be linked to N-terminal amino groups, or to amino acid residues with reactive amino or hydroxyl groups (Lys, His, Ser, Thr and Tyr) directly or by using γ-amino butyric acid as linkers. PEG can also be coupled to carboxyl (Asp, Glu, C-terminal) or sulfhydryl (Cys) groups.

Functional equivalent variants of the peptides according to the invention can also comprise chemical derivatives of the amino acids created by reaction with a functional side. Such derivatised molecules include molecules in which free amino groups have been derivatised to form amine hydrochlorides, *p*-toluene sulphonyl groups, carboxybenzoxy groups, *t*-butyl-oxycarbonyl groups, chloroacetyl groups or formyl groups. Free carboxyl groups can be derivatised to form salts, methyl and ethyl esters or other types of esters and hydrazides. Free hydroxyl groups can be derivatised to form O-acyl or O-alkyl derivatives.

Functional equivalent variants of the peptides according to the invention can also comprise peptidomimetic variants of the peptides. A peptidomimetic is a compound that mimics the conformation and particular features of the peptide. For example, peptidomimetics include peptides with reversed (-CO-NH-) linkages. In addition, peptidomimetics include variants where the amino acid residues are linked by a $\gamma(CH_2NH)$-bond that replaces the conventional amide linkage. Furthermore, peptidomimetics also include omega-amino acids, where the amino- and carboxyl-groups are separated by polymethylene units of variable length.

The peptides according to the invention can include modifications such as amidation, amino terminal acylation (e.g. acetylation or thioglycolic acid amidation), terminal carboxylamidation (e.g. with ammonia or methylamine), and other terminal modifications there the peptide's N- or C-terminal regions are blocked to help reduce susceptibility to exoproteolytic digestion. Further, by acetylation of the N-terminal into and amidation of the C-terminal, the peptides will be uncharged at the ends. Assuming that receptors bind the corresponding sequences of

LF (where there are no N- and C-terminal charges), the capped peptides should bind better as they in this respect resemble the native protein more than uncapped peptides.

The peptides according to the invention can be C-terminally end-tagged with Tryptophan to increase potency, as described by Pasupuleti et al. Biochim Biophys Acta 2009, 1790:800-8.

Further, if present, a cysteine residue in the peptides can be replaced by an acetamidomethyl-cysteine. Further, the peptides according to the invention can be in a cyclic form, obtained by creation of a disulphide bridge between two cysteines in the sequence. Further, peptides according to the invention can include formed lactams.

The peptides according to the invention are suitable for treatment and/or prevention of infections, inflammations, tumours, pain, wounds, and scars. The term "treatment" used herein refers to curing, reversing, attenuating, alleviating, minimising, suppressing or halting the deleterious effects of a disease state, disease progression or other abnormal condition, and the term "prevention" used herein refers to minimising, reducing or suppressing the risk of developing a disease state or progression or other abnormal or deleterious conditions.

The infections treatable with the peptides or medicinal products/medical devices according to the invention include infections caused by all kinds of pathogens, such as bacteria, viruses, fungi, etc. The peptides according to the invention may be used to coat/treat different medicinal products/medical device products for reducing/preventing device-related infections

It is also possible to treat different types of inflammations. Inflammation is a complex phenomenon marked i.a. by abnormal "redness" and swelling of tissues and organs, pain and heat in affected areas, capillary dilation, leucocyte infiltration, etc. Inflammation is primarily caused by exposure to bacterial and other noxious agents and physical injury. Allergic inflammation is an important pathophysiological feature of several disabilities or medical conditions including allergic asthma, atopic dermatitis, allergic rhinitis and several ocular allergic diseases.

Accordingly, one aspect of the present invention provides methods for treatment and/or prevention of infections, inflammations, tumours, pain, wounds and scars wherein an effective amount of a peptide of the invention, and functionally equivalent variants thereof, is administered to a patient. Said peptide may be formulated for orally, systemically, parenterally, locally or topically administered. Further, said peptide may be included in food stuff or included in an infant formula food.

Further, another aspect of the present invention provides peptides of the invention for use in the treatment and/or prevention of infections, inflammations, tumours, pain, wounds and scars. Said peptide may be formulated for oral administration, systemic administration,

parenteral administration, local administration or topical administration. Further, said peptide for use may be included in food stuff or included in an infant formula food.

Further, another aspect of the present invention provides use the peptides of the invention, for the production of a medicinal product/medical device product for treatment and/or prevention of infections, inflammations, tumours, pain, wounds and scars. Said medicinal product may be formulated for oral administration, systemic administration, parenteral administration, local administration or topical administration. Further, medicinal product/medical device product may be included in food stuff or included in an infant formula food.

Inflammation has many forms and is mediated by a variety of different cytokines and other chemical signals. These mediators of inflammation include tumour necrosis factor-α (TNF-α), interleukin-1 (IL-1), interleukin-4 (IL-4), interleukin-5 (IL-5), interleukin-6 (IL-6), interleukin-8 (IL-8), interferon-gamma (IFN-γ) and various colony-stimulating factors (CSFs).

Though inhibition of infections and modulation of inflammatory response, the peptides are suitable for treatment/prevention of wounds and scar formation. As stated above, the peptides according to the invention are also suitable for treatment of tumours.

The peptides according to the invention may either be used as they are or be included in a medical device, medicinal product or a pharmaceutical composition. The medicinal product or a pharmaceutical composition according to the invention may also comprise substances used to facilitate the production of the pharmaceutical preparation or the administration of the preparations. Such substances are well known to people skilled in the art and may for example be pharmaceutically acceptable adjuvants, carriers and preservatives.

Accordingly, one aspect of the present invention provides pharmaceutical compositions comprising a peptide according to the invention.

Another aspect of the invention provides pharmaceutical compositions comprising a peptide according to the invention for use in treatment and/or prevention of infections, inflammations, tumours, pain, wounds and scars.

The peptides according to the invention may either be formulated for oral administration, systemic administration, parenteral administration, local administration or topical administration.

The peptides, medicinal products, medical device and pharmaceutical composition according to the invention can be administered to a patient either orally, systemically, parenterally, locally or topically.

The term "patient" used herein relates to any person at risk for or suffering from a disease state, disease progression or other abnormal or deleterious condition.

