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SUBSTITUTION ANALOGUES OF MAGAININ PEPTIDES

This invention relates to a class of biologically active peptides known as magainins. More particularly, this invention relates to analogues of magainin peptides wherein at least one amino acid residue in the peptide has been substituted with another amino acid residue, with said analogues being commonly referred to as "substitution analogues."

In accordance with an aspect of the present invention, there is provided a compound comprising an analogue of Magainin I Peptide or Magainin II peptide. The Magainin I or Magainin II peptide is in an amide or carboxy terminated form. Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residues refer to the position of the residue in the peptide.

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Magainin II is represented by the following structural formula using the single letter amino acid code and the

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numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

The Magainin I or Magainin II peptide is substituted in at least one of positions 1-23. The substituents which may be employed in each of positions 1-23 are shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

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Preferably, the substituents are as follows:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

It is to be understood that for purposes of the present invention, that the tryptophan residues may be protected with a formyl group or be unprotected. The phenylalanine residues, whether such residue is present in its normal position, or employed as a substitution residue, may be a normal phenylalanine residue or an iodinated phenylalanine residue.

In accordance with one embodiment, the peptide is a Magainin I peptide, and at least one of amino acid residues 8, 10, 13, 16, 18 and 19 is substituted with an alanine residue. In another embodiment, the Magainin I peptide has alanine residue substitutions at each of amino acid residues 3, 8, 16, 19 and 23.

In accordance with another embodiment, the Magainin I peptide has alanine residue substitution at four of amino acid residues 3, 8, 16, 19 and 23,

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and the remaining one of these residues is substituted with a lysine residue.

In accordance with yet a further embodiment, amino acid 21 of a Magainin I peptide is substituted with a proline residue.

In accordance with another embodiment, at least one of amino acid residues 3, 7, 8, 10, 18-21, and 23 of Magainin I is substituted with a lysine residue.

In accordance with another embodiment, amino acid residues 3, 8, 9, 19 and 23 of Magainin I are each substituted with a lysine residue and amino acid residue 16 is substituted with an alanine residue.

In accordance with another embodiment, at least one of amino acid residues 2, 4, 19, or 23 of Magainin I is a D-amino acid residue, whose structure corresponds to that of the L-amino acid residue originally present in Magainin I.

In accordance with a further embodiment, at least one and amino acid residues 3, 5, 8, 10, 12, 13, 15, 18, and 20 of Magainin I is substituted with a protected tryptophan residue, wherein the protecting group is preferably a formyl group. In accordance with another embodiment, at least one of amino acid residues 9, 13, 15 and 17 of Magainin I is substituted with an unprotected tryptophan residue.

In accordance with another embodiment, the peptide is a Magainin II peptide, and at least one of amino acid residues 1-8, 10, 13, 14, 16 and 18-23 is an alanine residue.

In accordance with another embodiment, at least one of amino acid residues 1-3, 5-9, 12, 13 and 15-23 of Magainin II is a lysine residue.

In accordance with yet another embodiment, at least one of amino acid residues 2,4-12, 15-17, 19, 20, 22 and 23 of Magainin II is substituted with a

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D-amino acid residue whose structure corresponds to that of the L-amino acid residue originally present in Magainin II.

In accordance with another aspect of the present invention, there is provided an analogue of Magainin I or Magainin II peptide, said Magainin I or Magainin II peptide being in an amide- or carboxy-terminated form and having the structural formulas hereinabove described, and wherein at least one of amino acid residues 15-23 is omitted and at least one of the remaining amino acid residues is substituted. The substituents which may be employed in at least one of positions 1-23 are shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met,Phe
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

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Preferably, the substituents are as follows:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

In accordance with a particular embodiment, amino acid residues 16-23 of Magainin I are deleted, and amino acid residues 3, 8 and 10 are substituted with an alanine residue.

In accordance with yet another embodiment, amino acid residue 19 of Magainin I is deleted, and preferably amino acid residues 5, 8, 9 and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are substituted with an alanine residue.

In accordance with another embodiment, in carboxy- or amide-terminated (preferably amide-terminated) Magainin I or Magainin II peptide, amino acid residues 17-23 or 16-23 or 15-23 are deleted, and amino acid residues 3, 7, and 8 are each

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substituted with a lysine residue, and optionally amino acid residue 13 and/or amino acid residue 10 is substituted with an alanine residue. Preferred peptides are as follows:

GIKKFLKKAGKFGK-NH_2

GIKKFLKKAGKFGKAF-NH_2

GIKKFLKKAKKFGKA-NH_2

GIKKFLKKAKKFAKA-NH_2

GIKKFLKKAAKFAKA-NH_2

Preliminary studies indicate that the above-mentioned preferred peptides possess low hemolytic activity. In accordance with a further embodiment, amino acid residue 21 of Magainin I may be deleted, and preferably amino acid residues 5,10, 18, and 19 are each substituted with a lysine residue, amino acid residue 7 is substituted with a phenylalanine residue, and amino acid residue 22 is substituted with an alanine residue.

In accordance with another embodiment, in carboxy or amide terminated (preferably amide terminated) Magainin I or Magainin II (preferably Magainin II), amino acid residue 19 is omitted, and at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18 21, 22 or 23 is substituted with another amino acid as follows:

Residue number	Substituent
3	Leu
7	Lys
8	Lys, Ala
10	Ala, Lys
13	Trp, Leu, Phe, Ala
15	Phe
16	Ala
18	Lys, Ala, Phe
21	Lys, Ile

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22 Lys

23 Lys, D-Ser

Representative peptides are disclosed in Examples 14 and 21-23.

In a preferred embodiment, the peptide is a Magainin II peptide, and the substitution analogue wherein amino acid 19 is deleted is selected from the class consisting of the following substitution analogues:

GIGKFLHSAKKFGKAFVGIMKS;

GIGKFLHSAKKFGKAFVAIMKS;

GIGKFLHSAKKFGKAFVFIMNS*, wherein

S* is D-Serine;

GIGKFLHSAKKFFKAFVFIMNS;

GIGKFLKSAKKFGKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNS;

GIGKFLKSAKKFAKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNK;

GIGKFLKKAKKFGKAFVFIMKK; and

GIGKFLHSAKKFGKAFVK**IMNS; wherein

K** is E-F-moc-lysine.

Preliminary studies indicate that these preferred analogues possess low hemolytic activity.

In accordance with another embodiment, there are provided derivatives of Magainin I or Magainin II (carboxy- or amide-terminated), preferably Magainin II, wherein a portion of the basic peptide is deleted and at least one of the remaining amino acid residues is substituted as hereinabove described; in particular, amino acid residue 19 is omitted and in addition either amino acid residues 1-4 or 3,5, and 6 are omitted. Preferred peptides are as follows:

FLHSAKKFGKAFVFIMNS

GIKHSAKKFAKAFKAIMNS

FLKSAKKFGKAFVGIMNS

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FLKSAKKFAKAFVGIMNS

Applicants have found that when employing the substitution analogues of Magainin I or Magainin II as hereinabove described, such peptides display biological activity equal to or greater than the parent Magainin I or Magainin II peptide. Such peptides are referred to as "successful substitution analogues".

The use of these compounds which comprise a substitution analogue of Magainin I or Magainin II peptide, in accordance with the present invention, is effective as an antibiotic, and can be employed to inhibit, prevent or destroy the growth or proliferation of microbes, such as bacteria, fungi viruses or the like. Similarly, such compounds can be employed as an anti-viral composition to inhibit, prevent or destroy the growth or proliferation of viruses.

As used herein, the term "substitution analogue" includes magainin peptides in which at least one amino acid residue of the peptide structure has been substituted with a different amino acid residue, as well as magainin peptides in which, in addition to the above-mentioned substitution(s), also have had at least one of amino acid residues 15-23 omitted from the peptide sequence. The term also includes magainin peptides having D-amino acid or iodinated phenylalanine residues which have been substituted into the peptide sequence.

Such compounds can also be employed as a spermicide to inhibit, prevent or destroy the motility of sperm.

Such compounds can also be employed as anti-tumor agents to inhibit the growth of or destroy tumors.

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The compounds have a broad range of potent antibiotic activity against a plurality of microorganisms, including Gram-positive and Gram-negative bacteria, fungi, protozoa and the like. Such compounds can be employed for treating or controlling microbial infection caused by organisms which are sensitive to such compounds.

The compounds can also be used as preservatives or sterilants for materials susceptible to microbial contamination. In vitro activity against bacteria is exemplified hereinafter in Examples 3-27.

In general, a substitution analogue of the Magainin I or Magainin II peptide is administered in a dosage of from about 1 mg to about 500 mg per kilogram of body weight, when administered systemically. When administered topically, the peptide is used in a concentration of from about 0.5% to about 5%.

The compounds comprising the substitution analogues of Magainin I or Magainin II, in accordance with the present invention, can be employed for treating a wide variety of hosts. In accordance with a preferred embodiment, a host can be an animal, and such animal can be a human or non-human animal.

The compounds comprising the substitution analogues of Magainin I or Magainin II can be employed in a wide variety of pharmaceutical compositions in combination with a non-toxic pharmaceutical carrier or vehicle such as a filler, non-toxic buffer, or physiological saline solution. Such pharmaceutical compositions can be used topically or systemically and can be in any suitable form such as a liquid, solid, semi-solid, injectable solutions, tablet, ointment, lotion, paste, capsule or the like. The compounds comprising the

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substitution analogues of Magainin I or Magainin II can also be used in combination with adjuvants, protease inhibitors, or compatible drugs where such a combination is seen to be desirable or advantageous in controlling infection caused by harmful microorganisms including protozoa, viruses, and the like.

The compounds comprising the substitution analogues of Magainin I or Magainin II of the present invention can be administered to a host; in particular an animal, in an effective antibiotic and/or anti-tumor and/or anti-viral and/or anti-microbial and/or a spermicidal amount.

Magainin I and Magainin II, as well as the substitution analogues of the Magainin I and Magainin II peptides of the present invention, (both amide- and carboxy-terminated Magainin I and Magainin II forms) can be synthesized by any convenient method of peptide synthesis as are well-known to skilled workers. Solid phase synthesis methods are particularly preferred.

The peptides described herein were prepared by the method of simultaneous multiple peptide synthesis (SMPS). This method is described in detail in Houghten, R.A., "General Method for the Rapid Solid-Phase Synthesis of Large Numbers of Peptides; Specificity of Antigen-Antibody Interaction at the Level of Individual Amino Acids," Proc. Natl. Acad. Sci., U.S.A., Vol. 82, pgs. 5131-5135 (1985), and in Houghten, R.A., et al. "Simultaneous Multiple Peptide Synthesis; The Rapid Preparation of Large Numbers of Discrete Peptides for Biological, Immunological, and Methodological Studies," Peptide Chemistry, pgs. 295-298 (1987).

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For purposes of the following examples, substitution analogues of Magainin I and Magainin II were prepared wherein various amino acid residues were substituted and/or other amino acid residue(s) were deleted.

For purposes of comparison, a complete Magainin I or Magainin II peptide can also be prepared by the SMPS method. It is also contemplated within the scope of the present invention that substitution analogues which have one or more amino acid residue(s) omitted from the Magainin I or Magainin II structure can also be prepared by the SMPS method.

The invention will now be described with respect to the following examples, however, the scope of the present invention is not intended to be limited thereby.

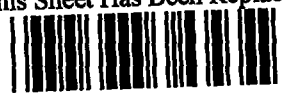
Example 1 - Peptide Synthesis

Peptide synthesis of Magainin I and the substitution analogues of Magainin I, was accomplished by using the strategy of simultaneous multiple peptide synthesis. All solvents and reagents were of analytical grade and were used without further purification. Standard N-t-Boc-protected amino acids were employed in the synthesis. The side chain functionalities used were benzyl (Ser, Glu), 2-Cl-Z (Lys)(Z=benzyloxycarbonyl), N^{im}- DNP (His), and sulfoxide (Met). Peptide synthesis was performed beginning with 100 mg of either Boc-amino acids-Pam resin to produce C-terminal carboxyl peptide (PAM purchased from Applied Biosystems, substitution 0.56 meq/gm is an amino acyl -4- [oxymethyl] phenylacetic acid derivative of amino polystyrene) or methylbenzhydrylamine (MBHA) resin

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(substitution-0.65meq/gm) per resin packet to produce C-terminal amide peptide.

After synthesis, completely protected peptide resins were treated three times with 0.5 M thiophenol in DMF to remove the N^{im}- dinitrophenyl group from Histidine. The final Boc-group was removed with TFA to avoid t-butylation of methionyl residues during final HF treatment. Cleavage was performed using the Low-High HF procedure. Tam, et al. J. Am. Chem. Soc. Vol. 105, P. 6442 (1983). For peptides synthesized on Pam resin, the low-HF was carried out without removing the resin from the packet, using a multiple vessel HF apparatus for 2 hrs. at 0°C. For peptides prepared using MBHA resin, the low HF procedure was performed in a common reaction vessel for 2 hrs. at 0°C. For Pam resin peptides, the low-HF mixture was evacuated from the 24 individual reaction vessels by a water aspirator followed by a mechanical pump. The low-HF reaction vessel containing the bags with MBHA resin was emptied of the low-HF mixture by pouring off the liquid into a waste container. The bags were washed immediately with cold ether followed by alternating washes of CH_2Cl_2, DMF, CH_2Cl_2, IPA, CH_2Cl_2. The packets were then dried and put into individual tubes of the 24 vessel HF apparatus with 0.7 ml of anisole as scavenger. The high-HF was performed by condensing dry hydrogen fluoride at -70°C. The reaction took place at -10°C for 1 h. and -5°C - 0°C for the last 30 min. HF was evaporated using a strong flow of nitrogen. Finally, residual carbonium ion scavengers were removed by washing with dry ether.

The crude peptides were subsequently extracted with 10% acetic acid and subjected to RP-HPLC on an analytical reversed phase column (Vidac ODS 25 cm x

4.6 mm), using a Beckman-Altek model 421 HPLC system and two model 110A pumps. The solvent system was composed of buffer A, 0.05% TFA/H_2O, and buffer B, 0.05% TFA/CH_3CN with a flow rate of 1.0 ml/min. The peptides were detected at 215 nm using a Hitachi 100-20 spectrophotometer.

Purification of the peptides was accomplished by reverse - phase HPLC on a Vidac C_{18} (22 mm x 25cm), 10 µm packing column with an eluting gradient composed of CH_3CN and 0.05% TFA. Amino acid analysis was carried out on a Beckman 6300 analyzer following hydrolysis of the peptides in constant (boiling) 6 N HCl at 110°C for 24 hr., and such analysis was within ±10% of theory.

Example 2 - Antimicrobial Assays

Antimicrobial assays were carried out in 96 - well tissue culture plates. Each well was incubated with a given microorganism (Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus, or Pseudomonas aeruginosa) suspended in LB medium (Examples 3-17), or TSB medium (Examples 18-27). Upon the addition of Magainin I or its substitution analogues, (dissolved in 1 X PBS, pH 7.0) each well contained a final cell density of 1.0×10^6 colony forming units (CFU)/ml. The final peptide concentrations used were 100 µg/ml., 75.0 µg/ml, 50.0 µg/ml, 25 µg/ml, 12.5 µg/ml, 10 µg/ml, 5µg/ml, 2.5 µg/ml, and 1.25 µg/ml.

Addition of peptides to the wells was defined as time zero. At six hours, the plates were placed in a Titertek Multiskan apparatus and the $O.D._{620}$ determined. The plates as well as the initial innoculum were incubated at 37°C.

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Five wells per plate contained media alone, while five others contained medium plus cells. These controls were used to eliminate the possibility of media contamination while providing a measure of uninhibited growth of the microorganisms.

The degree of peptide activity was determined by comparing the substitution analogues with uninhibited growth of the control cells over a six-hour period. The effective growth inhibition of the substitution analogues is listed in the examples and tables below.