The systemic administration is suitable e.g. for treatment of urinary tract infection, colitis and tumours. The systemic administration can be undertaken by oral, nasal, pulmonary, oropharyngeal, intravenous, intraartery, intracavitary, intramuscular, subcutaneous, transdermal, suppositories (including rectal) or other routes known to those of skill in the art.

The local administration is suitable e.g. for treatment of skin and skin structure infections and inflammations, respiratory infections, all infections and inflammations in mucosal membranes etc. The local administration can be undertaken by topical, epicutaneous, oral, nasal, vaginal, ophthalmic, otic, pulmonary or oropharyngeal route. For treatment of local infections or inflammations the peptides or medicinal products or medical device according to the invention may e.g. be included in a gel, a cream, an ointment, solution or a paste, an inhalation powder/solution, an otic or ophthalmic solution/suspension/ointment.

In the method according to the invention an effective amount of a peptide according to the invention is administered to a patient. The term "effective amount" used herein relates to an amount sufficient to treat or prevent a disease state, disease progression or other abnormal or deleterious conditions.

The peptides or medicinal products or medical device and methods according to the invention are particularly well suited for treatment and/or prevention of urinary tract infection and colitis, skin and skin structure infections and inflammation, infections and inflammation in outer ear, ear canal, inner ear and eye and respiratory system, chronic and acute wounds, but several other inflammatory and infectious diseases are also treatable according to the present invention, such as inflammatory bowel diseases, rheumatoid arthritis, arthrosis, conditions caused by the virus HIV-1, conditions caused by the virus CMV, and conditions caused by fungi, e.g. Candida species such as Candida albicans and Candida krusei, Aspergillus and Cryptococcus neoformans. This listing is in no way limiting the scope of the invention.

The peptides, medicinal products, medical device and methods according to the invention are also well suited for preventive medical care by reducing the risk of developing inflammatory or infectious diseases in patients with an increased risk of attracting such complications.

The peptides of the present invention are suited for anti-inflammatory and immunomodulatory therapies, exemplified but not limited to:

1) Generally, treatment and/or prevention of inflammation and/or medical condition resulting from inflammation, and specifically,

2a) Intestine; Morbus Crohn, Colitis, Ulcerative colitis,

2b) Joints; Rheumatoid arthritis, Arthritis, Arthrosis, Localized disorders of muscles including muscle spasm, muscle tear, muscle injury, muscle strain, muscle sprain,

2c) Dermatology; Psoriasis, Eczema (excema), Dermatitis, Acne,

2d) Heart; Pericarditis, Endocarditis Cardiac insufficiency,

2e) Pain; (further specified under 2f below),

2f) Nervous system; Alzheimer, Multiple Sclerosis, Carpal tunnel syndrome, Disc herniation, Cervical rhizopathy, Bells palsy, Acute spinal cord injury, Spinal cord compression, Spinal stenosis, Postherpetic neuralgia, Viral encephalitis, Viral meningitis, Menieres disease, Polio and postpolio complications, Chronic Inflammatory Demyelinating Polyneuropathy, Polyneuropathy, Trigminal neuralgia, Chronic epileptic disorders,

2g) Sensory organs; Glaucoma,

2h) Mucosal surfaces (inflammation as a result of chemo/radiation therapy),

2i) Allergy,

2j) Autoimmune diseases.

The peptides of the invention are further suited for prevention and/or treatment of wounds and/or scars in connection with conditions and procedure, exemplified but not limited to:

3a) surgical procedures on various tissues such as skin, muscles, tendons, nervous tissue, blood vessels, and at different locations of the body such as eyes, ears, vocal cord, hand, spinal cord, intra-abdominal cavity, intra-thoracic cavity, intra-cranial cavity, oral cavity, gynecological procedures, endometrios, phimosis,

3b) acne.

3c) hypertrophic scars & keloids,

3d) pleuritis,

3e) peritoneal dialysis,

3f) acute and chronic wounds.

The peptides of the invention are further believed to have anti-angiogenetic effects and are therefore suited for treatment and/or prevention of :

4a) Cancer,

4b) Rheumatoid arthritis.

The peptides of the invention have anti-infectious effects, and are suited for the prevention and/or treatment of:

<u>5a) Antibacterial effects:</u>

Upper and lower respiratory tract (tonsillitis, sinusitis, pneumonia, chronic obstructive

pulmonary disease, cystic fibrosis, etc.)
Infections of the eye (e.g. conjunctivitis)
Urinary tract infections
Sexually transmitted diseases (including antimicrobial coating of condomes)
Genital tract (including vaginosis, vaginitis, cervicitis, endometritis, PID)
Gastrointestinal tract infections (systemic infections initiated in the GI)
Central nervous system infections
Infections of the skin and skin structures such as secondarily infected traumatic lesions including surgical site infections, cellulitis or abscesses, secondarily infected dermatoses, impetigo, and carbuncles or furunculosis (including both Gram postivie and Gram negative bacteria, staphylococci, for instance MRSA, streptococci, nosocomial, wounds, burns), muscle, joints (e.g. septic arthritis), bone and hemopoietic system
Infections related to the mouth, eye, inner and outer ear and ear canal, including parodontitis, gingivitis

5b) Antiviral effects:
Upper and lower respiratory tract
Sexually transmitted diseases
Gastrointestinal tract infections (systemic infections initiated in the GI)
Central nervous system infections

5c) Antifungal effects:
Upper and lower respiratory tract (such as aphthae, mucocutanous candidiasis)
Genitourinary tract (such as vulvovaginal candidiasis, balanitis)
Gastrointestinal tract infections (systemic infections initiated in the GI)
Central nervous system infections
Infections of the skin and skin structure (such as mucocutanous candidiasis), dermatosis and excema.

Most preferably the peptides of the present invention are used for the treatment, prophylaxis and/or prevention of impetigo, burn wounds, infected abrasions, infected lacerations, excoriations, erysipelas, cellulitis, abscesses, furuncles, carbuncles, sutured wounds, surgical site infections, secondarily infected dermatoses: atopic dermatitis, psoriasis, and allergic contact dermatitis, animal bites, catheter related infection.

The peptides, medicinal products and methods according to the invention may either be used alone, in combination with each other or in combination with conventional therapy.