Example 3 - Magainin I analogues with alanine substitutions

Magainin I and analogues wherein an alanine residue was substituted for various amino acid residues of Magainin I were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E. coli at a concentration given in µg/ml as hereianbove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine-substituted Magainin I analogues is listed below in Table I. As used herein, the heading "Amino Acid Residue Substituted" refers to the number of the amino acid residue in the peptide which is substituted with a desired amino acid residue. All other residues in the peptide remain the same as that of the normal peptide sequence. For purposes of explanation of the term "% effective growth inhibition," a value of "100 at 25", for example, indicates 100% effective growth inhibition at a concentration of 25 µg/ml.

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Table 1 - Alanine-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml
None (Magainin I)	100 at 25
23	100 at 10
22	100 at 50
21	100 at 50
20	100 at 50
19	100 at 5
18	100 at 25
17	100 at 75
16	100 at 25
14	100 at 100
13	100 at 25
12	100 at 50
11	0 at 100
10	100 at 25
8	100 at 5
7	100 at 75
6	0 at 100
5	0 at 100
4	0 at 100
3	100 at 75
2	100 at 100
1	100 at 100

Magainin I analogues were also prepared wherein amino acid residues 19, 16, or 8, respectively, were substituted with alanine residues, and such substitution analogues were tested for % effective growth inhibition of S. epidermidis and/or S. aureus as compared to Magainin I without any substitutions.

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Magainin I had a % effective growth inhibition of S.epidermidis of 100% at 25 µg/ml and of S.aureus of 80% at 100 µg/ml. The % effective growth inhibition of S. epidermidis for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 µg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 16 was substituted with an alanine residue was 75% at 100 µg/ml. The % effective growth inhibition of S. aureus for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 µg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 8 was substituted with alanine was 100% at 50 µg/ml.

Example 4 - Magainin I analogues with Proline Substitutions

Magainin I analogues wherein a proline residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E. coli at a concentration given in µg/ml. The % effective growth inhibition for each of the proline-substituted analogues of Magainin I is listed below in Table II.

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Table II - Proline-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 25
20	100 at 100
19	100 at 50
18	100 at 75
17	0 at 100
16	0 at 100
15	50 at 100
14	0 at 100
13	100 at 100
12	0 at 100
11	0 at 100
10	0 at 100
9	100 at 100
8	100 at 75
7	0 at 100
6	0 at 100
4	0 at 100
3	100 at 75
2	0 at 100
1	100 at 100

Example 5 - Lysine-Substituted Magainin I Analogues

Magainin I analogues wherein a lysine residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E.coli at a concentration given in µg/ml. The % effective

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growth inhibition of each lysine-substituted analogue of Magainin I is given below in Table III.

Table III - Lysine-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
23	100 at 5
21	100 at 25
20	100 at 25
19	100 at 2.5
18	100 at 25
17	100 at 100
16	0 at 100
15	100 at 50
13	100 at 50
12	100 at 100
10	100 at 25
9	100 at 100
8	100 at 5
7	100 at 5
6	0 at 100
5	0 at 100
3	100 at 25
2	100 at 100
1	100 at 50

Magainin I analogues wherein amino acid residues 23, 19, 8, or 7, respectively, were substituted with a lysine residue were tested for % effective growth inhibition of *S. epidermidis* and/or *S. aureus*. The substitution analogue of Magainin I wherein amino acid residue 23 was substituted with a lysine residue

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had a % effective growth inhibition of S. aureus of 30% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 19 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 50% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 8 was substituted with a lysine residue had a % effective growth inhibition of S. aureus of 70% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 7 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 100% at 50 µg/ml.

Example 6 - Glutamic Acid-Substituted Magainin I Analogues

Magainin I analogues wherein a glutamic acid residue was substituted for various amino acid residues of Magainin I were prepared and tested for % effective growth inhibition of E.coli according to the methods hereinabove described. The % effective growth inhibition for each glutamic acid-substituted Magainin I analogue is described below in Table IV.

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Table IV Glutamic Acid-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 75
20	0 at 100
18	100 at 75
17	0 at 100
16	0 at 100
15	0 at 100
14	0 at 100
13	0 at 100
12	0 at 100
11	0 at 100
10	100 at 75
9	0 at 100
8	100 at 75
7	32 at 100
3	0 at 100

Example 7 - Magainin I peptides containing D-amino acid residues

Magainin I peptides were synthesized wherein in each peptide one of amino acid residues 23, 19, 17, 16, 14, 4, or 2, respectively, is substituted with a D-amino acid residue. Each of these Magainin I peptide analogues was then tested as hereinabove described for % effective growth inhibition of E.coli in µg/ml. The % effective growth inhibition for each of the D-amino acid residue-subsituted analogues of Magainin I is listed below in Table V.

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Table V - D-amino acid residue-substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
23	100 at 10
19	100 at 25
17	100 at 50
16	100 at 50
14	100 at 50
4	100 at 25
2	100 at 25

Example 8

In this example, a substitution analogue of Magainin I was prepared wherein amino acid residue 19, (E, or glutamic acid) was deleted, and amino acid residues 5, 8, 9, and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are each substituted with an alanine residue. The substitution analogue had the following structure:

GIGKKLHKKGKFGKFKGAILKA

The % effective growth inhibition of E.coli for this peptide was tested and found to be 100% at 5 µg/ml.

Example 9

In this example, a substitution analogue of Magainin I was prepared wherein amino acid 21 was deleted and amino acid residues 5, 10, 18, and 19

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were each substituted with a lysine residue, amino acid residue 7 was substituted with a phenylalanine residue, and amino acid 22 was substituted with an alanine residue. The peptide had the following structure:

GIGKKLFSAKKFGKAFVKKIAS

The % effective growth inhibition of E.coli for this peptide was tested and found to be 100% at 2.5 µg/ml.

Example 10

Magainin I and Magainin II peptides were prepared wherein phenylalanine residues 5 and 12 in each peptide were iodinated. The % effective growth inhibition of E.coli for each peptide, containing the iodinated phenylalanine residues, was tested. For the Magainin I peptide, the % effective growth inhibition was 100% at 10 µg/ml. For the Magainin II peptide, the % effective growth inhibition was 100% at 5 µg/ml.

Example 11 - Tryptophan (Formyl Group Removed)-Substituted Analogues of Magainin I

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I. The tryptophan had the formyl group removed, thus resulting in the substitution of unprotected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E.coli and S. epidermidis was tested for these analogues. % effective growth inhibition of E. coli and S. epidermidis in µg/ml is listed below in Table VI.

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Table VI - Tryptophan (Formyl Group Removed) - Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml	
	E.coli	S. epidermidis
1	100 at 50	80 at 75
3	100 at 25	100 at 50
4	90 at 100	0 at 100
5	100 at 25	80 at 100
6	100 at 50	50 at 75
8	100 at 100	100 at 50
9	100 at 25	40 at 100
10	100 at 25	100 at 50
11	0 at 100	0 at 100
12	100 at 25	0 at 100
13	100 at 25	100 at 50
14	N/A	0 at 100
15	96 at 10	90 at 100
16	95 at 50	0 at 100
17	100 at 25	100 at 100
18	93 at 25	90 at 100
19	100 at 10	100 at 75
20	90 at 25	30 at 100
21	100 at 50	0 at 100
22	40 at 75	0 at 100

Example 12 - Tryptophan (containing formyl group)-Substituted Magainin I Analogues

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I, as in Example 11, except that in this example, the formyl group remained on

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the tryptophan residue thus resulting in the substitution of protected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E.coli and S. epidermidis was tested for each of these analogues. % effective growth inhibition of E.coli and S. epidermidis in µg/ml is listed below in Table VII.

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Table VII - Tryptophan (containing formyl group)-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml	
	E.coli	S. epidermidis
1	100 at 50	100 at 75
3	100 at 50	100 at 75
4	70 at 100	0 at 100
5	100 at 50	100 at 100
6	100 at 50	100 at 100
7	100 at 75	90 at 100
8	100 at 25	100 at 75
9	100 at 50	44 at 100
10	100 at 25	100 at 75
11	0 at 100	0 at 100
12	100 at 25	90 at 75
13	100 at 10	100 at 50
14	0 at 100	0 at 100
15	100 at 10	100 at 75
16	100 at 50	0 at 100
17	100 at 50	100 at 75
18	100 at 25	63 at 100
19	100 at 75	N/A
20	100 at 25	55 at 100
21	92 at 50	36 at 100
22	80 at 75	0 at 100

Example 13 - Multiple-Substitution Analogues of Magainin I with Lysine and/or alanine Residues

Analogues of Magainin I were prepared wherein amino acid residues 3, 8, 9, 16, 19, and/or 23 were

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substituted with alanine (A) or lysine (K) residues. % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus was tested for each substitution analogue. The structure of each synthesized substitution analogue as well as the % effective growth inhibition of E. coli, S. epidermidis, and S. aureus in µg/ml are given below in Table VIII.

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TABLE VIII

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN μg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AUREUS
GIAKFLHAAGKFGKAAVGAIMKA	90 at 2.5	N/A	100 at 75
GIAKFLHAAGKFGKAAVGAIMKK	100 at 2.5	100 at 25	74 at 100
GIAKFLHAAGKFGKAAVGKIMKA	100 at 2.5	100 at 25	100 at 75
GIAKFLHAKGKFGKAAVGAIMKA	90 at 10	N/A	0 at 100
GIAKFLHKAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 50
GIKKFLHAAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 25
GIKKFLHKKGKFGKAAVGKIMKK	96 at 2.5	N/A	0 at 100

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Example 14 - Magainin I Analogues with Glutamic Acid Omissions and Alanine or Lysine Substitutions

Magainin I analogues were prepared wherein amino acid residue 19 (E, or glutamic acid) was deleted, and either alanine or lysine was substituted for one of the remaining amino acid residues in the peptide. Alanine was substituted for either residue 16, 10 or 8, or lysine was substituted for either residue 18, 8, or 7. Each of these substitution analogues was tested for % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus. The structures of each peptide and the % effective growth inhibition of E. coli, S. epidermidis, or S. aureus in μg/ml are listed below in Table IX.

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TABLE IX

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN μg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AUREUS
GIGKFLHSAGKFGKAAVGIMKS	100 at 25	100 at 100	N/A
GIGKFLHSAAKFGKAFVGIMKS	100 at 2.5	N/A	100 at 50
GIGKFLHAAGKFGKAFVGIMKS	100 at 2.5	100 at 25	100 at 50
GIGKFLHSAGKFGKAFVKIMKS	100 at 2.5	100 at 10	N/A
GIGKFLHKAGKFGKAFVGIMKS	100 at 2.5	84 at 10	N/A
GIGKFLKSAGKFGKAFVGIMKS	100 at 2.5	97 at 12.5	N/A

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Example 15

Magainin I substitution analogues were prepared in which, in one analogue, each of amino acid residues 8, 19, and 23 was substituted with lysine, and, in another analogue each of amino acid residues 7, 8, 19, and 23 was substituted with lysine. % effective growth inhibition of E. coli and S. epidermidis in µg/ml was then measured. For the analogue in which amino acid residues 8, 19, and 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 2.5 µg/ml and of S. epidermidis was 100% at 12.5 µg/ml, for the analogue in which amino acid residues 7, 8, 19, 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 1.25 µg/ml and the % effective growth inhibition of S. epidermidis was 100% at 5 µg/ml.

Example 16

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and residues 3, 7, and 8 were substituted with lysine residues. The resulting peptide had the following structure:

GIKKFLKKAGKFGKA

The peptide was then tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 5 µg/ml.

Example 17

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and amino acid residues 3, 8, and 10

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were substituted with an alanine residue. The resulting peptide has the following structure:

GIAKFLHAAAKFGKA

The peptide was tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 25 µg/ml.

Example 18 - Magainin II Analogues with Alanine Substitutions

Magainin II and analogues wherein an alanine residue was substituetd for various amino acid residues of Magainin II were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E-Coli, P.aeruginosa, and S. epidermidis as hereinabove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine - substituted Magainin II analogues is listed below in Table X.

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Table X - Alanine - Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration µg/ml E. Coli	P. aeruginosa	S. epidermidis
None (Magainin II)	100 at 10	100 at 50	100 at 25
23	100 at 10	100 at >50	100 at 25
22	100 at 25	100 at 25	100 at 25
21	100 at 25	100 at 25	100 at 25
20	100 at 50	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 10	100 at 5	100 at 25
16	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at 25	100 at >50
13	100 at 5	100 at 10	100 at 25
12	100 at 25	100 at >50	100 at >50
11	100 at 25	100 at >50	100 at >50
10	100 at 10	100 at 25	100 at 25
8	100 at 10	100 at 10	100 at 10
7	100 at 25	100 at 25	100 at 25
6	100 at 50	100 at 50	100 at >50
5	100 at 50	100 at 50	100 at >50

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Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
4	100 at 25	100 at 50	100 at 50
3	100 at 25	100 at 25	100 at 25
2	100 at 25	100 at 50	100 at 50
1	100 at 25	100 at 25	100 at 50

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Example 19 - Magainin II Analogues with Lysine Substiutions

Magainin II analogues wherein a lysine residue was substituted for various amino acid residues of Magainin II where prepared and tested as hereinabove described for % effective growth inhibition of E. Coli, P. aeruginosa, and S. epidermidis at concentrations given in µg/ml. The % effective growth inhibition for each of the Lysine-substituted analogue of Magainin II is listed below in Table XI.

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Table XI - Lysine-Substitued Margainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml		
	E. Coli	P. aeruginosa	S. epidermidis
23	100 at 25	100 at 50	100 at 50
22	100 at 25	100 at 25	100 at 10
21	100 at 10	100 at 25	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 2.5	100 at 5	100 at 5
17	100 at 25	100 at 25	100 at 25
16	100 at 25	100 at 25	100 at 50
15	100 at 5	100 at 10	100 at 10
13	100 at 5	100 at 25	100 at 25
12	100 at 10	100 at 25	100 at 25
9	100 at 25	100 at 25	100 at 25
8	100 at 5	100 at 5	100 at 25
7	100 at 5	100 at 5	100 at 25

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Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
6	100 at 10	100 at 25	100 at 50
5	100 at 25	100 at 50	100 at 50
3	100 at 5	100 at 25	100 at 10
2	100 at 10	100 at 10	100 at 25
1	100 at 5	100 at 10	100 at 25

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Example 20 - Magainin II Peptides Containing D-Amino Acid Residues.

Magainin II peptides were synthesized wherein various amino acid residues were substituted with a D-amino acid residue, whose structure corresponded to to that of the residue originally present in Magainin II. Each of these Magainin II peptide analogues was then tested as hereinabove described for % effective growth inhibition of E. Coli, P. aeruginosa, and S. epidermidis in µg/ml. The % effective growth inhibition for each of the D-Amino acid residue substituted analogues of Magainin II is listed below in Table XII.

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Table XII-D-Amino Acid Residue - Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml		
	E. Coli	P. aeruginosa	S. epidermidis
23	100 at 5	100 at 10	100 at 25
22	100 at 10	100 at 10	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 25	100 at 25	100 at 25
17	100 at 25	100 at 25	100 at 50
16	100 at 25	100 at 25	100 at 25
15	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at >25	100 at >50
12	-	100 at 25	100 at 50
11	100 at 25	100 at 25	100 at 25
10	100 at 25	100 at 25	100 at 25
9	100 at 25	100 at 25	100 at 25
8	100 at 25	100 at 25	100 at 25
7	100 at 10	100 at 25	100 at 25
6	100 at 25	100 at 25	100 at 50

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Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
5	100 at 25	100 at 25	100 at 50
4	100 at 25	100 at 25	100 at 50
2	100 at 25	100 at 25	100 at 50

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Example 21 - Magainin II Analogues with Glutamic Acid Deletions

In this example, analogues of Magainin II were synthesized, said analogues having amino acid residue 19 (glutamic acid) deleted from the peptide structure, and wherein one or more of the other amino acid residues was substituted with an amino acid residue different from the normal amino acid residue. Analogues of the following structures were then synthesized according to the method described in Example 1.

Analogue	Stucture
1	GIGKFLHSAKKFWKAFVGIMNS
2	GIGKFLHSAKKFLKAFVGILNS
3	GILKFLHSAKKFLKAFVGILNS
4	GILKFLHSAKKFFKAFVKILNS
5	GIGKFLHSAKKFFKAFVFILNS
6	GIGKFLHSAKKFGKAFVGIMKS
7	GIGKFLHSAKKFGKAFVAIMKS
8	GIGKFLHSAKKFGKAFVFIMNS*
9	GIGKFLHSAKKFAKAFVFIMNS
10	GIGKFLHSAKKFFKAFVFIMNS
11	GIGKFLKSAKKFGKAFVFIMNS
12	GIGKFLHKAKKFAKAFVFIMNS
13	GIGKFLKSAKKFAKAFVFIMNS
14	GIGKFLHKAKKFFKAFVFIMNS
15	GIGKFLKSAKKFFKAFVFIMNS
16	GIGKFLHKAKKFAKAFVFIMNK
17	GIGKFLKSAKKFAKFFVFIMNK
18	GIGKFLKKAKKFGKAFVFIMKK
19	GIGKFLHSAKKFGKAFVK**IMNS
20	GIGKFLHSAKKFGKAFVKIMNS
21	GIGKFLHKAKKFGKAFVKIMNS

*D-Serine

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**-ε-F moc-lysine

Each of the peptides was then tested as hereinabove described for % effective growth inhibition of E. Coli, P.aeruginosa, and S.epidermidis in µg/ml. The % effective growth inhibition of each of these analogues is given in Table XIII below.

TABLE XIII

Analogue	% Effective Growth Inhibition, Concentration in µg/ml		
	E. Coli	P. aeruginosa	S. epidermidis
1	100 at 5	100 at 5	100 at 5
2	100 at 2.5	100 at 2.5	100 at 5
3	100 at 2.5	100 at 2.5	100 at 5
4	100 at 2.5	100 at 2.5	100 at 5
5	100 at 10	100 at 5	100 at 5
6	100 at 5	100 at 10	100 at 25
7	100 at 2.5	100 at 5	100 at 5
8	100 at 5	100 at 5	100 at 5
9	100 at 5	100 at 2.5	100 at 5
10	100 at 5	100 at 10	100 at 5
11	100 at 5	100 at 5	100 at 5
12	100 at 1.25	100 at 2.5	100 at 1.25
13	100 at 2.5	100 at 1.25	100 at 2.5
14	100 at 10	100 at 2.5	100 at 2.5
15	100 at 5	100 at 5	100 at 1.25
16	100 at 1.25	100 at 1.25	100 at 1.25
17	100 at 1.25	100 at 5	100 at 2.5
18	100 at 2.5	100 at 2.5	100 at 2.5
19	100 at 10	100 at 10	100 at 5
20	100 at 1.25	100 at 2.5	100 at 1.25
21	100 at 1.25	100 at 5	100 at 2.5

Example 22

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Amide (NH_2) - terminated Magainin II analogues wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substitued. The analogues are as follows:
Analogue 1 GIGKFLKKAKKFAKAFVKIINN-NH_2
Analogue 2 GIGKFLKKAAKFAKAFVKIINN-NH_2

The analogues were then tested as hereinabove described for % effective growth inhibition of E. Coli, P.aeruginosa, and S.epidermidis Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli, 100% at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis Analogue 2 had % effective growth inhibitions of 100% at 1.25 µg/ml for P. aeruginosa and 100% at 1.25 µg/ml for S.epidermidis.

Example 23

Amide (NH_2) -terminated analogues, which by virtue of their structures, may be analogues of Magainin I or Magainin II, were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substituted. The analogues are as follows:
Analogue 1 GIGKFLKKAKKFGKAFVKIMKK-NH_2
Analogue 2 GIGKFLKKAKKFAKAFVKIMKK-NH_2
Analogue 3 GIGKFLKKAKKFAKAFVKIIKK-NH_2

The analogues were then tested for % effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli, 100% at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis. Analogue 2 had % effective growth inhibitions of 100% at 2.5 µg/ml for E.Coli, 100 at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis. Analogue 3 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli,

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100% at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis

Example 24

Amide (NH_2) terminated analogues of Magainin I were synthesized wherein at least amino acid residues 17-23 were deleted and amino acid residues 3, 7, and 8 were substituted with lysine residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAGKFGK-NH_2

Analogue 2 - GIKKFLKKAGKFGKAF-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for E. Coli, 100% at 10 µg/ml for P.aeruginosa, and 100% at 10 µg/ml for S.epidermidis. Analogue 2 had % effective growth inhibitions of 100% of 2.5 µg/ml for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100% at 5 µg/ml for S.epidermidis.

Example 25

Amide (NH_2)-terminated analogues of Magainin II were synthesized wherein at least amino acid residues 16-23 were deleted and substitutions were made for other residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAKKFGKA-NH_2

Analogue 2 - GIKKFLKKAKKFAKA-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for P.aeruginosa, and 100 at 5.0 µg/ml for S.epidermidis. Analogue 2 had % effective grwoth inhibitions of 100% of 5 µg/ml, for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100% at 5 µg/ml for S.epidermidis.

Example 26

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An amide (NH_2)-terminated analogue, which by virtue of its structure may be an analogue of Magainin I or Magainin II, was synthesized wherein amino acids 16-23 were deleted, amino acid residues 3,7, and 8 were substituted with lysine residues, and amino acid residue 10 and 13 were substituted with alanine residues. The analogue was of the following structure.

GIKKFLKKAAKFAKA-NH_2

The analogue was then tested for % effective growth inhibition. The analogue had % effective growth inhibitions of 100% at 5 µg/ml for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100 at 5 µg/ml for S.epidermidis.

Example 27

Analogues of Magainin II were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and amino acids 1-4, or 3,5, and 6 were deleted and at least one of the remaining amino acid residues was substituted. The analogues were of the following structures:

Analogue 1: FLKSAKKFGKAFVGIMNS

Analogue 2: FLKSAKKFAKAFVGIMNS

Analogue 3: FLHSAKKFGKAFVFIMNS

Analogue 4: GIKHSAKKFAKAFKAIMNS

The analogues were then tested for % effective growth inhibition of E.coli, P.aeruginosa, and S.epidermidis. The % effective growth inhibition of each of these analogues is given in Table XIV below.

TABLE XIV

Analogue	% Effective Growth Inhibition, Concentration in µg/ml		
	E.Coli	P.aeruginosa	S.epidermidis
1	100 at 25	100 at 25	100 at 50
2	100 at 10	100 at 25	100 at 50

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3	100 at 25	100 at 25	100 at 10
4	100 at 10	100 at 25	100 at 5

Numerous modifications and variations of the present invention are possible in light of the above teachings, and, therefore, within the scope of the accompanying claims, the invention may be practiced other than as particularly described.

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WHAT IS CLAIMED IS:

1. A compound comprising:

an analogue of Magainin I peptide or Magainin II peptide, said Magainin I peptide or Magainin II peptide being in an amide-or carboxy-terminated form, and wherein Magainin I is respresented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

wherein Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

and wherein said Magainin I or Magainin II peptide is substituted in at least one of positions 1-23, wherein the substituents which may be employed in each of positions 1-23 are shown in the following table:

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* C L M S *

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Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

2. The compound of Claim 1 wherein said Magainin I or Magainin II peptide is substituted in at least one of positions 1-23, wherein each of the

* C L M S *

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substituents in each of positions 1-23 is shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

3. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 8, 10, 13, 16, 18 and 19 is substituted with an alanine residue.

4. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein amino



acid residues 3, 8, 16, 19 and 23 are substituted with alanine residues.

5. The compound of Claim 2 wherein the peptide is a Magainin I peptide and four of amino acid residues 3, 8, 16, 19 and 23 are each substituted with an alanine residue, and the remaining one of amino acid residues 3, 8, 16, 19 and 23 is substituted with a lysine residue.

6. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein amino acid residue 21 is substituted with a proline residue.

7. The compound of Claim 2 wherein the peptide is a Magainin I peptide and at least one of amino acid residues 3, 7, 8, 10, 18-21, and 23 is substituted with a lysine residue.

8. The compound of Claim 2 wherein the peptide is a Magainin I peptide, and wherein amino acid residues 3, 8, 9, 19 and 23 are each substituted with a lysine residue and amino acid residue 16 is substituted with an alanine residue.

9. The compound of Claim 2 wehrein the peptide is a Magainin I peptide, and wherein at least one of amino acid residues 2, 4, 19 or 23 is a D-amino acid residue.

10. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 3, 5, 8, 10, 12, 13, 15, 18 and 20 is a protected tryptophan residue.

11. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 9, 13, 15, and 17 is an unprotected tryptophan residue.

12. The composition of Claim 2 wherein the peptide is a Magainin II peptide, and wherein at



least one of amino acid residues 1-8, 10, 13, 14, 16, or 18-23 is an alanine residue.

13. The compound of Claim 2 wherein the peptide is a Magainin II peptide and wherein at least one of amino acid residues 1-3, 5-9, 12, 13, or 15-23 is a lysine residue.

14. The compound of Claim 2 wherein the peptide is a Magainin II peptide and wherein at least one of amino acid residues 2, 4-12, 15-17, 19, 20, 22, or 23 is substituted with a D-amino acid residue.

15. A compound comprising:

an analogue of Magainin I peptide or Magainin II peptide, said Magainin I peptide or Magainin II peptide being in an amide-or carboxy-terminated form, and wherein Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23,

and wherein Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23,

and wherein at least one of amino acid residues 15-23 is omitted, and wherein said Magainin I or Magainin II peptide is substituted in at least one of the remaining positions 1-23, wherein the substituents which may be employed in each of positions 1-23 are shown in the following table:



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Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys, Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met,Phe
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

16. The compound of Claim 15 wherein said Magainin I or Magainin II peptide is substituted in at least one of the remaining positions 1-23, wherein

* C L M S *

each of the substituents in each of positions 1-23 is shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys, Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

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17. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and amino acid residues 16-23 are deleted and amino acid residues 3, 8 and 10 are substituted with an alanine residue.

18. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and wherein amino acid residue 19 is deleted.

* C L M S *

19. The compound of Claim 18 wherein amino acid residues 5, 8, 9 and 16 are each substituted with a lysine residue; amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are each substituted with an alanine residue.

20. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and wherein amino acid residue 21 is deleted.

21. The compound of Claim 20 wherein amino acid residues 5, 10, 18, and 19 are each substituted with a lysine residue; amino acid 7 is substituted with a phenylalanine residue, and amino acid residue 22 is substituted with an alanine residue.

22. The compound of Claim 15 wherein amino acids 17-23 or 16-23 or 15-23 are deleted, and amino acids, 3,7, and 8 are substituted with a lysine residue.

23. The compound of Claim 22 wherein said analogue of Magainin I or Magainin II peptide is selected from the group consisting of:

GIKKFLKKAGKFGK-NH_2

GIKKFLKKAGKFGKAF-NH_2;

GIKKFLKKAKKFGKA-NH_2;

GIKKFLKKAKKFAKA-NH_2; and

GIKKFLKKAAKFAKA-NH_2.

24. The compound of Claim 15 wherein amino acid residue 19 is omitted, and at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18, 21, 22, or 23 is substituted with another amino acid residue as shown in the following table:

Residue No.	Substituent
3	Leu
7	Lys
8	Lys,Ala

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10	Ala,Lys
13	Trp,Phe,Leu,Ala
15	Phe
16	Ala
18	Lys,Ala,Phe
21	Lys,Ile
22	Lys
23	Lys,D-Ser

25. The compound of Claim 24 wherein the peptide is a Magainin II peptide.

26. The compound of Claim 25 wherein said peptide is selected from the group consisting of:

GIGKFLHSAKKFGKAFVGIMKS;

GIGKFLHSAKKFGKAFVAIMKS;

GIGKFLHSAKKFGKAFVFIMNS*, wherein S* is D-serine;

GIGKFLHSAKKFFKAFVFIMNS;

GIGKFLKSAKKFGKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNS;

GIGKFLKSAKKFAKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNK;

GIGKFLKKAKKFGKAFVFIMKK; and

GIGKFLHSAKKFGKAFVK **IMNS, wherein K** is E-F-moc-lysine.

27. The compound of Claim 15 wherein amino acid residue 19 is omitted, and either amino acid residues 1-4 are omitted or amino acid residues 3, 5, and 6 are omitted.

28. The compound of Claim 27 wherein the peptide is a Magainin II peptide.

29. The compound of Claim 15 wherein the peptide is selected from the group consisting of:

FLHSAKKFGKAFVFIMNS

GIKHSAKKFAKAFKAIMNS

FLKSAKKFGKAFVGIMNS

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FLKSAKKFAKAFVGIMNS

30. A process comprising:

administering to a host an effective anti-microbial amount of the compound of Claim 1.

31. A process, comprising:

administering to a host an effective anti-viral amount of the compound of Claim 1.

32. A process, comprising:

administering to a host an effective anti-tumor amount of the compound of Claim 1.

33. A process, comprising:

administering to a host an effective spermicidal amount of the compound of Claim 1.

34. A process, comprising:

administering to a host an effective anti-microbial amount of the compound of Claim 15.

35. A process, comprising:

administering to a host an effective anti-viral amount of the compound of Claim 15.

36. A process, comprising:

administering to a host an effective anti-tumor amount of the compound of Claim 15.

37. A process, comprising:

administering to a host an effective spermicidal amount of the compound of Claim 15.

38. The compound of Claim 24 wherein said analogue of Magainin I or Magainin II peptide is represented by the following structural formula using the single letter amino acid code:

GIGKFLKKAKKFGKAFVKIMKK-NH_2

ABSTRACT

SUBSTITUTION ANALOGUES OF MAGAININ PEPTIDES

A compound comprising a Magainin I or Magainin II peptide wherein at least one substitution may be made for certain amino acid residues with other amino acid residues, said peptides known as substitution analogues. In addition to such substitutions, there may be included within the scope of the invention analogues wherein at least one of amino acid residues 15 and 23 may have been deleted as well, and wherein substitutions were made in the remaining peptide chain. Certain substitution analogues within the scope of the present invention have been shown to possess increased biological activity.

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SUBSTITUTION ANALOGUES OF MAGAININ PEPTIDES

This invention relates to a class of biologically active peptides known as magainins. More particularly, this invention relates to analogues of magainin peptides wherein at least one amino acid residue in the peptide has been substituted with another amino acid residue, with said analogues being commonly referred to as "substitution analogues."

In accordance with an aspect of the present invention, there is provided a compound comprising an analogue of Magainin I Peptide or Magainin II peptide. The Magainin I or Magainin II peptide is in an amide or carboxy terminated form. Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residues refer to the position of the residue in the peptide.

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Magainin II is represented by the following structural formula using the single letter amino acid code and the

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numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

The Magainin I or Magainin II peptide is substituted in at least one of positions 1-23. The substituents which may be employed in each of positions 1-23 are shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

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Preferably, the substituents are as follows:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys
	Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

It is to be understood that for purposes of the present invention, that the tryptophan residues may be protected with a formyl group or be unprotected. The phenylalanine residues, whether such residue is present in its normal position, or employed as a substitution residue, may be a normal phenylalanine residue or an iodinated phenylalanine residue.

In accordance with one embodiment, the peptide is a Magainin I peptide, and at least one of amino acid residues 8, 10, 13, 16, 18 and 19 is substituted with an alanine residue. In another embodiment, the Magainin I peptide has alanine residue substitutions at each of amino acid residues 3, 8, 16, 19 and 23.

In accordance with another embodiment, the Magainin I peptide has alanine residue substitution at four of amino acid residues 3, 8, 16, 19 and 23,

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and the remaining one of these residues is substituted with a lysine residue.

In accordance with yet a further embodiment, amino acid 21 of a Magainin I peptide is substituted with a proline residue.