According to the present invention it is also possible to include the peptides, in an effective amount, in any kind of food or beverage intended to reduce infections and/or inflammations in patients running an increased risk of such conditions due to an underlying disease, a low birth weight or a medical treatment. For example, it is possible to include the peptides, in an effective amount, in an infant formula food intended to inhibit harmful effects of bacteria, such as weight loss caused by inflammation induced by bacteria, viruses or fungi in infants. When the peptides according to the invention is to be used in food stuffs, e.g. for nutritional purposes, it is especially preferred to use peptides of natural origin.

Since the peptides according to the invention have antimicrobial effects they can also be used as preservatives in different food stuffs and medicinal products such as gels, creams, ointments, pastes, solutions, emulsions etc.

The invention will now be further explained in the following examples. These examples are only intended to illustrate the invention and should in no way be considered to limit the scope of the invention.

DESCRIPTION OF FIGURES

Figure 1. Representation of the different classes of amino acids, showing similarity in terms of hydrophobicity, size and charge.

Figure 2. Top view of the helix corresponding to a part of the peptide SEQ ID NO:1, namely KCFQWQRNMRKVR

Figure 3. Scatter plot showing clustering of the peptides. Peptides are plotted according to their physicochemical properties. Peptides with TNF-α inhibitory activity (at a peptide concentration of 40 µM) can be found in two clusters: clusters A and B.

Figure 4. Dose-response effect of peptide 265 (A) on bacterial colonization of infected excision wounds in rats. Wounds infected with MRSA (CCUG 41879) and treated with the corresponding peptide in H_2O, in the concentrations 0.1, 0.5 and 2 mg/ml,demonstrate a significant reduction in bacterial counts in a dose response fashion. Results are presented as relative bacterial survival (%) compared to control group ± SEM (n=15 wounds). Statistical significance was estimated by Student´s t test. *=$p<0.05$, **=$p<0.01$, ***=$p<0.001$.

Figure 5. Dose response effect of peptide 265 (A), on bacterial colonization of infected wounds in pig skin. Wounds infected with *S. aureus* in PBS/serum (50/50) and treated with corresponding peptide in H_2O, in the concentrations 0.1, 0.5 and 2 mg/ml demonstrate a significant reduction in bacterial counts with a dose response relation. Results are presented

as relative bacterial survival (%) compared to control group ± SEM (n=10 wounds). Statistical significance was estimated by Student´s t test. *=p<0.05, **=p<0.01, ***=p<0.001.

EXAMPLES

Example 1. Peptide screen 1

The lactoferrin derived peptides shown in table 1 have been designed and tested. Active peptides have been identified.

New peptide variants were designed based on the measured anti-inflammatory and antimicrobial activity of peptides having sequences similar to SEQ ID NO:1. In addition, structural considerations of the corresponding sequences for these peptides were taken into account. In practice, this meant to keep and enhance the helicity of the peptides. New variants of peptides were designed by increasing the positive charge and the hydrophobic regions of the peptides. Thus, the amphipathic character of the peptides was increased (Figure. 2). Based on the new designs, new peptides were ordered as a PEPscreen library (Sigma) and tested both for anti-inflammatory and for antimicrobial activity.

Table 1. List of peptides tested in screen 1

Peptide	Sequence	SEQ ID NO
Peptide 116	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 4
Peptide 126	FQWQRKMRKVRGSRRRRG	SEQ ID NO: 5
Peptide 127	FQWKRRMRKVRGSRRRRG	SEQ ID NO: 6
Peptide 130	WFQWKRAMRKVRGSRRRRG	SEQ ID NO: 7
Peptide 132	FWWKRAMRKVRGSRRRRG	SEQ ID NO: 8
Peptide 150	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 9
Peptide 152	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 10
Peptide 153	FQWQRNMRKVRGPSRRRRG	SEQ ID NO: 11
Peptide 154	FQWQRNMRKVRGPPSRRRRG	SEQ ID NO: 12
Peptide 155	CFQWKRAMRKVRGSRRRRG	SEQ ID NO: 13
Peptide 156	EATKCFQWQRNMRKVRGPPVSSIKR	SEQ ID NO: 14
Peptide 157	CFQWQRNMRKVRGPPVSCIKR	SEQ ID NO: 15
Peptide 159	CFQWKRAMRKVRGPPVSCIKRDS	SEQ ID NO: 16

Anti-inflammatory activity was measured as inhibition of TNF-α production in LPS stimulated THP-1 cells.

The THP-1 cell line (TIB-202; ATCC, Manassas, VA, USA) corresponding to human monocytes was maintained in RPMI 1640 (PAA Laboratories GmbH, Pasching, Austria)

supplemented with 10% fetal bovine serum (FBS; PAA Laboratories GmbH, Pasching, Austria), 1 mM sodium pyruvate (Sigma-Aldrich, St. Louis, MO, USA), and 20 mM HEPES (PAA, Laboratories GmbH, Pasching, Austria).

The cell density was adjusted to 10^6 cells/ml and 100 µl of the suspension was added per well to 96-well cell culture plates (Sarstedt, Nümbrecht, Germany). The cells were treated with 10 ng/ml PMA (phorbol 12-myristate 13-acetate; Sigma-Aldrich, St. Louis, MO, USA) for 48 hours in order to differentiate the monocytes into macrophage-like cells. Thereafter, the cells were stimulated by addition of 0.1 ng/ml lipopolysaccharide (LPS; *E. coli* serotype O55:B5; Sigma-Aldrich, St. Louis, MO, USA) into the medium specified above except of containing 5% heat inactivated FBS. 30 minutes after addition of LPS, peptides (40 µM) were added in triplicates. After 6 hours of incubation at +37 ºC, 5% CO_2 and in a humid atmosphere, the cell supernatants were collected, centrifuged and kept frozen in -20°C until analyzed for TNF-α content by ELISA (R&D Systems, Minneapolis, MN, USA). The results are presented as mean relative secretion (%), with stimulated TNF-α level without peptide added set to 100% and basal secretion set to 0% (Table 2).

Table 2. Anti-inflammatory effects of peptides tested in screen 1

SEQ ID NO	Peptide	TNF-α at 40 µM peptide
SEQ ID NO 13	155	5%
SEQ ID NO 7	130	6%
SEQ ID NO 6	127	9%
SEQ ID NO 8	132	18%
SEQ ID NO 16	159	60%
SEQ ID NO 4	116	83%
SEQ ID NO 5	126	107%
SEQ ID NO 10	152	110%
SEQ ID NO 14	156	124%
SEQ ID NO 9	150	134%
SEQ ID NO 15	157	153%
SEQ ID NO 11	153	159%
SEQ ID NO 12	154	162%

Antimicrobial activity was measured as bactericidal effect on S. aureus using Minimal microbicidal concentration, MMC_{99}, assay)

S. aureus (#1800; CCUG, Gothenburg, Sweden) cultured on blood-agar plates [Columbia agar (Oxoid, Basingstoke, UK) supplemented with 5% defibrinated horse blood (National Veterinary Institute (SVA), Uppsala, Sweden)] were transferred to brain heart infusion broth

(3.7% BHI; Difco, BD Diagnostics, Franklin Lakes, NJ, USA) and incubated in a shaker at 250 rpm +37°C over night. The culture was thereafter be diluted 1:10 in fresh BHI broth and incubated for additional two hours to reach log-phase growth. The bacteria were pelleted and suspended in 1% BHI medium (BHI broth diluted 100 times in ultra-pure water) to a concentration of 10^7 bacteria/ml as estimated by measuring optical density at 600 nm. Peptides were serially diluted by two-fold steps from 160 µM to 1.25 µM in 1% BHI medium. The peptides (100 µl) were thereafter incubated with bacteria (5 µl á 10^7 bact./ml) for 2 hours at +37°C. Drops (5 µl) of the suspension were placed on blood agar plates. The blood agar plates were incubated over night at +37°C. The MMC_{99} values, i.e. the lowest peptide concentration needed to achieve a 99% reduction of viable bacteria, were recorded (Table 3). The concentration of the bacterial suspension used in the assay was confirmed by viable counts on blood agar plates.

Table 3. Antibacterial effects of peptides tested in screen 1

SEQ ID NO	Peptide	MMC_{99} µM in 1% BHI medium
SEQ ID NO 6	127	5
SEQ ID NO 7	130	5
SEQ ID NO 8	132	5
SEQ ID NO 4	116	10
SEQ ID NO 5	126	10
SEQ ID NO 9	150	10
SEQ ID NO 10	152	10
SEQ ID NO 11	153	10
SEQ ID NO 12	154	10
SEQ ID NO 13	155	10
SEQ ID NO 14	156	20
SEQ ID NO 15	157	20
SEQ ID NO 16	159	20

Example 2. Peptide screen 2

The TNF-α activities for the peptides from this first screening round were subjected to multivariate analysis using the ProPHECY™ software (Saromics, Lund, Sweden). A large number of descriptors were computed for each peptide. The TNF-α activities were then correlated with these descriptors. Separate regression models were created for the peptide class. In addition, global models that considered the peptide class were also created. Analysis of the regression model suggested several variables that contributed towards improved TNF-α activity. New peptides for the second screening round were suggested for thepeptide class, primarily based on modulation of charge, amphipathicity, and

hydrophobicity. Based on the new designs, about 80 peptides were ordered as a PEPscreen library (Sigma) and tested both for anti-inflammatory and antimicrobial activity.

Table 4. List of peptides tested in screen 2

Peptide 224	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 17
Peptide 256	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 18
Peptide 257	FQWKRRMRKVRGSKKKKG	SEQ ID NO: 19
Peptide 258	FQWKRRMRKVRGSLRRWG	SEQ ID NO: 20
Peptide 259	RQWKRRMRKVFHSYRRMG	SEQ ID NO: 21
Peptide 260	KQWKRWMRKVFVSLRRVG	SEQ ID NO: 22
Peptide 261	RQWKRVMRKVFGSRWWRG	SEQ ID NO: 23
Peptide 262	KQWKRMMRKVFSVRRWFL	SEQ ID NO: 24
Peptide 263	FRWKRRMRKVRGSRRRQG	SEQ ID NO: 25
Peptide 264	FQWKRRMRKVRSGRRRGR	SEQ ID NO: 26
Peptide 265	FRQWKRWMRKVFHSWRRW	SEQ ID NO: 27
Peptide 266	FQWKRRKRMRRGSVRRRG	SEQ ID NO: 28
Peptide 268	GRRRRSGRVKRMRRKQWF	SEQ ID NO: 29
Peptide 269	GRRRRSFQWKRRMRKVR	SEQ ID NO: 30
Peptide 270	FWWKRAMRKVRLSRRRRG	SEQ ID NO: 31
Peptide 271	FWWKRAMRKVRNSRRRRG	SEQ ID NO: 32
Peptide 272	VYYKRTARKARGSRRRRG	SEQ ID NO: 33
Peptide 273	FWWKKAMKKVKGTRRRRG	SEQ ID NO: 34
Peptide 276	CFLWRRNMRKVRGSRRRRG	SEQ ID NO: 35
Peptide 282	FQWQRNMRKVRGSRRRRG	SEQ ID NO: 36

Anti-inflammatory activity was measured as inhibition of TNF-α production in LPS stimulated THP-1 cells.

The THP-1 cell line (TIB-202; ATCC, Manassas, VA, USA) corresponding to human monocytes was maintained in RPMI 1640 (PAA Laboratories GmbH, Pasching, Austria) supplemented with 10% fetal bovine serum (FBS; PAA Laboratories GmbH, Pasching, Austria), 1 mM sodium pyruvate (Sigma-Aldrich, St. Louis, MO, USA), and 20 mM HEPES (PAA, Laboratories GmbH, Pasching, Austria).

The cell density was adjusted to 10^6 cells/ml and 100 µl of the suspension was added per well to 96-well cell culture plates (Sarstedt, Nümbrecht, Germany). The cells were treated with 10 ng/ml PMA (phorbol 12-myristate 13-acetate; Sigma-Aldrich, St. Louis, MO, USA) for 48 hours in order to differentiate the monocytes into macrophage-like cells. Thereafter, the cells were stimulated by addition of 0.1 ng/ml lipopolysaccharide (LPS; *E. coli* serotype O55:B5; Sigma-Aldrich, St. Louis, MO, USA) into the medium specified above except of containing 5% heat inactivated FBS. 30 minutes after addition of LPS, peptides (40 µM, 10 µM and 4 µM) were added in triplicates. After 6 hours of incubation, the cell supernatants

were collected, centrifuged, and kept frozen in -20°C until analyzed for TNF-α content by ELISA (R&D Systems, Minneapolis, MN, USA). The results are presented as mean relative secretion (%), with stimulated TNF-α level without peptide added set to 100% and basal secretion set to 0% (Table 5).