In accordance with another embodiment, at least one of amino acid residues 3, 7, 8, 10, 18-21, and 23 of Magainin I is substituted with a lysine residue.

In accordance with another embodiment, amino acid residues 3, 8, 9, 19 and 23 of Magainin I are each substituted with a lysine residue and amino acid residue 16 is substituted with an alanine residue.

In accordance with another embodiment, at least one of amino acid residues 2, 4, 19, or 23 of Magainin I is a D-amino acid residue, whose structure corresponds to that of the L-amino acid residue originally present in Magainin I.

In accordance with a further embodiment, at least one and amino acid residues 3, 5, 8, 10, 12, 13, 15, 18, and 20 of Magainin I is substituted with a protected tryptophan residue, wherein the protecting group is preferably a formyl group. In accordance with another embodiment, at least one of amino acid residues 9, 13, 15 and 17 of Magainin I is substituted with an unprotected tryptophan residue.

In accordance with another embodiment, the peptide is a Magainin II peptide, and at least one of amino acid residues 1-8, 10, 13, 14, 16 and 18-23 is an alanine residue.

In accordance with another embodiment, at least one of amino acid residues 1-3, 5-9, 12, 13 and 15-23 of Magainin II is a lysine residue.

In accordance with yet another embodiment, at least one of amino acid residues 2,4-12, 15-17, 19, 20, 22 and 23 of Magainin II is substituted with a

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D-amino acid residue whose structure corresponds to that of the L-amino acid residue originally present in Magainin II.

In accordance with another aspect of the present invention, there is provided an analogue of Magainin I or Magainin II peptide, said Magainin I or Magainin II peptide being in an amide- or carboxy-terminated form and having the structural formulas hereinabove described, and wherein at least one of amino acid residues 15-23 is omitted and at least one of the remaining amino acid residues is substituted. The substituents which may be employed in at least one of positions 1-23 are shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met,Phe
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

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Preferably, the substituents are as follows:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

In accordance with a particular embodiment, amino acid residues 16-23 of Magainin I are deleted, and amino acid residues 3, 8 and 10 are substituted with an alanine residue.

In accordance with yet another embodiment, amino acid residue 19 of Magainin I is deleted, and preferably amino acid residues 5, 8, 9 and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are substituted with an alanine residue.

In accordance with another embodiment, in carboxy- or amide-terminated (preferably amide-terminated) Magainin I or Magainin II peptide, amino acid residues 17-23 or 16-23 or 15-23 are deleted, and amino acid residues 3, 7, and 8 are each

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substituted with a lysine residue, and optionally amino acid residue 13 and/or amino acid residue 10 is substituted with an alanine residue. Preferred peptides are as follows:

GIKKFLKKAGKFGK-NH_2

GIKKFLKKAGKFGKAF-NH_2

GIKKFLKKAKKFGKA-NH_2

GIKKFLKKAKKFAKA-NH_2

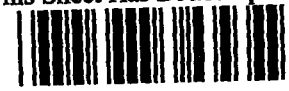
GIKKFLKKAAKFAKA-NH_2

Preliminary studies indicate that the above-mentioned preferred peptides possess low hemolytic activity. In accordance with a further embodiment, amino acid residue 21 of Magainin I may be deleted, and preferably amino acid residues 5,10, 18, and 19 are each substituted with a lysine residue, amino acid residue 7 is substituted with a phenylalanine residue, and amino acid residue 22 is substituted with an alanine residue.

In accordance with another embodiment, in carboxy or amide terminated (preferably amide terminated) Magainin I or Magainin II (preferably Magainin II), amino acid residue 19 is omitted, and at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18 21, 22 or 23 is substituted with another amino acid as follows:

Residue number	Substituent
3	Leu
7	Lys
8	Lys, Ala
10	Ala, Lys
13	Trp, Leu, Phe, Ala
15	Phe
16	Ala
18	Lys, Ala, Phe
21	Lys, Ile

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22 Lys

23 Lys, D-Ser

Representative peptides are disclosed in Examples 14 and 21-23.

In a preferred embodiment, the peptide is a Magainin II peptide, and the substitution analogue wherein amino acid 19 is deleted is selected from the class consisting of the following substitution analogues:

GIGKFLHSAKKFGKAFVGIMKS;

GIGKFLHSAKKFGKAFVAIMKS;

GIGKFLHSAKKFGKAFVFIMNS*, wherein

S* is D-Serine;

GIGKFLHSAKKFFKAFVFIMNS;

GIGKFLKSAKKFGKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNS;

GIGKFLKSAKKFAKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNK;

GIGKFLKKAKKFGKAFVFIMKK; and

GIGKFLHSAKKFGKAFVK**IMNS; wherein

K** is E-F-moc-lysine.

Preliminary studies indicate that these preferred analogues possess low hemolytic activity.

In accordance with another embodiment, there are provided derivatives of Magainin I or Magainin II (carboxy- or amide-terminated), preferably Magainin II, wherein a portion of the basic peptide is deleted and at least one of the remaining amino acid residues is substituted as hereinabove described; in particular, amino acid residue 19 is omitted and in addition either amino acid residues 1-4 or 3,5, and 6 are omitted. Preferred peptides are as follows:

FLHSAKKFGKAFVFIMNS

GIKHSAKKFAKAFKAIMNS

FLKSAKKFGKAFVGIMNS

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FLKSAKKFAKAFVGIMNS

Applicants have found that when employing the substitution analogues of Magainin I or Magainin II as hereinabove described, such peptides display biological activity equal to or greater than the parent Magainin I or Magainin II peptide. Such peptides are referred to as "successful substitution analogues".

The use of these compounds which comprise a substitution analogue of Magainin I or Magainin II peptide, in accordance with the present invention, is effective as an antibiotic, and can be employed to inhibit, prevent or destroy the growth or proliferation of microbes, such as bacteria, fungi viruses or the like. Similarly, such compounds can be employed as an anti-viral composition to inhibit, prevent or destroy the growth or proliferation of viruses.

As used herein, the term "substitution analogue" includes magainin peptides in which at least one amino acid residue of the peptide structure has been substituted with a different amino acid residue, as well as magainin peptides in which, in addition to the above-mentioned substitution(s), also have had at least one of amino acid residues 15-23 omitted from the peptide sequence. The term also includes magainin peptides having D-amino acid or iodinated phenylalanine residues which have been substituted into the peptide sequence.

Such compounds can also be employed as a spermicide to inhibit, prevent or destroy the motility of sperm.

Such compounds can also be employed as anti-tumor agents to inhibit the growth of or destroy tumors.

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The compounds have a broad range of potent antibiotic activity against a plurality of microorganisms, including Gram-positive and Gram-negative bacteria, fungi, protozoa and the like. Such compounds can be employed for treating or controlling microbial infection caused by organisms which are sensitive to such compounds.

The compounds can also be used as preservatives or sterilants for materials susceptible to microbial contamination. In vitro activity against bacteria is exemplified hereinafter in Examples 3-27.

In general, a substitution analogue of the Magainin I or Magainin II peptide is administered in a dosage of from about 1 mg to about 500 mg per kilogram of body weight, when administered systemically. When administered topically, the peptide is used in a concentration of from about 0.5% to about 5%.

The compounds comprising the substitution analogues of Magainin I or Magainin II, in accordance with the present invention, can be employed for treating a wide variety of hosts. In accordance with a preferred embodiment, a host can be an animal, and such animal can be a human or non-human animal.

The compounds comprising the substitution analogues of Magainin I or Magainin II can be employed in a wide variety of pharmaceutical compositions in combination with a non-toxic pharmaceutical carrier or vehicle such as a filler, non-toxic buffer, or physiological saline solution. Such pharmaceutical compositions can be used topically or systemically and can be in any suitable form such as a liquid, solid, semi-solid, injectable solutions, tablet, ointment, lotion, paste, capsule or the like. The compounds comprising the

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substitution analogues of Magainin I or Magainin II can also be used in combination with adjuvants, protease inhibitors, or compatible drugs where such a combination is seen to be desirable or advantageous in controlling infection caused by harmful microorganisms including protozoa, viruses, and the like.

The compounds comprising the substitution analogues of Magainin I or Magainin II of the present invention can be administered to a host; in particular an animal, in an effective antibiotic and/or anti-tumor and/or anti-viral and/or anti-microbial and/or a spermicidal amount.

Magainin I and Magainin II, as well as the substitution analogues of the Magainin I and Magainin II peptides of the present invention, (both amide- and carboxy-terminated Magainin I and Magainin II forms) can be synthesized by any convenient method of peptide synthesis as are well-known to skilled workers. Solid phase synthesis methods are particularly preferred.

The peptides described herein were prepared by the method of simultaneous multiple peptide synthesis (SMPS). This method is described in detail in Houghten, R.A., "General Method for the Rapid Solid-Phase Synthesis of Large Numbers of Peptides; Specificity of Antigen-Antibody Interaction at the Level of Individual Amino Acids," Proc. Natl. Acad. Sci., U.S.A., Vol. 82, pgs. 5131-5135 (1985), and in Houghten, R.A., et al. "Simultaneous Multiple Peptide Synthesis; The Rapid Preparation of Large Numbers of Discrete Peptides for Biological, Immunological, and Methodological Studies," Peptide Chemistry, pgs. 295-298 (1987).

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For purposes of the following examples, substitution analogues of Magainin I and Magainin II were prepared wherein various amino acid residues were substituted and/or other amino acid residue(s) were deleted.

For purposes of comparison, a complete Magainin I or Magainin II peptide can also be prepared by the SMPS method. It is also contemplated within the scope of the present invention that substitution analogues which have one or more amino acid residue(s) omitted from the Magainin I or Magainin II structure can also be prepared by the SMPS method.

The invention will now be described with respect to the following examples, however, the scope of the present invention is not intended to be limited thereby.

Example 1 - Peptide Synthesis

Peptide synthesis of Magainin I and the substitution analogues of Magainin I, was accomplished by using the strategy of simultaneous multiple peptide synthesis. All solvents and reagents were of analytical grade and were used without further purification. Standard N-t-Boc-protected amino acids were employed in the synthesis. The side chain functionalities used were benzyl (Ser, Glu), 2-Cl-Z (Lys)(Z=benzyloxycarbonyl), N^{im}- DNP (His), and sulfoxide (Met). Peptide synthesis was performed beginning with 100 mg of either Boc-amino acids-Pam resin to produce C-terminal carboxyl peptide (PAM purchased from Applied Biosystems, substitution 0.56 meq/gm is an amino acyl -4- [oxymethyl] phenylacetic acid derivative of amino polystyrene) or methylbenzhydrylamine (MBHA) resin

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(substitution-0.65meq/gm) per resin packet to produce C-terminal amide peptide.

After synthesis, completely protected peptide resins were treated three times with 0.5 M thiophenol in DMF to remove the N^{im}- dinitrophenyl group from Histidine. The final Boc-group was removed with TFA to avoid t-butylation of methionyl residues during final HF treatment. Cleavage was performed using the Low-High HF procedure. Tam, et al. J. Am. Chem. Soc. Vol. 105, P. 6442 (1983). For peptides synthesized on Pam resin, the low-HF was carried out without removing the resin from the packet, using a multiple vessel HF apparatus for 2 hrs. at 0°C. For peptides prepared using MBHA resin, the low HF procedure was performed in a common reaction vessel for 2 hrs. at 0°C. For Pam resin peptides, the low-HF mixture was evacuated from the 24 individual reaction vessels by a water aspirator followed by a mechanical pump. The low-HF reaction vessel containing the bags with MBHA resin was emptied of the low-HF mixture by pouring off the liquid into a waste container. The bags were washed immediately with cold ether followed by alternating washes of CH_2Cl_2, DMF, CH_2Cl_2, IPA, CH_2Cl_2. The packets were then dried and put into individual tubes of the 24 vessel HF apparatus with 0.7 ml of anisole as scavenger. The high-HF was performed by condensing dry hydrogen fluoride at -70°C. The reaction took place at -10°C for 1 h. and -5°C - 0°C for the last 30 min. HF was evaporated using a strong flow of nitrogen. Finally, residual carbonium ion scavengers were removed by washing with dry ether.

The crude peptides were subsequently extracted with 10% acetic acid and subjected to RP-HPLC on an analytical reversed phase column (Vidac ODS 25 cm x

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4.6 mm), using a Beckman-Altek model 421 HPLC system and two model 110A pumps. The solvent system was composed of buffer A, 0.05% TFA/H_2O, and buffer B, 0.05% TFA/CH_3CN with a flow rate of 1.0 ml/min. The peptides were detected at 215 nm using a Hitachi 100-20 spectrophotometer.

Purification of the peptides was accomplished by reverse - phase HPLC on a Vidac C_{18} (22 mm x 25cm), 10 µm packing column with an eluting gradient composed of CH_3CN and 0.05% TFA. Amino acid analysis was carried out on a Beckman 6300 analyzer following hydrolysis of the peptides in constant (boiling) 6 N HCl at 110°C for 24 hr., and such analysis was within ±10% of theory.

Example 2 - Antimicrobial Assays

Antimicrobial assays were carried out in 96 - well tissue culture plates. Each well was incubated with a given microorganism (Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus, or Pseudomonas aeruginosa) suspended in LB medium (Examples 3-17), or TSB medium (Examples 18-27). Upon the addition of Magainin I or its substitution analogues, (dissolved in 1 X PBS, pH 7.0) each well contained a final cell density of 1.0×10^6 colony forming units (CFU)/ml. The final peptide concentrations used were 100 µg/ml., 75.0 µg/ml, 50.0 µg/ml, 25 µg/ml, 12.5 µg/ml, 10 µg/ml, 5µg/ml, 2.5 µg/ml, and 1.25 µg/ml.

Addition of peptides to the wells was defined as time zero. At six hours, the plates were placed in a Titertek Multiskan apparatus and the $O.D._{620}$ determined. The plates as well as the initial innoculum were incubated at 37°C.

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Five wells per plate contained media alone, while five others contained medium plus cells. These controls were used to eliminate the possibility of media contamination while providing a measure of uninhibited growth of the microorganisms.

The degree of peptide activity was determined by comparing the substitution analogues with uninhibited growth of the control cells over a six-hour period. The effective growth inhibition of the substitution analogues is listed in the examples and tables below.

Example 3 - Magainin I analogues with alanine substitutions

Magainin I and analogues wherein an alanine residue was substituted for various amino acid residues of Magainin I were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E. coli at a concentration given in µg/ml as hereianbove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine-substituted Magainin I analogues is listed below in Table I. As used herein, the heading "Amino Acid Residue Substituted" refers to the number of the amino acid residue in the peptide which is substituted with a desired amino acid residue. All other residues in the peptide remain the same as that of the normal peptide sequence. For purposes of explanation of the term "% effective growth inhibition," a value of "100 at 25", for example, indicates 100% effective growth inhibition at a concentration of 25 µg/ml.

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Table 1 - Alanine-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
None (Magainin I)	100 at 25
23	100 at 10
22	100 at 50
21	100 at 50
20	100 at 50
19	100 at 5
18	100 at 25
17	100 at 75
16	100 at 25
14	100 at 100
13	100 at 25
12	100 at 50
11	0 at 100
10	100 at 25
8	100 at 5
7	100 at 75
6	0 at 100
5	0 at 100
4	0 at 100
3	100 at 75
2	100 at 100
1	100 at 100

Magainin I analogues were also prepared wherein amino acid residues 19, 16, or 8, respectively, were substituted with alanine residues, and such substitution analogues were tested for % effective growth inhibition of S. epidermidis and/or S. aureus as compared to Magainin I without any substitutions.

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Magainin I had a % effective growth inhibition of S.epidermidis of 100% at 25 µg/ml and of S.aureus of 80% at 100 µg/ml. The % effective growth inhibition of S. epidermidis for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 µg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 16 was substituted with an alanine residue was 75% at 100 µg/ml. The % effective growth inhibition of S. aureus for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 µg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 8 was substituted with alanine was 100% at 50 µg/ml.