Table 5. Anti-inflammatory effects of peptides tested in screen 2

SEQ ID NO	Peptide	TNF-α at 40 μM peptide	TNF-α at 10 μM peptide	TNF-α at 4 μM peptide
SEQ ID NO 17	224	113.4%	nd	nd
SEQ ID NO 18	256	100.5%	nd	nd
SEQ ID NO 19	257	62.8%	109.1%	114.5%
SEQ ID NO 20	258	39.8%	115.4%	110.4%
SEQ ID NO 21	259	33.0%	108.5%	108.4%
SEQ ID NO 22	260	5.9%	74.0%	99.3%
SEQ ID NO 23	261	24.5%	56.2%	86.0%
SEQ ID NO 24	262	12.1%	45.3%	79.6%
SEQ ID NO 25	263	61.4%	100.1%	93.6%
SEQ ID NO 26	264	87.2%	nd	nd
SEQ ID NO 27	265	13.8%	31.1%	87.0%
SEQ ID NO 28	266	101.1%	nd	nd
SEQ ID NO 29	268	74.4%	129.7%	114.5%
SEQ ID NO 30	269	66.2%	113.8%	115.7%
SEQ ID NO 31	270	23.1%	71.5%	96.2%
SEQ ID NO 32	271	24.5%	74.4%	101.7%
SEQ ID NO 33	272	102.8%	nd	nd
SEQ ID NO 34	273	52.7%	78.6%	86.2%
SEQ ID NO 35	276	38.8%	135.3%	111.0%
SEQ ID NO 36	282	114.8%	nd	nd

nd= not done

Antimicrobial activity was measured as bactericidal effect on S. aureus using Minimal microbicidal concentration, MMC_{99}, assay)

S. aureus (#1800; CCUG, Gothenburg, Sweden) cultured on blood-agar plates [Columbia agar (Oxoid, Basingstoke, UK) supplemented with 5% defibrinated horse blood (National Veterinary Institute (SVA), Uppsala, Sweden)] were transferred to brain heart infusion broth (3.7% BHI; Difco, BD Diagnostics, Franklin Lakes, NJ, USA) and incubated in a shaker at 250 rpm +37°C over night. The culture was thereafter be diluted 1:10 in fresh BHI broth and incubated for additional two hours to reach log-phase growth. The bacteria were pelleted and suspended in 1% BHI medium (BHI broth diluted 100 times in ultra-pure water) to a final concentration of 10^7 bacteria/ml as estimated by measuring optical density at 600 nm.

Peptides were serially diluted by two-fold steps from 400 µM to 0.78 µM in either 1% BHI medium or in 50% heat inactivated simulated wound fluid [SWF, containing 1 part 0.1% peptone (Oxoid, Basingstoke, UK) in saline and 1 part fetal bovine serum, diluted 2 times in ultra-pure water].

The peptides (100 µl) were thereafter incubated with bacteria (5 µl á 10^7 bact./ml) for 2 hours at +37°C. Drops (5 µl) of the suspension were placed on blood agar plates. The blood agar plates were incubated over night at +37°C. The MMC_{99} values, i.e. the lowest peptide concentration needed to achieve a 99% reduction of viable bacteria were recorded (Table 6). The concentration of the bacterial suspension used in the assay was confirmed by viable counts on blood agar plates.

Table 6. Antibacterial effects of peptides tested in screen 2

SEQ ID NO	Peptide	MMC_{99} µM in 1% BHI medium	MMC_{99} µM in 50% SWF
SEQ ID NO 17	224	12.5	400
SEQ ID NO 18	256	12.5	200
SEQ ID NO 19	257	6.25	200
SEQ ID NO 20	258	6.25	12.5
SEQ ID NO 21	259	6.25	25
SEQ ID NO 22	260	6.25	25
SEQ ID NO 23	261	12.5	12.5
SEQ ID NO 24	262	6.25	6.25
SEQ ID NO 25	263	6.25	100
SEQ ID NO 27	265	6.25	12.5
SEQ ID NO 29	268	6.25	200
SEQ ID NO 30	269	6.25	200
SEQ ID NO 31	270	6.25	12.5
SEQ ID NO 32	271	6.25	6.25
SEQ ID NO 34	273	6.25	12.5
SEQ ID NO 35	276	6.25	12.5
SEQ ID NO 36	282	12.5	200

nd= not done

The peptides

The template for the peptides is an arginine substituted peptide. The peptides discussed below are of similar lengths and the scatter plot in Figure 3 shows two clusters with peptides with pronounced TNF-α activities at 40 µM. The template peptide was almost inactive at the same concentration, but it is active at higher concentrations.

Table 7: The peptides

Position:	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Template:	x	F	Q	W	Q	R	N	M	R	K	V	R	G	S	R	R	R	R	G
CLUSTER A																			
259:		R			**K**		R					**F**	H		Y			M	
260:		**K**			**K**		**W**					**F**	**V**		**L**			**V**	
261:		R			**K**		V					**F**	G			W	**W**		
262:		**K**			**K**		M					**F**	S	V			**W**	**F**	**L**
265:	F	R			**K**		**W**					**F**	H		W			**W**	-
CLUSTER B																			
127:					**K**		R												
130:	W				**K**		**A**												
132:			**W**		**K**		**A**												
257:					**K**		R								K	K	K	K	
258:					**K**		R								**L**			**W**	
263:			R		**K**		R											Q	
264:					**K**		R						S	G				G	R
270:			**W**		**K**		**A**						**L**						
271:			**W**		**K**		**A**						**N**						
273:			**W**		**K**	K	**A**		K			K		T					

Residues in bold indicate amino acid types that contribute positively to the activity. The template sequence is partly (pos. 1 – 12) from mature human lactoferrin and corresponds to amino acids positions 20-31. Position 13 – 18 corresponds to the reversed sequence in position 1-5 in mature human lactoferrin.

Table 7 shows the large number of mutations in both cluster A and B. It is clearly seen that the two groups of peptides both overlaps and complements each other with respect to positional mutations. The active peptides from cluster A all have charged amino acids, R or K, in position 1 and 4 and a hydrophobic amino acid, F, at position 11. Both hydrophobic amino acids V, M and W, and the charged amino acid R is found at position 6. Positions 14, 16 and 17 all have hydrophobic uncharged amino acids, F, M, V or W, which is different from the template which has R in the same positions. Cluster B shows that Q in position 2 can be replaced with either hydrophobic residues W, L or charged amino acid, R.

The modifications made in cluster A and cluster B are complementary to each other at some of the positions. Thus position -1 can have an added hydrophobic, C, F or W, or a polar, S, amino acid. The amino acid at position 12, which is a G for the template peptide, can be exchanged with a number of different residues, both polar and hydrophobic, exemplified with H, V, S, N, L. The situation is similar at position 13, where S of the template can be exchanged with V, G and T. Active peptides can have both hydrophobic and charged amino acids at positions 14, 15, 16, 17 and 18. At position 17 one also finds active peptides with G and Q.

Finally, in principle all of the active peptides belonging to cluster A and B display high antimicrobial effects even at close to physiological salt concentrations.

Example 3. *In vitro* antimicrobial effect

The antimicrobial effects of the peptide 265 (SEQ ID NO: 27) was analysed by MMC_{99} (minimal microbicidal concentration) assay against *S. aureus* (CCUG 1800), MRSA (CCUG 41879), *P. aeruginosa* (ATCC 15442), *E. coli* (CCUG 31246), *S. pyogenes* (CCUG 4207), *P. acnes* (CCUG 1794T), *S. epidermidis* (ATCC12228), *K. pneumoniae* (ATCC 13883), *A. baumannii* (ATCC 19606), and *C. albicans* (ATCC 64549). The peptides were purchased from Biopeptide Company (San Diego, CA, USA) and Bachem AG (Bubendorf, Switzerland) and results are presented in Table 8A and 8B respectively.

Peptide was serially diluted in two different assay medium, 1% BHI medium (brain-heart infusion medium) or 50% heat inactivated simulated wound fluid (SWF), and thereafter incubated with the microorganisms for 2 hours. Drops of the suspension were placed on blood agar plates. The MMC_{99} values, i.e. the lowest peptide concentration needed to achieve a 99% reduction of viable microorganisms, were recorded. As presented in Table 8, the peptide has the ability to kill microorganisms frequently appearing in infections.

Table 8A. *In vitro* antimicrobial effect measured as MMC99 (µg/ml)

	Peptide 265 (SEQ ID NO 27)	
	1% BHI	50% SWF
S. aureus	4	8
MRSA	6	50
P. aeruginosa	4	134
E. coli	5	67
P. acnes	<3	50
S. pyogenes	<3	25

Table 8B. *In vitro* antimicrobial effect measured as MMC99 (µg/ml)

	Peptide 265 (SEQ ID NO 27)	
	1% BHI	50% SWF
S. epidermidis	<2	6
K. pneumoniae	3	25
A. baumannii	<2	12
C. albicans	6	100

Example 4. *In vivo* antimicrobial effect in excision wound model in rats

The *in vivo* antimicrobial effects of the peptide 265 (SEQ ID NO: 27) was investigated in an excision wound model in rats. The wounds were inoculated with methicillin resistant *S. aureus* (MRSA) for two hours, followed by a single administration of peptide or control (H_2O) for two hours before termination and harvest of the bacteria. The peptide showed pronounced antimicrobial effect (Figure 4).

Example 5. *In vivo* antimicrobial effect in infected wounds in pig

The antimicrobial effects of the peptide 265 (SEQ ID NO: 27) was investigated in an ex vivo model on pig skin. The wounds were inoculated with S. aureus in the presence of PBS/Serum 50/50. Two hours after inoculation the wounds were treated with a single administration of the peptide or placebo (H_2O). Four hours after the treatment bacteria were harvested and viable counts of each wound were determined. The results confirm the findings in rat indicating that the peptide is highly effective anti-infectious agents when applied locally (Figure 5).

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

CLAIMS

1. A peptide selected from any one of the peptides

R-Q-W-K-R-R-M-R-K-V-F-H-S-Y-R-R-M-G	(SEQ ID NO: 21);
K-Q-W-K-R-W-M-R-K-V-F-V-S-L-R-R-V-G	(SEQ ID NO: 22);
R-Q-W-K-R-V-M-R-K-V-F-G-S-R-W-W-R-G	(SEQ ID NO: 23);
K-Q-W-K-R-M-M-R-K-V-F-S-V-R-R-W-F-L	(SEQ ID NO: 24);
F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27);
F-Q-W-K-R-R-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 6);
W-F-Q-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 7);
F-W-W-K-R-A-M-R-K-V-R-G-S-R-R-R-R-G	(SEQ ID NO: 8);
F-Q-W-K-R-R-M-R-K-V-R-G-S-K-K-K-K-G	(SEQ ID NO: 19);
F-Q-W-K-R-R-M-R-K-V-R-G-S-L-R-R-W-G	(SEQ ID NO: 20);
F-R-W-K-R-R-M-R-K-V-R-G-S-R-R-R-Q-G	(SEQ ID NO: 25);
F-W-W-K-R-A-M-R-K-V-R-L-S-R-R-R-R-G	(SEQ ID NO: 31);
F-W-W-K-R-A-M-R-K-V-R-N-S-R-R-R-R-G	(SEQ ID NO: 32); and
F-W-W-K-K-A-M-K-K-V-K-G-T-R-R-R-R-G	(SEQ ID NO: 34).

2. A peptide according to claim 1, which peptide is

F-R-Q-W-K-R-W-M-R-K-V-F-H-S-W-R-R-W	(SEQ ID NO: 27).

3. A peptide according to claim 1 or 2, wherein a free COOH at the carboxy terminal end has been transformed into $CONH_2$.

4. A peptide according to any one of claims 1 to 3, wherein a free NH_2 group at the amino terminal end has been transformed into the amide CH_3CONH.

5. A peptide according to any one of claims 1 to 4 for use as a medicament.

6. A peptide according to any one of claims 1 to 4, for use in the treatment and/or prevention of infections or inflammations.

7. Use of a peptide according to any one of claims 1 to 4, for the manufacture of a medicament for the treatment and/or prevention of infections or inflammations.

8. A method for the treatment and/or prevention of infections or inflammations, whereby a peptide according to any one of claims 1 to 4, is administered to a subject in need of such treatment and/or prevention.