Example 4 - Magainin I analogues with Proline Substitutions

Magainin I analogues wherein a proline residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E. coli at a concentration given in µg/ml. The % effective growth inhibition for each of the proline-substituted analogues of Magainin I is listed below in Table II.

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Table II - Proline-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 25
20	100 at 100
19	100 at 50
18	100 at 75
17	0 at 100
16	0 at 100
15	50 at 100
14	0 at 100
13	100 at 100
12	0 at 100
11	0 at 100
10	0 at 100
9	100 at 100
8	100 at 75
7	0 at 100
6	0 at 100
4	0 at 100
3	100 at 75
2	0 at 100
1	100 at 100

Example 5 - Lysine-Substituted Magainin I Analogues

Magainin I analogues wherein a lysine residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E.coli at a concentration given in µg/ml. The % effective

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growth inhibition of each lysine-substituted analogue of Magainin I is given below in Table III.

Table III - Lysine-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
23	100 at 5
21	100 at 25
20	100 at 25
19	100 at 2.5
18	100 at 25
17	100 at 100
16	0 at 100
15	100 at 50
13	100 at 50
12	100 at 100
10	100 at 25
9	100 at 100
8	100 at 5
7	100 at 5
6	0 at 100
5	0 at 100
3	100 at 25
2	100 at 100
1	100 at 50

Magainin I analogues wherein amino acid residues 23, 19, 8, or 7, respectively, were substituted with a lysine residue were tested for % effective growth inhibition of *S. epidermidis* and/or *S. aureus*. The substitution analogue of Magainin I wherein amino acid residue 23 was substituted with a lysine residue

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had a % effective growth inhibition of S. aureus of 30% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 19 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 50% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 8 was substituted with a lysine residue had a % effective growth inhibition of S. aureus of 70% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 7 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 100% at 50 µg/ml.

Example 6 - Glutamic Acid-Substituted Magainin I Analogues

Magainin I analogues wherein a glutamic acid residue was substituted for various amino acid residues of Magainin I were prepared and tested for % effective growth inhibition of E.coli according to the methods hereinabove described. The % effective growth inhibition for each glutamic acid-substituted Magainin I analogue is described below in Table IV.

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Table IV Glutamic Acid-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 75
20	0 at 100
18	100 at 75
17	0 at 100
16	0 at 100
15	0 at 100
14	0 at 100
13	0 at 100
12	0 at 100
11	0 at 100
10	100 at 75
9	0 at 100
8	100 at 75
7	32 at 100
3	0 at 100

Example 7 - Magainin I peptides containing D-amino acid residues

Magainin I peptides were synthesized wherein in each peptide one of amino acid residues 23, 19, 17, 16, 14, 4, or 2, respectively, is substituted with a D-amino acid residue. Each of these Magainin I peptide analogues was then tested as hereinabove described for % effective growth inhibition of E.coli in µg/ml. The % effective growth inhibition for each of the D-amino acid residue-subsituted analogues of Magainin I is listed below in Table V.

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Table V - D-amino acid residue-substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
23	100 at 10
19	100 at 25
17	100 at 50
16	100 at 50
14	100 at 50
4	100 at 25
2	100 at 25

Example 8

In this example, a substitution analogue of Magainin I was prepared wherein amino acid residue 19, (E, or glutamic acid) was deleted, and amino acid residues 5, 8, 9, and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are each substituted with an alanine residue. The substitution analogue had the following structure:

GIGKKLHKKGKFGKFKGALLKA

The % effective growth inhibition of E.coli for this peptide was tested and found to be 100% at 5 µg/ml.

Example 9

In this example, a substitution analogue of Magainin I was prepared wherein amino acid 21 was deleted and amino acid residues 5, 10, 18, and 19

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were each substituted with a lysine residue, amino acid residue 7 was substituted with a phenylalanine residue, and amino acid 22 was substituted with an alanine residue. The peptide had the following structure:

GIGKKLFSAKKFGKAFVKKIAS

The % effective growth inhibition of E.coli for this peptide was tested and found to be 100% at 2.5 µg/ml.

Example 10

Magainin I and Magainin II peptides were prepared wherein phenylalanine residues 5 and 12 in each peptide were iodinated. The % effective growth inhibition of E.coli for each peptide, containing the iodinated phenylalanine residues, was tested. For the Magainin I peptide, the % effective growth inhibition was 100% at 10 µg/ml. For the Magainin II peptide, the % effective growth inhibition was 100% at 5 µg/ml.

Example 11 - Tryptophan (Formyl Group Removed)-Substituted Analogues of Magainin I

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I. The tryptophan had the formyl group removed, thus resulting in the substitution of unprotected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E.coli and S. epidermidis was tested for these analogues. % effective growth inhibition of E. coli and S. epidermidis in µg/ml is listed below in Table VI.

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Table VI - Tryptophan (Formyl Group Removed) - Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml	
	E.coli	S. epidermidis
1	100 at 50	80 at 75
3	100 at 25	100 at 50
4	90 at 100	0 at 100
5	100 at 25	80 at 100
6	100 at 50	50 at 75
8	100 at 100	100 at 50
9	100 at 25	40 at 100
10	100 at 25	100 at 50
11	0 at 100	0 at 100
12	100 at 25	0 at 100
13	100 at 25	100 at 50
14	N/A	0 at 100
15	96 at 10	90 at 100
16	95 at 50	0 at 100
17	100 at 25	100 at 100
18	93 at 25	90 at 100
19	100 at 10	100 at 75
20	90 at 25	30 at 100
21	100 at 50	0 at 100
22	40 at 75	0 at 100

Example 12 - Tryptophan (containing formyl group)-Substituted Magainin I Analogues

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I, as in Example 11, except that in this example, the formyl group remained on

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the tryptophan residue thus resulting in the substitution of protected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E.coli and S. epidermidis was tested for each of these analogues. % effective growth inhibition of E.coli and S. epidermidis in µg/ml is listed below in Table VII.

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Table VII - Tryptophan (containing formyl group)-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml	
	E.coli	S. epidermidis
1	100 at 50	100 at 75
3	100 at 50	100 at 75
4	70 at 100	0 at 100
5	100 at 50	100 at 100
6	100 at 50	100 at 100
7	100 at 75	90 at 100
8	100 at 25	100 at 75
9	100 at 50	44 at 100
10	100 at 25	100 at 75
11	0 at 100	0 at 100
12	100 at 25	90 at 75
13	100 at 10	100 at 50
14	0 at 100	0 at 100
15	100 at 10	100 at 75
16	100 at 50	0 at 100
17	100 at 50	100 at 75
18	100 at 25	63 at 100
19	100 at 75	N/A
20	100 at 25	55 at 100
21	92 at 50	36 at 100
22	80 at 75	0 at 100

Example 13 - Multiple-Substitution Analogues of Magainin I with Lysine and/or alanine Residues

Analogues of Magainin I were prepared wherein amino acid residues 3, 8, 9, 16, 19, and/or 23 were

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substituted with alanine (A) or lysine (K) residues. % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus was tested for each substitution analogue. The structure of each synthesized substitution analogue as well as the % effective growth inhibition of E. coli, S. epidermidis, and S. aureus in µg/ml are given below in Table VIII.

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TABLE VIII

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN μg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AUREUS
GIAKFLHAAGKFGKAAVGAIMKA	90 at 2.5	N/A	100 at 75
GIAKFLHAAGKFGKAAVGAIMKK	100 at 2.5	100 at 25	74 at 100
GIAKFLHAAGKFGKAAVGKIMKA	100 at 2.5	100 at 25	100 at 75
GIAKFLHAKGKFGKAAVGAIMKA	90 at 10	N/A	0 at 100
GIAKFLHKAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 50
GIKKFLHAAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 25
GIKKFLHKKGKFGKAAVGKIMKK	96 at 2.5	N/A	0 at 100

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Example 14 - Magainin I Analogues with Glutamic Acid Omissions and Alanine or Lysine Substitutions

Magainin I analogues were prepared wherein amino acid residue 19 (E, or glutamic acid) was deleted, and either alanine or lysine was substituted for one of the remaining amino acid residues in the peptide. Alanine was substituted for either residue 16, 10 or 8, or lysine was substituted for either residue 18, 8, or 7. Each of these substitution analogues was tested for % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus. The structures of each peptide and the % effective growth inhibition of E. coli, S. epidermidis, or S. aureus in µg/ml are listed below in Table IX.

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TABLE IX

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN µg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AUREUS
GIGKFLHSAGKFGKAAVGIMKS	100 at 25	100 at 100	N/A
GIGKFLHSAAKFGKAFVGIMKS	100 at 2.5	N/A	100 at 50
GIGKFLHAAGKFGKAFVGIMKS	100 at 2.5	100 at 25	100 at 50
GIGKFLHSAGKFGKAFVKIMKS	100 at 2.5	100 at 10	N/A
GIGKFLHKAGKFGKAFVGIMKS	100 at 2.5	84 at 10	N/A
GIGKFLKSAGKFGKAFVGIMKS	100 at 2.5	97 at 12.5	N/A

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Example 15

Magainin I substitution analogues were prepared in which, in one analogue, each of amino acid residues 8, 19, and 23 was substituted with lysine, and, in another analogue each of amino acid residues 7, 8, 19, and 23 was substituted with lysine. % effective growth inhibition of E. coli and S. epidermidis in µg/ml was then measured. For the analogue in which amino acid residues 8, 19, and 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 2.5 µg/ml and of S. epidermidis was 100% at 12.5 µg/ml, for the analogue in which amino acid residues 7, 8, 19, 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 1.25 µg/ml and the % effective growth inhibition of S. epidermidis was 100% at 5 µg/ml.

Example 16

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and residues 3, 7, and 8 were substituted with lysine residues. The resulting peptide had the following structure:

GIKKFLKKAGKFGKA

The peptide was then tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 5 µg/ml.

Example 17

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and amino acid residues 3, 8, and 10

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were substituted with an alanine residue. The resulting peptide has the following structure:

GIAKFLHAAAKFGKA

The peptide was tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 25 µg/ml.

Example 18 - Magainin II Analogues with Alanine Substitutions

Magainin II and analogues wherein an alanine residue was substituetd for various amino acid residues of Magainin II were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E-Coli, P.aeruginosa, and S. epidermidis as hereinabove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine - substituted Magainin II analogues is listed below in Table X.

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Table X - Alanine - Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration µg/ml E. Coli	P. aeruginosa	S. epidermidis
None (Magainin II)	100 at 10	100 at 50	100 at 25
23	100 at 10	100 at >50	100 at 25
22	100 at 25	100 at 25	100 at 25
21	100 at 25	100 at 25	100 at 25
20	100 at 50	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 10	100 at 5	100 at 25
16	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at 25	100 at >50
13	100 at 5	100 at 10	100 at 25
12	100 at 25	100 at >50	100 at >50
11	100 at 25	100 at >50	100 at >50
10	100 at 10	100 at 25	100 at 25
8	100 at 10	100 at 10	100 at 10
7	100 at 25	100 at 25	100 at 25
6	100 at 50	100 at 50	100 at >50
5	100 at 50	100 at 50	100 at >50

Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
4	100 at 25	100 at 50	100 at 50
3	100 at 25	100 at 25	100 at 25
2	100 at 25	100 at 50	100 at 50
1	100 at 25	100 at 25	100 at 50

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Example 19 - Magainin II Analogues with Lysine Substiutions

Magainin II analogues wherein a lysine residue was substituted for various amino acid residues of Magainin II where prepared and tested as hereinabove described for % effective growth inhibition of E. Coli, P. aeruginosa, and S. epidermidis at concentrations given in µg/ml. The % effective growth inhibition for each of the Lysine-substituted analogue of Magainin II is listed below in Table XI.

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Table XI - Lysine-Substitued Margainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml		
	E. Coli	P. aeruginosa	S. epidermidis
23	100 at 25	100 at 50	100 at 50
22	100 at 25	100 at 25	100 at 10
21	100 at 10	100 at 25	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 2.5	100 at 5	100 at 5
17	100 at 25	100 at 25	100 at 25
16	100 at 25	100 at 25	100 at 50
15	100 at 5	100 at 10	100 at 10
13	100 at 5	100 at 25	100 at 25
12	100 at 10	100 at 25	100 at 25
9	100 at 25	100 at 25	100 at 25
8	100 at 5	100 at 5	100 at 25
7	100 at 5	100 at 5	100 at 25

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Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
6	100 at 10	100 at 25	100 at 50
5	100 at 25	100 at 50	100 at 50
3	100 at 5	100 at 25	100 at 10
2	100 at 10	100 at 10	100 at 25
1	100 at 5	100 at 10	100 at 25

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Example 20 - Magainin II Peptides Containing D-Amino Acid Residues.

Magainin II peptides were synthesized wherein various amino acid residues were substituted with a D-amino acid residue, whose structure corresponded to to that of the residue originally present in Magainin II. Each of these Magainin II peptide analogues was then tested as hereinabove described for % effective growth inhibition of E. Coli, P. aeruginosa, and S. epidermidis in µg/ml. The % effective growth inhibition for each of the D-Amino acid residue substituted analogues of Magainin II is listed below in Table XII.

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Table XII-D-Amino Acid Residue - Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml		
	E. Coli	P. aeruginosa	S. epidermidis
23	100 at 5	100 at 10	100 at 25
22	100 at 10	100 at 10	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 25	100 at 25	100 at 25
17	100 at 25	100 at 25	100 at 50
16	100 at 25	100 at 25	100 at 25
15	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at >25	100 at >50
12	-	100 at 25	100 at 50
11	100 at 25	100 at 25	100 at 25
10	100 at 25	100 at 25	100 at 25
9	100 at 25	100 at 25	100 at 25
8	100 at 25	100 at 25	100 at 25
7	100 at 10	100 at 25	100 at 25
6	100 at 25	100 at 25	100 at 50

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Amino Acid Residue Substituted	E. Coli	P. aeruginosa	S. epidermidis
5	100 at 25	100 at 25	100 at 50
4	100 at 25	100 at 25	100 at 50
2	100 at 25	100 at 25	100 at 50

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Example 21 - Magainin II Analogues with Glutamic Acid Deletions

In this example, analogues of Magainin II were synthesized, said analogues having amino acid residue 19 (glutamic acid) deleted from the peptide structure, and wherein one or more of the other amino acid residues was substituted with an amino acid residue different from the normal amino acid residue. Analogues of the following structures were then synthesized according to the method described in Example 1.

Analogue	Stucture
1	GIGKFLHSAKKFWKAFVGIMNS
2	GIGKFLHSAKKFLKAFVGILNS
3	GILKFLHSAKKFLKAFVGILNS
4	GILKFLHSAKKFFKAFVKILNS
5	GIGKFLHSAKKFFKAFVFILNS
6	GIGKFLHSAKKFGKAFVGIMKS
7	GIGKFLHSAKKFGKAFVAIMKS
8	GIGKFLHSAKKFGKAFVFIMNS*
9	GIGKFLHSAKKFAKAFVFIMNS
10	GIGKFLHSAKKFFKAFVFIMNS
11	GIGKFLKSAKKFGKAFVFIMNS
12	GIGKFLHKAKKFAKAFVFIMNS
13	GIGKFLKSAKKFAKAFVFIMNS
14	GIGKFLHKAKKFFKAFVFIMNS
15	GIGKFLKSAKKFFKAFVFIMNS
16	GIGKFLHKAKKFAKAFVFIMNK
17	GIGKFLKSAKKFAKFFVFIMNK
18	GIGKFLKKAKKFGKAFVFIMKK
19	GIGKFLHSAKKFGKAFVK**IMNS
20	GIGKFLHSAKKFGKAFVKIMNS
21	GIGKFLHKAKKFGKAFVKIMNS

*D-Serine

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**-ε-F moc-lysine

Each of the peptides was then tested as hereinabove described for % effective growth inhibition of E. Coli, P.aeruginosa, and S.epidermidis in µg/ml. The % effective growth inhibition of each of these analogues is given in Table XIII below.