9. A pharmaceutical composition comprising a peptide according to any of claims 1 to 4.

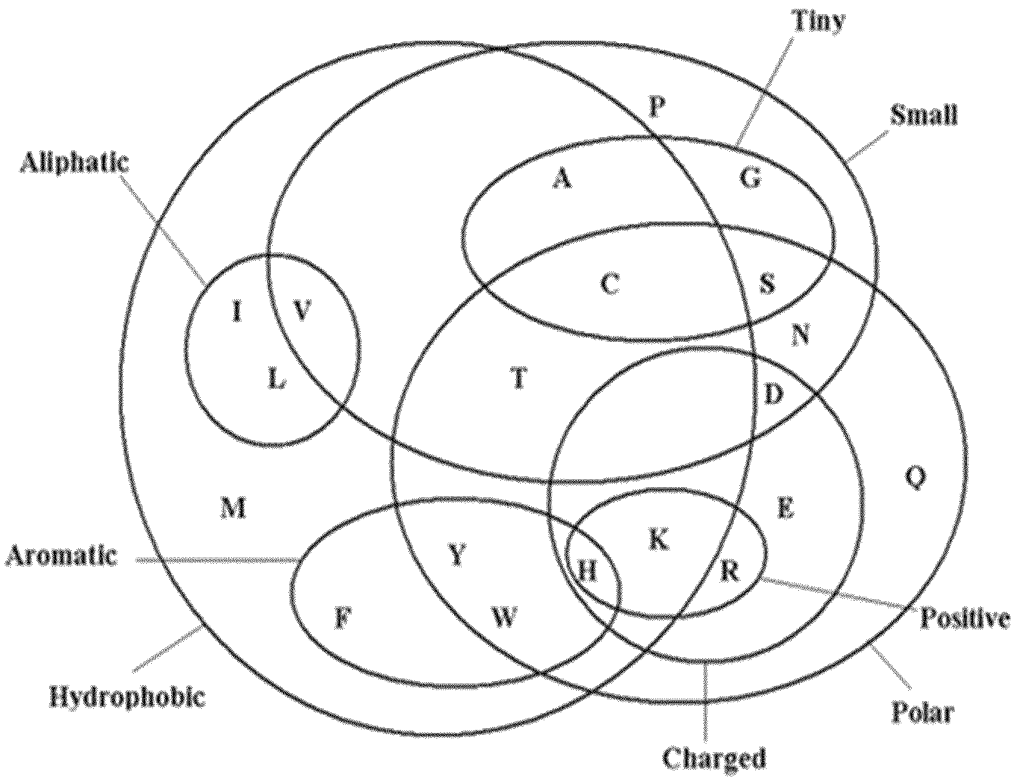
Tiny
Small
Aliphatic
P
A
G
C
S
I
V
N
L
T
D
Q
M
E
K
Aromatic
Y
H
R
Positive
F
W
Hydrophobic
Polar
Charged

Figure 1

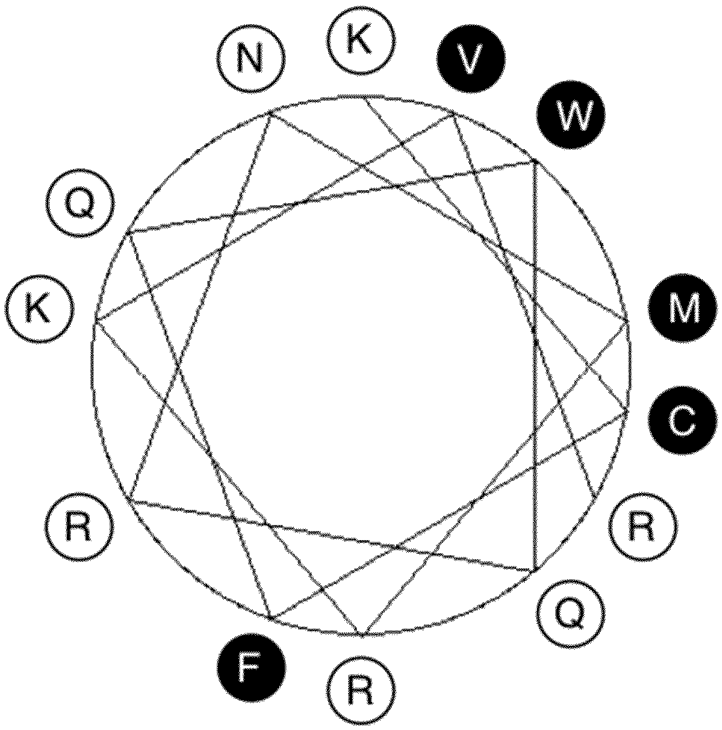

Figure 2

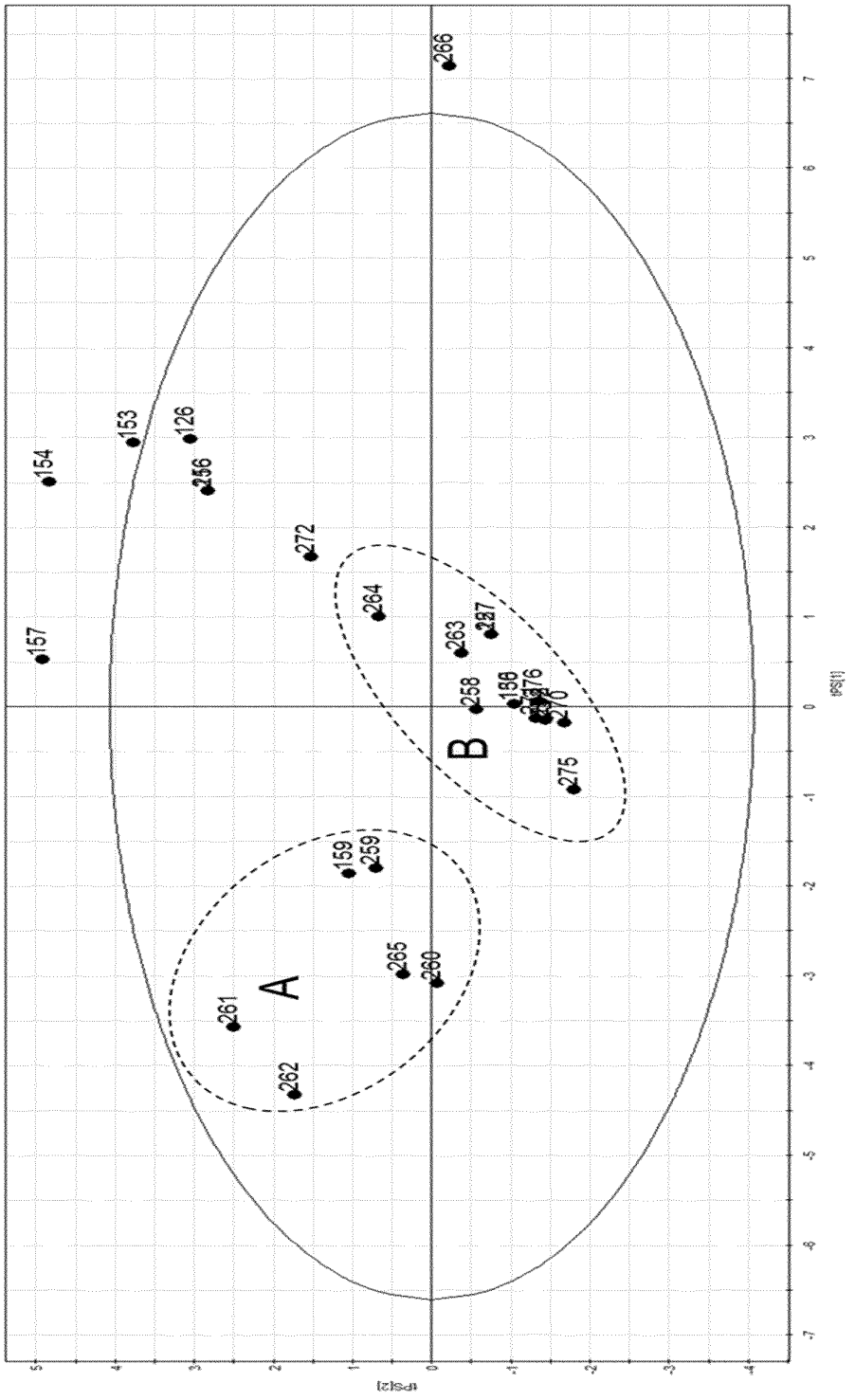
266
153
126
154
256
272
264
157
263
257
258
186
275
159
259
265
260
261
262
A
B
PS[2]
PS[1]

Figure 3

A

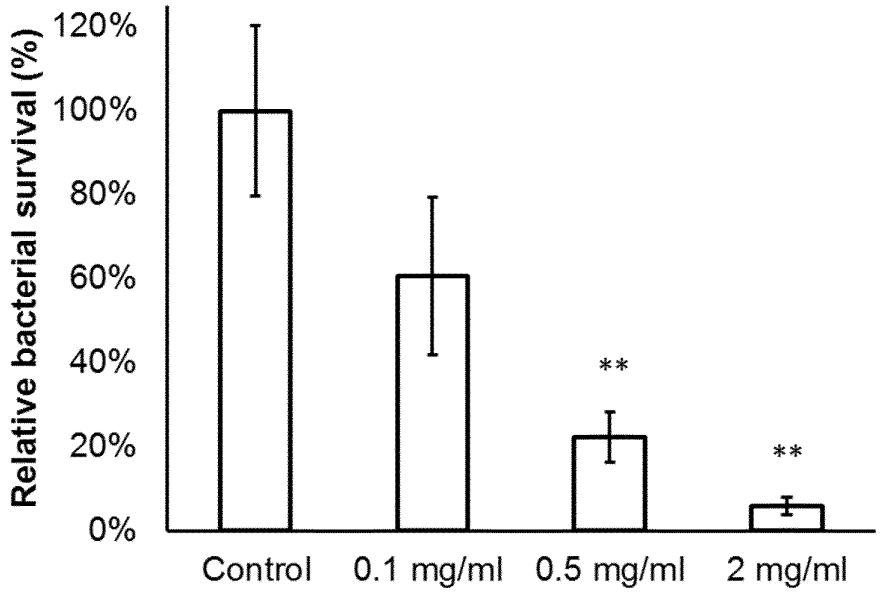
Relative bacterial survival (%)
120%
100%
80%
60%
40%
20%
0%
**
**
Control
0.1 mg/ml
0.5 mg/ml
2 mg/ml

Figure 4

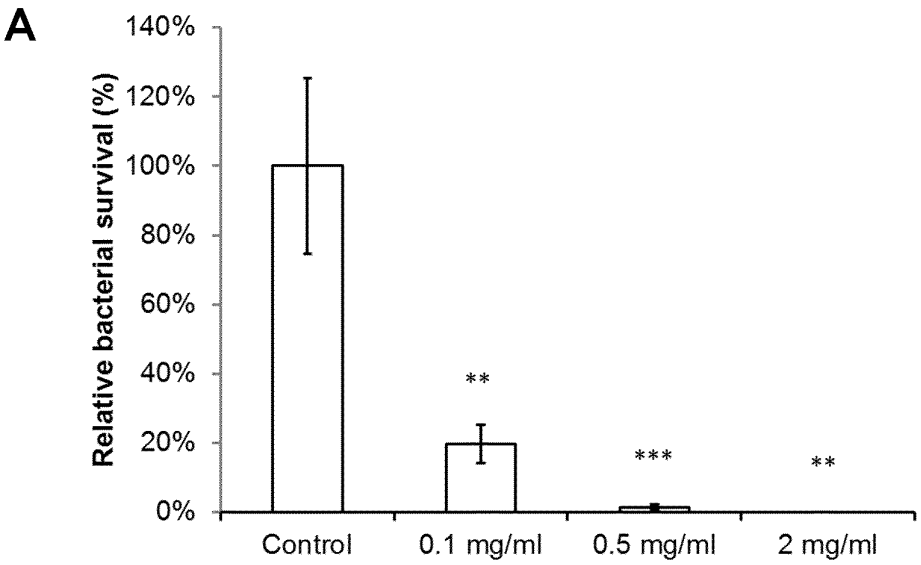
A
140%
120%
100%
80%
60%
40%
20%
0%
Relative bacterial survival (%)
**
***
**
Control
0.1 mg/ml
0.5 mg/ml
2 mg/ml

Figure 5