TABLE XIII

Analogue	% Effective Growth Inhibition, Concentration in µg/ml		
	E. Coli	P. aeruginosa	S. epidermidis
1	100 at 5	100 at 5	100 at 5
2	100 at 2.5	100 at 2.5	100 at 5
3	100 at 2.5	100 at 2.5	100 at 5
4	100 at 2.5	100 at 2.5	100 at 5
5	100 at 10	100 at 5	100 at 5
6	100 at 5	100 at 10	100 at 25
7	100 at 2.5	100 at 5	100 at 5
8	100 at 5	100 at 5	100 at 5
9	100 at 5	100 at 2.5	100 at 5
10	100 at 5	100 at 10	100 at 5
11	100 at 5	100 at 5	100 at 5
12	100 at 1.25	100 at 2.5	100 at 1.25
13	100 at 2.5	100 at 1.25	100 at 2.5
14	100 at 10	100 at 2.5	100 at 2.5
15	100 at 5	100 at 5	100 at 1.25
16	100 at 1.25	100 at 1.25	100 at 1.25
17	100 at 1.25	100 at 5	100 at 2.5
18	100 at 2.5	100 at 2.5	100 at 2.5
19	100 at 10	100 at 10	100 at 5
20	100 at 1.25	100 at 2.5	100 at 1.25
21	100 at 1.25	100 at 5	100 at 2.5

Example 22

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Amide (NH_2) - terminated Magainin II analogues wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substitued. The analogues are as follows:

Analogue 1 GIGKFLKKAKKFAKAFVKIINN-NH_2

Analogue 2 GIGKFLKKAAKFAKAFVKIINN-NH_2

The analogues were then tested as hereinabove described for % effective growth inhibition of E. Coli, P.aeruginosa, and S.epidermidis Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli, 100% at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis Analogue 2 had % effective growth inhibitions of 100% at 1.25 µg/ml for P. aeruginosa and 100% at 1.25 µg/ml for S.epidermidis.

Example 23

Amide (NH_2) -terminated analogues, which by virtue of their structures, may be analogues of Magainin I or Magainin II, were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substituted. The analogues are as follows:

Analogue 1 GIGKFLKKAKKFGKAFVKIMKK-NH_2

Analogue 2 GIGKFLKKAKKFAKAFVKIMKK-NH_2

Analogue 3 GIGKFLKKAKKFAKAFVKIIKK-NH_2

The analogues were then tested for % effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli, 100% at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis. Analogue 2 had % effective growth inhibitions of 100% at 2.5 µg/ml for E.Coli, 100 at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis. Analogue 3 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. Coli,

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100% at 2.5 µg/ml for P.aeruginosa, and 100% at 1.25 µg/ml for S.epidermidis

Example 24

Amide (NH_2) terminated analogues of Magainin I were synthesized wherein at least amino acid residues 17-23 were deleted and amino acid residues 3, 7, and 8 were substituted with lysine residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAGKFGK-NH_2

Analogue 2 - GIKKFLKKAGKFGKAF-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for E. Coli, 100% at 10 µg/ml for P.aeruginosa, and 100% at 10 µg/ml for S.epidermidis. Analogue 2 had % effective growth inhibitions of 100% of 2.5 µg/ml for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100% at 5 µg/ml for S.epidermidis.

Example 25

Amide (NH_2)-terminated analogues of Magainin II were synthesized wherein at least amino acid residues 16-23 were deleted and substitutions were made for other residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAKKFGKA-NH_2

Analogue 2 - GIKKFLKKAKKFAKA-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for P.aeruginosa, and 100 at 5.0 µg/ml for S.epidermidis. Analogue 2 had % effective grwoth inhibitions of 100% of 5 µg/ml, for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100% at 5 µg/ml for S.epidermidis.

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An amide (NH_2)-terminated analogue, which by virtue of its structure may be an analogue of Magainin I or Magainin II, was synthesized wherein amino acids 16-23 were deleted, amino acid residues 3,7, and 8 were substituted with lysine residues, and amino acid residue 10 and 13 were substituted with alanine residues. The analogue was of the following structure.

GIKKFLKKAAKFAKA-NH_2

The analogue was then tested for % effective growth inhibition. The analogue had % effective growth inhibitions of 100% at 5 µg/ml for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100 at 5 µg/ml for S.epidermidis.

Example 27

Analogues of Magainin II were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and amino acids 1-4, or 3,5, and 6 were deleted and at least one of the remaining amino acid residues was substituted. The analogues were of the following structures:

Analogue 1: FLKSAKKFGKAFVGIMNS

Analogue 2: FLKSAKKFAKAFVGIMNS

Analogue 3: FLHSAKKFGKAFVFIMNS

Analogue 4: GIKHSAKKFAKAFKAIMNS

The analogues were then tested for % effective growth inhibition of E.coli, P.aeruginosa, and S.epidermidis. The % effective growth inhibition of each of these analogues is given in Table XIV below.

TABLE XIV

Analogue	% Effective Growth Inhibition, Concentration in µg/ml		
	E.Coli	P.aeruginosa	S.epidermidis
1	100 at 25	100 at 25	100 at 50
2	100 at 10	100 at 25	100 at 50

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3	100 at 25	100 at 25	100 at 10
4	100 at 10	100 at 25	100 at 5

Numerous modifications and variations of the present invention are possible in light of the above teachings, and, therefore, within the scope of the accompanying claims, the invention may be practiced other than as particularly described.

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WHAT IS CLAIMED IS:

1. A compound comprising:

an analogue of Magainin I peptide or Magainin II peptide, said Magainin I peptide or Magainin II peptide being in an amide-or carboxy-terminated form, and wherein Magainin I is respresented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

wherein Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

and wherein said Magainin I or Magainin II peptide is substituted in at least one of positions 1-23, wherein the substituents which may be employed in each of positions 1-23 are shown in the following table:

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Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

2. The compound of Claim 1 wherein said Magainin I or Magainin II peptide is substituted in at least one of positions 1-23, wherein each of the

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substituents in each of positions 1-23 is shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

3. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 8, 10, 13, 16, 18 and 19 is substituted with an alanine residue.

4. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein amino

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acid residues 3, 8, 16, 19 and 23 are substituted with alanine residues.

5. The compound of Claim 2 wherein the peptide is a Magainin I peptide and four of amino acid residues 3, 8, 16, 19 and 23 are each substituted with an alanine residue, and the remaining one of amino acid residues 3, 8, 16, 19 and 23 is substituted with a lysine residue.

6. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein amino acid residue 21 is substituted with a proline residue.

7. The compound of Claim 2 wherein the peptide is a Magainin I peptide and at least one of amino acid residues 3, 7, 8, 10, 18-21, and 23 is substituted with a lysine residue.

8. The compound of Claim 2 wherein the peptide is a Magainin I peptide, and wherein amino acid residues 3, 8, 9, 19 and 23 are each substituted with a lysine residue and amino acid residue 16 is substituted with an alanine residue.

9. The compound of Claim 2 wehrein the peptide is a Magainin I peptide, and wherein at least one of amino acid residues 2, 4, 19 or 23 is a D-amino acid residue.

10. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 3, 5, 8, 10, 12, 13, 15, 18 and 20 is a protected tryptophan residue.

11. The compound of Claim 2 wherein the peptide is a Magainin I peptide and wherein at least one of amino acid residues 9, 13, 15, and 17 is an unprotected tryptophan residue.

12. The composition of Claim 2 wherein the peptide is a Magainin II peptide, and wherein at

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least one of amino acid residues 1-8, 10, 13, 14, 16, or 18-23 is an alanine residue.

13. The compound of Claim 2 wherein the peptide is a Magainin II peptide and wherein at least one of amino acid residues 1-3, 5-9, 12, 13, or 15-23 is a lysine residue.

14. The compound of Claim 2 wherein the peptide is a Magainin II peptide and wherein at least one of amino acid residues 2, 4-12, 15-17, 19, 20, 22, or 23 is substituted with a D-amino acid residue.

15. A compound comprising:

an analogue of Magainin I peptide or Magainin II peptide, said Magainin I peptide or Magainin II peptide being in an amide-or carboxy-terminated form, and wherein Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23,

and wherein Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23,

and wherein at least one of amino acid residues 15-23 is omitted, and wherein said Magainin I or Magainin II peptide is substituted in at least one of the remaining positions 1-23, wherein the substituents which may be employed in each of positions 1-23 are shown in the following table:

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Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala, D-Ile,Arg,Leu,Val,His,Met
3	Lys,Ala,Trp,Arg,His
4	D-Lys,Ala,Arg,His
5	D-Phe,Ala,Lys,Trp,Leu,Ile,Val,Met
6	D-Leu,Lys,Ala,Ile,Val,Met
7	Lys,D-His,Ala,Arg,Ile,Val,Met
8	Ala,Lys,D-Ser,Trp,Met,Ile,Arg,His, Thr,Leu,Val
9	Lys,D-Ala,Trp,Arg,His,Leu,Ile,Val
10	D-Lys,Lys, Ala,Trp,Arg,His,Leu,Ile,Val
11	D-Lys,Arg,His
12	D-Phe,Lys,Trp,Arg,His
13	Ala,Lys,Trp,Met,Arg,His,Phe,Leu, Ile,Val
14	Ala,D-Lys,Arg,His
15	Lys,Trp,D-Ala,Arg,His,Phe
16	Ala,Lys,D-Phe,Ile,Val,Met,Leu
17	Ala,Lys,D-Val,Trp,Arg,His,Met,Leu
18	Ala,Lys,Trp,Arg,His,Leu,Met,Phe
19	Ala,Lys,D-Glu,Gly,Arg,His,Leu Ile,Phe,Asn
20	D-Ile,Ala,Lys,Trp,Leu,Phe,Val,Met
21	Lys,Pro,Ala,His,Leu,Arg,Ile,Phe
22	Lys,Ala,D-Asn,Gln,Arg,His
23	D-Ser,Lys,Ala,Thr,Gly,Leu,Ile, Gln,Asn

16. The compound of Claim 15 wherein said Magainin I or Magainin II peptide is substituted in at least one of the remaining positions 1-23, wherein

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each of the substituents in each of positions 1-23 is shown in the following table:

Residue No.	Substituent
1	Lys,Ala
2	Lys,Ala,D-Ile
3	Lys,Ala,Trp
4	D-Lys,Ala
5	D-Phe,Ala,Lys,Trp
6	D-Leu,Lys,Ala
7	Lys,D-His,Ala
8	Ala,Lys,D-Ser,Trp
9	Lys,D-Ala,Trp
10	D-Lys,Lys, Ala,Trp
11	D-Lys
12	D-Phe,Lys,Trp
13	Ala,Lys,Trp
14	Ala,D-Lys
15	Lys,Trp,D-Ala
16	Ala,Lys,D-Phe
17	Ala,Lys,D-Val,Trp
18	Ala,Lys,Trp
19	Ala,Lys,D-Glu
20	D-Ile,Ala,Lys,Trp
21	Lys,Pro,Ala
22	Lys,Ala,D-Asn
23	D-Ser,Lys,Ala

17. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and amino acid residues 16-23 are deleted and amino acid residues 3, 8 and 10 are substituted with an alanine residue.

18. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and wherein amino acid residue 19 is deleted.

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19. The compound of Claim 18 wherein amino acid residues 5, 8, 9 and 16 are each substituted with a lysine residue; amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are each substituted with an alanine residue.

20. The compound of Claim 16 wherein the peptide is a Magainin I peptide, and wherein amino acid residue 21 is deleted.

21. The compound of Claim 20 wherein amino acid residues 5, 10, 18, and 19 are each substituted with a lysine residue; amino acid 7 is substituted with a phenylalanine residue, and amino acid residue 22 is substituted with an alanine residue.

22. The compound of Claim 15 wherein amino acids 17-23 or 16-23 or 15-23 are deleted, and amino acids, 3,7, and 8 are substituted with a lysine residue.

23. The compound of Claim 22 wherein said analogue of Magainin I or Magainin II peptide is selected from the group consisting of:

GIKKFLKKAGKFGK-NH_2

GIKKFLKKAGKFGKAF-NH_2;

GIKKFLKKAKKFGKA-NH_2;

GIKKFLKKAKKFAKA-NH_2; and

GIKKFLKKAAKFAKA-NH_2.

24. The compound of Claim 15 wherein amino acid residue 19 is omitted, and at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18, 21, 22, or 23 is substituted with another amino acid residue as shown in the following table:

Residue No.	Substituent
3	Leu
7	Lys
8	Lys,Ala

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10	Ala,Lys
13	Trp,Phe,Leu,Ala
15	Phe
16	Ala
18	Lys,Ala,Phe
21	Lys,Ile
22	Lys
23	Lys,D-Ser.

25. The compound of Claim 24 wherein the peptide is a Magainin II peptide.

26. The compound of Claim 25 wherein said peptide is selected from the group consisting of:

GIGKFLHSAKKFGKAFVGIMKS;

GIGKFLHSAKKFGKAFVAIMKS;

GIGKFLHSAKKFGKAFVFIMNS*, wherein S* is D-serine;

GIGKFLHSAKKFFKAFVFIMNS;

GIGKFLKSAKKFGKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNS;

GIGKFLKSAKKFAKAFVFIMNS;

GIGKFLHKAKKFAKAFVFIMNK;

GIGKFLKKAKKFGKAFVFIMKK; and

GIGKFLHSAKKFGKAFVK **IMNS, wherein K** is E-F-moc-lysine.

27. The compound of Claim 15 wherein amino acid residue 19 is omitted, and either amino acid residues 1-4 are omitted or amino acid residues 3, 5, and 6 are omitted.

28. The compound of Claim 27 wherein the peptide is a Magainin II peptide.

29. The compound of Claim 15 wherein the peptide is selected from the group consisting of:

FLHSAKKFGKAFVFIMNS

GIKHSAKKFAKAFKAIMNS

FLKSAKKFGKAFVGIMNS

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FLKSAKKFAKAFVGIMNS

30. A process comprising:

administering to a host an effective anti-microbial amount of the compound of Claim 1.

31. A process, comprising:

administering to a host an effective anti-viral amount of the compound of Claim 1.

32. A process, comprising:

administering to a host an effective anti-tumor amount of the compound of Claim 1.

33. A process, comprising:

administering to a host an effective spermicidal amount of the compound of Claim 1.

34. A process, comprising:

administering to a host an effective anti-microbial amount of the compound of Claim 15.

35. A process, comprising:

administering to a host an effective anti-viral amount of the compound of Claim 15.

36. A process, comprising:

administering to a host an effective anti-tumor amount of the compound of Claim 15.

37. A process, comprising:

administering to a host an effective spermicidal amount of the compound of Claim 15.

38. The compound of Claim 24 wherein said analogue of Magainin I or Magainin II peptide is represented by the following structural formula using the single letter amino acid code:

GIGKFLKKAKKFGKAFVKIMKK-NH_2

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ABSTRACT

SUBSTITUTION ANALOGUES OF MAGAININ PEPTIDES

A compound comprising a Magainin I or Magainin II peptide wherein at least one substitution may be made for certain amino acid residues with other amino acid residues, said peptides known as substitution analogues. In addition to such substitutions, there may be included within the scope of the invention analogues wherein at least one of amino acid residues 15 and 23 may have been deleted as well, and wherein substitutions were made in the remaining peptide chain. Certain substitution analogues within the scope of the present invention have been shown to possess increased biological activity.

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REPLACEMENT SHEETS SG
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☑ Claim(s) : paged 47 to paged 52
☐ Drawing(s) : paged ..... to paged .....
☐ Abstract : paged ..... to paged .....
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SUBSTITUTION ANALOGUES OF MAGAININ PEPTIDES

This invention relates to a class of biologically active peptides known as magainins. More particularly, this invention relates to analogues of magainin peptides wherein at least one amino acid residue in the peptide has been substituted with another amino acid residue, with said analogues being commonly referred to as "substitution analogues".

H-C Chen et al., FEBS Letters, 236(2), 462-466 (1988) disclose a limited range of substitution analogues of Magainin II (mostly involving alanine substitutions at residues 8, 13 and 18), with improved antimicrobial activity. J.H. Cuervo et al., Peptide Research, 1(2), 81-86 (1988) disclose amino acid omission analogues of Magainin I and Magainin II.

In accordance with the present invention, there is provided a compound comprising an analogue of Magainin I peptide or Magainin II peptide. The Magainin I or Magainin II peptide is in an amide or carboxy terminated form. Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

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G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

In the analogues of the present invention, any of amino acid residues 15-23 of Magainin I peptide or Magainin II peptide is optionally omitted, and one to seven of the remaining amino acid residues of said Magainin peptide is substituted by another amino acid residue, at least one of amino acid residues 3, 7, 8, 10, 18-21 and 23 (in the case of Magainin I) or at least one of amino acid residues 1-3, 5-8, 12, 13 and 15-23 (in the case of Magainin II) being substituted by Lys and any further substitutions being as shown in the following table, provided that residue 18 may be substituted by Phe only if one of residues 15-17 or 19-23 is omitted.

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Residue No.	Substituent
1	Lys, Ala
2	Lys, Ala, D-Ile, Arg, Leu, Val, His, Met
3	Lys, Ala, Trp, Arg, His
4	D-Lys, Ala, Arg, His
5	D-Phe, Ala, Lys, Trp, Leu, Ile, Val, Met
6	D-Leu, Lys, Ala, Ile, Val, Met
7	Lys, D-His, Ala, Arg, Ile, Val, Met
8	Ala, Lys, D-Ser, Trp, Met, Ile, Arg, His, Thr, Leu, Val
9	Lys, D-Ala, Trp, Arg, His, Leu, Ile, Val
10	D-Lys, Lys Ala, Trp, Arg, His, Leu, Ile, Val
11	D-Lys, Arg, His
12	D-Phe, Lys, Trp, Arg, His
13	Ala, Lys, Trp, Met, Arg, His, Phe, Leu, Ile, Val
14	Ala, D-Lys, Arg, His
15	Lys, Trp, D-Ala, Arg, His, Phe
16	Ala, Lys, D-Phe, Ile, Val, Met, Leu
17	Ala, Lys, D-Val, Trp, Arg, His, Met, Leu
18	Ala, Lys, Trp, Arg, His, Leu, Met, Phe
19	Ala, Lys, D-Glu, Gly, Arg, His, Leu, Ile, Phe, Asn
20	D-Ile, Ala, Lys
21	Lys, Pro, Ala, His, Leu, Arg, Ile, Phe
22	Lys, Ala, D-Asn, Gln, Arg, His
23	D-Ser, Lys, Ala, Thr, Gly, Leu, Ile, Gln, Asn

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It is to be understood that for purposes of the present invention, the tryptophan residues may be protected with a formyl group or be unprotected. The phenylalanine residues, whether such residue is present in its normal position, or employed as a substitution residue, may be a normal phenylalanine residue or an iodinated phenylalanine residue.

In accordance with one embodiment, at least one of amino acid residues 3, 7, 8, 10, 18-21, and 23 of Magainin I is substituted with a lysine residue.

In accordance with another embodiment, amino acid residues 3, 8, 9, 19, and 23 of Magainin I are each substituted with a lysine residue and amino acid residue 16 is substituted with an alanine residue.

In accordance with another embodiment, at least one of amino acid residues 1-3, 5-8, 12, 13 and 15-23 of Magainin II is a lysine residue.

In accordance with yet another embodiment, amino acid residue 19 of Magainin I is deleted, and amino acid residues 5, 8, 9 and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are substituted with an alanine residue.

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In accordance with another embodiment, in carboxy or amide terminated (preferably amide--terminated) Magainin I or Magainin II peptide, amino acid residues 17-23 or 16-23 or 15-23 are deleted, and amino acid residues 3, 7, and 8 are each substituted with a lysine residue, and optionally amino acid residue 13 and/or amino acid residue 10 is substituted with an alanine residue. Preferred peptides are as follows:

GIKKFLKKAGKFGK-NH_2

GIKKFLKKAGKFGKAF-NH_2

GIKKFLKKAKKFGKA-NH_2

GIKKFLKKAKKFAKA-NH_2

GIKKFLKKAAKFAKA-NH_2

Preliminary studies indicate that the above-mentioned preferred peptides possess low hemolytic activity.

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In accordance with a further embodiment, amino acid residue 21 of Magainin I may be deleted, and amino acid residues 5, 10, 18 and 19 are each substituted with a lysine residue, amino acid residue 7 is substituted with a phenylalanine residue, and amino acid residue 22 is substituted with an alanine residue.

In accordance with another embodiment, in carboxy or amide terminated (preferably amide terminated) Magainin I or Magainin II (preferably Magainin II) analogues of the invention as defined before, amino acid residue 19 is omitted, and at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18, 21, 22 or 23 is substituted with another amino acid as follows:

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Residue number	Substituent
3	Lys
7	Lys
8	Lys, Ala
10	Lys, Ala
13	Trp, Leu, Phe, Ala
15	Phe
16	Ala
18	Lys, Ala, Phe
21	Lys, Ile
22	Lys
23	Lys, D-Ser

Representative peptides are disclosed in Examples 14 and 21-23.

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In a preferred embodiment, the peptide is a Magainin II peptide, and the substitution analogue wherein amino acid residue 19 is deleted is selected from the class consisting of the following substitution analogues:

GIGKFLHSAKKFGKAFVGIMKS;
GIGKFLHSAKKFGKAFVAIMKS;
GIGKFLKSAKKFGKAFVFIMNS;
GIGKFLHKAKKFAKAFVFIMNS;
GIGKFLKSAKKFAKAFVFIMNS;
GIGKFLHKAKKFAKAFVFIMNK;
GIGKFLKKAKKFGKAFVFIMKK; and
GIGKFLHSAKKFGKAFVK**IMNS;
wherein K** is ϵ-F-moc-lysine.

Preliminary studies indicate that these preferred analogues possess low hemolytic activity.

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Applicants have found that when employing the substitution analogues of Magainin I or Magainin II as hereinabove described, such peptides display biological activity equal to or greater than the parent Magainin I or Magainin II peptide. Such peptides are referred to as "successful substitution analogues".

The use of these compounds which comprise a substitution analogue of Magainin I or Magainin II peptide, in accordance with the present invention, is effective as an antibiotic, and can be employed to inhibit, prevent or destroy the growth or proliferation of microbes, such as bacteria, fungi viruses or the like. Similarly, such compounds can be employed as an anti-viral composition to inhibit, prevent or destroy the growth or proliferation of viruses.

As used herein, the term "substitution analogue" includes magainin peptides in which at least one amino acid residue of the peptide structure has been substituted with a different amino acid residue, as well as magainin peptides in which, in addition to the above-mentioned substitution(s), also have had at least one of amino acid residues 15-23 omitted from the peptide sequence. The term also includes magainin peptides having D-amino acid or iodinated phenylalanine residues which have been substituted into the peptide sequence.

Such compounds can also be employed as a spermicide to inhibit, prevent or destroy the motility of sperm.

Such compounds can also be employed as anti-tumor agents to inhibit the growth of or destroy tumors.

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The compounds have a broad range of potent antibiotic activity against a plurality of microorganisms, including Gram-positive and Gram-negative bacteria, fungi, protozoa and the like. Such compounds can be employed for treating or controlling microbial infection caused by organisms which are sensitive to such compounds.

The compounds can also be used as preservatives or sterilants for materials susceptible to microbial contamination. In vitro activity against bacteria is exemplified hereinafter in Examples 3-27.

In general, a substitution analogue of the Magainin I or Magainin II peptide is administered in a dosage of from about 1 mg to about 500 mg per kilogram of body weight, when administered systemically. When administered topically, the peptide is used in a concentration of from about 0.5% to about 5%.

The compounds comprising the substitution analogues of Magainin I or Magainin II, in accordance with the present invention, can be employed for treating a wide variety of hosts. In accordance with a preferred embodiment, a host can be an animal, and such animal can be a human or non-human animal.

The compounds comprising the substitution analogues of Magainin I or Magainin II can be employed in a wide variety of pharmaceutical compositions in combination with a non-toxic pharmaceutical carrier or vehicle such as a filler, non-toxic buffer, or physiological saline solution. Such pharmaceutical compositions can be used topically or systemically and can be in any suitable form such as a liquid, solid, semi-solid, injectable solutions, tablet, ointment, lotion, paste, capsule or the like. The compounds comprising the

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substitution analogues of Magainin I or Magainin II can also be used in combination with adjuvants, protease inhibitors, or compatible drugs where such a combination is seen to be desirable or advantageous in controlling infection caused by harmful microorganisms including protozoa, viruses, and the like.

The compounds comprising the substitution analogues of Magainin I or Magainin II of the present invention can be administered to a host; in particular an animal, in an effective antibiotic and/or anti-tumor and/or anti-viral and/or anti-microbial and/or a spermicidal amount.

Magainin I and Magainin II, as well as the substitution analogues of the Magainin I and Magainin II peptides of the present invention, (both amide- and carboxy-terminated Magainin I and Magainin II forms) can be synthesized by any convenient method of peptide synthesis as are well-known to skilled workers. Solid phase synthesis methods are particularly preferred.

The peptides described herein were prepared by the method of simultaneous multiple peptide synthesis (SMPS). This method is described in detail in Houghten, R.A., "General Method for the Rapid Solid-Phase Synthesis of Large Numbers of Peptides; Specificity of Antigen-Antibody Interaction at the Level of Individual Amino Acids," Proc. Natl. Acad. Sci., U.S.A., Vol. 82, pgs. 5131-5135 (1985), and in Houghten, R.A., et al. "Simultaneous Multiple Peptide Synthesis; The Rapid Preparation of Large Numbers of Discrete Peptides for Biological, Immunological, and Methodological Studies," Peptide Chemistry, pgs. 295-298 (1987).

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For purposes of the following examples, substitution analogues of Magainin I and Magainin II were prepared wherein various amino acid residues were substituted and/or other amino acid residue(s) were deleted.

For purposes of comparison, a complete Magainin I or Magainin II peptide can also be prepared by the SMPS method. It is also contemplated within the scope of the present invention that substitution analogues which have one or more amino acid residue(s) omitted from the Magainin I or Magainin II structure can also be prepared by the SMPS method.

The invention will now be described with respect to the following examples, however, the scope of the present invention is not intended to be limited thereby.

Example 1 - Peptide Synthesis

Peptide synthesis of Magainin I and the substitution analogues of Magainin I, was accomplished by using the strategy of simultaneous multiple peptide synthesis. All solvents and reagents were of analytical grade and were used without further purification. Standard N-t-Boc-protected amino acids were employed in the synthesis. The side chain functionalities used were benzyl (Ser, Glu), 2-Cl-Z (Lys)(Z=benzyloxycarbonyl), N^{im}- DNP (His), and sulfoxide (Met). Peptide synthesis was performed beginning with 100 mg of either Boc-amino acids-Pam resin to produce C-terminal carboxyl peptide (PAM purchased from Applied Biosystems, substitution 0.56 meq/gm is an amino acyl -4- [oxymethyl] phenylacetic acid derivative of amino polystyrene) or methylbenzhydrylamine (MBHA) resin

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(substitution-0.65meq/gm) per resin packet to produce C-terminal amide peptide.

After synthesis, completely protected peptide resins were treated three times with 0.5 M thiophenol in DMF to remove the N^{im}- dinitrophenyl group from Histidine. The final Boc-group was removed with TFA to avoid t-butylation of methionyl residues during final HF treatment. Cleavage was performed using the Low-High HF procedure. Tam, et al. J. Am. Chem. Soc. Vol. 105, P. 6442 (1983). For peptides synthesized on Pam resin, the low-HF was carried out without removing the resin from the packet, using a multiple vessel HF apparatus for 2 hrs. at 0°C. For peptides prepared using MBHA resin, the low HF procedure was performed in a common reaction vessel for 2 hrs. at 0°C. For Pam resin peptides, the low-HF mixture was evacuated from the 24 individual reaction vessels by a water aspirator followed by a mechanical pump. The low-HF reaction vessel containing the bags with MBHA resin was emptied of the low-HF mixture by pouring off the liquid into a waste container. The bags were washed immediately with cold ether followed by alternating washes of CH_2Cl_2, DMF, CH_2Cl_2, IPA, CH_2Cl_2. The packets were then dried and put into individual tubes of the 24 vessel HF apparatus with 0.7 ml of anisole as scavenger. The high-HF was performed by condensing dry hydrogen fluoride at -70°C. The reaction took place at -10°C for 1 h. and -5°C - 0°C for the last 30 min. HF was evaporated using a strong flow of nitrogen. Finally, residual carbonium ion scavengers were removed by washing with dry ether.

The crude peptides were subsequently extracted with 10% acetic acid and subjected to RP-HPLC on an analytical reversed phase column (Vidac ODS 25 cm x

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4.6 mm), using a Beckman-Altek model 421 HPLC system and two model 110A pumps. The solvent system was composed of buffer A, 0.05% TFA/H_2O, and buffer B, 0.05% TFA/CH_3CN with a flow rate of 1.0 ml/min. The peptides were detected at 215 nm using a Hitachi 100-20 spectrophotometer.

Purification of the peptides was accomplished by reverse - phase HPLC on a Vidac C_{18} (22 mm x 25cm), 10 µm packing column with an eluting gradient composed of CH_3CN and 0.05% TFA. Amino acid analysis was carried out on a Beckman 6300 analyzer following hydrolysis of the peptides in constant (boiling) 6 N HCl at 110°C for 24 hr., and such analysis was within ±10% of theory.

Example 2 - Antimicrobial Assays

Antimicrobial assays were carried out in 96 - well tissue culture plates. Each well was incubated with a given microorganism (Escherichia coli, Staphylococcus epidermidis, Staphylococcus aureus, or Pseudomonas aeruginosa) suspended in LB medium (Examples 3-17), or TSB medium (Examples 18-27). Upon the addition of Magainin I or its substitution analogues, (dissolved in 1 X PBS, pH 7.0) each well contained a final cell density of 1.0×10^6 colony forming units (CFU)/ml. The final peptide concentrations used were 100 µg/ml., 75.0 µg/ml, 50.0 µg/ml, 25 µg/ml, 12.5 µg/ml, 10 µg/ml, 5µg/ml, 2.5 µg/ml, and 1.25 µg/ml.

Addition of peptides to the wells was defined as time zero. At six hours, the plates were placed in a Titertek Multiskan apparatus and the $O.D._{620}$ determined. The plates as well as the initial innoculum were incubated at 37°C.

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Five wells per plate contained media alone, while five others contained medium plus cells. These controls were used to eliminate the possibility of media contamination while providing a measure of uninhibited growth of the microorganisms.

The degree of peptide activity was determined by comparing the substitution analogues with uninhibited growth of the control cells over a six-hour period. The effective growth inhibition of the substitution analogues is listed in the examples and tables below.

Example 3 - Magainin I analogues with alanine substitutions (comparative)

Magainin I and analogues wherein an alanine residue was substituted for various amino acid residues of Magainin I were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E. coli at a concentration given in µg/ml as hereianbove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine-substituted Magainin I analogues is listed below in Table I. As used herein, the heading "Amino Acid Residue Substituted" refers to the number of the amino acid residue in the peptide which is substituted with a desired amino acid residue. All other residues in the peptide remain the same as that of the normal peptide sequence. For purposes of explanation of the term "% effective growth inhibition," a value of "100 at 25", for example, indicates 100% effective growth inhibition at a concentration of 25 µg/ml.

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Table 1 - Alanine-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
None (Magainin I)	100 at 25
23	100 at 10
22	100 at 50
21	100 at 50
20	100 at 50
19	100 at 5
18	100 at 25
17	100 at 75
16	100 at 25
14	100 at 100
13	100 at 25
12	100 at 50
11	0 at 100
10	100 at 25
8	100 at 5
7	100 at 75
6	0 at 100
5	0 at 100
4	0 at 100
3	100 at 75
2	100 at 100
1	100 at 100

Magainin I analogues were also prepared wherein amino acid residues 19, 16, or 8, respectively, were substituted with alanine residues, and such substitution analogues were tested for % effective growth inhibition of S. epidermidis and/or S. aureus as compared to Magainin I without any substitutions.

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Magainin I had a % effective growth inhibition of S. epidermidis of 100% at 25μg/ml and of S. aureus of 80% at 100 μg/ml. The % effective growth inhibition of S. epidermidis for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 μg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 16 was substituted with an alanine residue was 75% at 100 μg/ml. The % effective growth inhibition of S. aureus for the substitution analogue of Magainin I wherein amino acid residue 19 was substituted with alanine was 100% at 25 μg/ml, and for the substitution analogue of Magainin I wherein amino acid residue 8 was substituted with alanine was 100% at 50 μg/ml.

Example 4 - Magainin I analogues with Proline Substitutions (comparative)

Magainin I analogues wherein a proline residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E. coli at a concentration given in μg/ml. The % effective growth inhibition for each of the proline-substituted analogues of Magainin I is listed below in Table II.

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Table II - Proline-Substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 25
20	100 at 100
19	100 at 50
18	100 at 75
17	0 at 100
16	0 at 100
15	50 at 100
14	0 at 100
13	100 at 100
12	0 at 100
11	0 at 100
10	0 at 100
9	100 at 100
8	100 at 75
7	0 at 100
6	0 at 100
4	0 at 100
3	100 at 75
2	0 at 100
1	100 at 100

Example 5 - Lysine-Substituted Magainin I Analogues

Magainin I analogues wherein a lysine residue was substituted for various amino acid residues of Magainin I were prepared and tested as hereinabove described for % effective growth inhibition of E. coli at a concentration given in µg/ml. The % effective

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growth inhibition of each lysine-substituted analogue of Magainin I is given below in Table III.

Table III - Lysine-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in ug/ml
23	100 at 5
21	100 at 25
20	100 at 25
19	100 at 2.5
18	100 at 25
17 *	100 at 100
16 *	0 at 100
15 *	100 at 50
13 *	100 at 50
12 *	100 at 100
10	100 at 25
9 *	100 at 100
8	100 at 5
7	100 at 5
6 *	0 at 100
5 *	0 at 100
3	100 at 25
2 *	100 at 100
1 *	100 at 50

*comparative example

Magainin I analogues wherein amino acid residues 23, 19, 8, or 7, respectively, were substituted with a lysine residue were tested for % effective growth inhibition of S. epidermidis and/or S. aureus. The substitution analogue of Magainin I wherein amino acid residue 23 was substituted with a lysine residue

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had a % effective growth inhibition of S. aureus of 30% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 19 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 50% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 8 was substituted with a lysine residue had a % effective growth inhibition of S. aureus of 70% at 100 µg/ml. The substitution analogue of Magainin I wherein amino acid residue 7 was substituted with a lysine residue had a % effective growth inhibition of S. epidermidis of 100% at 25 µg/ml, and of S. aureus of 100% at 50 µg/ml.

Example 6 - Glutamic Acid-Substituted Magainin I Analogues (comparative)

Magainin I analogues wherein a glutamic acid residue was substituted for various amino acid residues of Magainin I were prepared and tested for % effective growth inhibition of E. coli according to the methods hereinabove described. The % effective growth inhibition for each glutamic acid-substituted Magainin I analogue is described below in Table IV.-

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Table IV Glutamic Acid-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
22	0 at 100
21	100 at 75
20	0 at 100
18	100 at 75
17	0 at 100
16	0 at 100
15	0 at 100
14	0 at 100
13	0 at 100
12	0 at 100
11	0 at 100
10	100 at 75
9	0 at 100
8	100 at 75
7	32 at 100
3	0 at 100

Example 7 - Magainin I peptides containing D-amino acid residues (comparative)

Magainin I peptides were synthesized wherein in each peptide one of amino acid residues 23, 19, 17, 16, 14, 4, or 2, respectively, is substituted with a D-amino acid residue. Each of these Magainin I peptide analogues was then tested as hereinabove described for % effective growth inhibition of E. coli in µg/ml. The % effective growth inhibition for each of the D-amino acid residue-subsituted analogues of Magainin I is listed below in Table V.

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Table V - D-amino acid residue-substituted Magainin I Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml
23	100 at 10
19	100 at 25
17	100 at 50
16	100 at 50
14	100 at 50
4	100 at 25
2	100 at 25

Example 8

In this example, a substitution analogue of Magainin I was prepared wherein amino acid residue 19, (E, or glutamic acid) was deleted, and amino acid residues 5, 8, 9, and 16 are each substituted with a lysine residue, amino acid residue 21 is substituted with a leucine residue, and amino acid residues 18 and 23 are each substituted with an alanine residue. The substitution analogue had the following structure:

GIGKKLHKKGKFGKFKGAILKA

The % effective growth inhibition of E. coli for this peptide was tested and found to be 100% at 5 µg/ml.

Example 9

In this example, a substitution analogue of Magainin I was prepared wherein amino acid 21 was deleted and amino acid residues 5, 10, 18, and 19

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were each substituted with a lysine residue, amino acid residue 7 was substituted with a phenylalanine residue, and amino acid 22 was substituted with an alanine residue. The peptide had the following structure:

GIGKKLFSAKKFGKAFVKKIAS

The % effective growth inhibition of E. coli for this peptide was tested and found to be 100% at 2.5 µg/ml.

Example 10 (comparative)

Magainin I and Magainin II peptides were prepared wherein phenylalanine residues 5 and 12 in each peptide were iodinated. The % effective growth inhibition of E. coli for each peptide, containing the iodinated phenylalanine residues, was tested. For the Magainin I peptide, the % effective growth inhibition was 100% at 10 µg/ml. For the Magainin II peptide, the % effective growth inhibition was 100% at 5 µg/ml.

Example 11 - Tryptophan (Formyl Group Removed)-Substituted Analogues of Magainin I (comparative)

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I. The tryptophan had the formyl group removed, thus resulting in the substitution of unprotected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E. coli and S. epidermidis was tested for these analogues. % effective growth inhibition of E. coli and S. epidermidis in µg/ml is listed below in Table VI.

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Table VI - Tryptophan (Formyl Group Removed) - Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml	
	E.coli	S. epidermidis
1	100 at 50	80 at 75
3	100 at 25	100 at 50
4	90 at 100	0 at 100
5	100 at 25	80 at 100
6	100 at 50	50 at 75
8	100 at 100	100 at 50
9	100 at 25	40 at 100
10	100 at 25	100 at 50
11	0 at 100	0 at 100
12	100 at 25	0 at 100
13	100 at 25	100 at 50
14	N/A	0 at 100
15	96 at 10	90 at 100
16	95 at 50	0 at 100
17	100 at 25	100 at 100
18	93 at 25	90 at 100
19	100 at 10	100 at 75
20	90 at 25	30 at 100
21	100 at 50	0 at 100
22	40 at 75	0 at 100

Example 12 - Tryptophan (containing formyl group)-Substituted Magainin I Analogues (comparative)

Magainin I analogues were prepared wherein a tryptophan residue was substituted for various amino acid residues of Magainin I, as in Example 11, except that in this example, the formyl group remained on

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the tryptophan residue thus resulting in the substitution of protected tryptophan residues into the Magainin I analogues. % effective growth inhibition of E. coli and S. epidermidis was tested for each of these analogues. % effective growth inhibition of E. coli and S. epidermidis in μg/ml is listed below in Table VII.

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Table VII - Tryptophan (containing formyl group)-Substituted Analogues of Magainin I

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml	
	E.coli	S. epidermidis
1	100 at 50	100 at 75
3	100 at 50	100 at 75
4	70 at 100	0 at 100
5	100 at 50	100 at 100
6	100 at 50	100 at 100
7	100 at 75	90 at 100
8	100 at 25	100 at 75
9	100 at 50	44 at 100
10	100 at 25	100 at 75
11	0 at 100	0 at 100
12	100 at 25	90 at 75
13	100 at 10	100 at 50
14	0 at 100	0 at 100
15	100 at 10	100 at 75
16	100 at 50	0 at 100
17	100 at 50	100 at 75
18	100 at 25	63 at 100
19	100 at 75	N/A
20	100 at 25	55 at 100
21	92 at 50	36 at 100
22	80 at 75	0 at 100

Example 13 - Multiple-Substitution Analogues of Magainin I with Lysine and/or alanine Residues

Analogues of Magainin I were prepared wherein amino acid residues 3, 8, 9, 16, 19, and/or 23 were

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substituted with alanine (A) or lysine (K) residues. % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus was tested for each substitution analogue. The structure of each synthesized substitution analogue as well as the % effective growth inhibition of E. coli, S. epidermidis, and S. aureus in µg/ml are given below in Table VIII.

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TABLE VIII

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN μg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AURRUS
* GIAKFLHAAGKFGKAAVGAIMKA	90 at 2.5	N/A	100 at 75
GIAKFLHAAGKFGKAAVGAIMKK	100 at 2.5	100 at 25	74 at 100
GIAKFLHAAGKFGKAAVGKIMKA	100 at 2.5	100 at 25	100 at 75
GIAKFLHAKGKFGKAAVGAIMKA	90 at 10	N/A	0 at 100
GIAKFLHKAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 50
GIKKFLHAAGKFGKAAVGAIMKA	100 at 2.5	100 at 25	100 at 25
GIKKFLHKKGKFGKAAVGKIMKK	96 at 2.5	N/A	0 at 100

*comparative

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Example 14 - Magainin I Analogues with Glutamic Acid Omissions and Alanine or Lysine Substitutions

Magainin I analogues were prepared wherein amino acid residue 19 (E, or glutamic acid) was deleted, and either alanine or lysine was substituted for one of the remaining amino acid residues in the peptide. Alanine was substituted for either residue 16, 10 or 8, or lysine was substituted for either residue 18, 8, or 7. Each of these substitution analogues was tested for % effective growth inhibition of E. coli, S. epidermidis, and/or S. aureus. The structures of each peptide and the % effective growth inhibition of E. coli, S. epidermidis, or S. aureus in µg/ml are listed below in Table IX.

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TABLE IX

% EFFECTIVE GROWTH INHIBITION

CONCENTRATION IN µg/ml

PEPTIDE STRUCTURE	E. COLI	S. EPIDERMIS	S. AUREUS
* GIGKFLHSAGKFGKAAVGIMKS	100 at 25	100 at 100	N/A
* GIGKFLHSAAKFGKAFVGIMKS	100 at 2.5	N/A	100 at 50
* GIGKFLHAAGKFGKAFVGIMKS	100 at 2.5	100 at 25	100 at 50
GIGKFLHSAGKFGKAFVKIMKS	100 at 2.5	100 at 10	N/A
GIGKFLHKAGKFGKAFVGIMKS	100 at 2.5	84 at 10	N/A
GIGKFLKSAGKFGKAFVGIMKS	100 at 2.5	97 at 12.5	N/A

*comparative

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Example 15

Magainin I substitution analogues were prepared in which, in one analogue, each of amino acid residues 8, 19, and 23 was substituted with lysine, and, in another analogue each of amino acid residues 7, 8, 19, and 23 was substituted with lysine. % effective growth inhibition of E. coli and S. epidermidis in µg/ml was then measured. For the analogue in which amino acid residues 8, 19, and 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 2.5 µg/ml and of S. epidermidis was 100% at 12.5 µg/ml, for the analogue in which amino acid residues 7, 8, 19, 23 were substituted with lysine, the % effective growth inhibition of E. coli was 100% at 1.25 µg/ml and the % effective growth inhibition of S. epidermidis was 100% at 5 µg/ml.

Example 16

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and residues 3, 7, and 8 were substituted with lysine residues. The resulting peptide had the following structure:

GIKKFLKKAGKFGKA

The peptide was then tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 5 µg/ml.

Example 17 (comparative)

In this example, an analogue of Magainin I was prepared wherein amino acid residues 16 through 23 were deleted and amino acid residues 3, 8, and 10

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were substituted with an alanine residue. The resulting peptide has the following structure:

GIAKFLHAAAKFGKA

The peptide was tested for % effective growth inhibition of E. coli. The % effective growth inhibition of E. coli for this peptide was found to be 100% at 25 µg/ml.

Example 18 - Magainin II Analogues with Alanine Substitutions (comparative)

Magainin II and analogues wherein an alanine residue was substituetd for various amino acid residues of Magainin II were prepared as hereinabove described in Example 1 and tested for % effective growth inhibition of E. coli, P. aeruginosa, and S. epidermidis as hereinabove described in Example 2. The % effective growth inhibition at a concentration in µg/ml for the alanine - substituted Magainin II analogues is listed below in Table X.

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Table X - Alanine - Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration µg/ml E. coli	P. aeruginosa	S. epidermidis
None (Magainin II)	100 at 10	100 at 50	100 at 25
23	100 at 10	100 at >50	100 at 25
22	100 at 25	100 at 25	100 at 25
21	100 at 25	100 at 25	100 at 25
20	100 at 50	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 10	100 at 5	100 at 25
16	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at 25	100 at >50
13	100 at 5	100 at 10	100 at 25
12	100 at 25	100 at >50	100 at >50
11	100 at 25	100 at >50	100 at >50
10	100 at 10	100 at 25	100 at 25
8	100 at 10	100 at 10	100 at 10
7	100 at 25	100 at 25	100 at 25
6	100 at 50	100 at 50	100 at >50
5	100 at 50	100 at 50	100 at >50

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Amino Acid Residue Substituted	E. coli	P. aeruginosa	S. epidermidis
4	100 at 25	100 at 50	100 at 50
3	100 at 25	100 at 25	100 at 25
2	100 at 25	100 at 50	100 at 50
1	100 at 25	100 at 25	100 at 50

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Example 19 - Magainin II Analogues with Lysine Substiutions

Magainin II analogues wherein a lysine residue was substituted for various amino acid residues of Magainin II where prepared and tested as hereinabove described for % effective growth inhibition of *E. coli*, *P. aeruginosa*, and *S. epidermidis* at concentrations given in µg/ml. The % effective growth inhibition for each of the Lysine-substituted analogue of Magainin II is listed below in Table XI.

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Table XI - Lysine-Substitued Margainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml		
	E. coli	P. aeruginosa	S. epidermidis
23	100 at 25	100 at 50	100 at 50
22	100 at 25	100 at 25	100 at 10
21	100 at 10	100 at 25	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 5	100 at 10	100 at 5
18	100 at 2.5	100 at 5	100 at 5
17	100 at 25	100 at 25	100 at 25
16	100 at 25	100 at 25	100 at 50
15	100 at 5	100 at 10	100 at 10
13	100 at 5	100 at 25	100 at 25
12	100 at 10	100 at 25	100 at 25
9 *	100 at 25	100 at 25	100 at 25
8	100 at 5	100 at 5	100 at 25
7	100 at 5	100 at 5	100 at 25

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Amino Acid Residue Substituted	E. coli	P. aeruginosa	S. epidermidis
6	100 at 10	100 at 25	100 at 50
5	100 at 25	100 at 50	100 at 50
3	100 at 5	100 at 25	100 at 10
2	100 at 10	100 at 10	100 at 25
1	100 at 5	100 at 10	100 at 25

*comparative

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Example 20 - Magainin II Peptides Containing D-Amino Acid Residues (comparative)

Magainin II peptides were synthesized wherein various amino acid residues were substituted with a D-amino acid residue, whose structure corresponded to to that of the residue originally present in Magainin II. Each of these Magainin II peptide analogues was then tested as hereinabove described for % effective growth inhibition of E. coli, P. aeruginosa, and S. epidermidis in µg/ml. The % effective growth inhibition for each of the D-Amino acid residue substituted analogues of Magainin II is listed below in Table XII.

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Table XII-D-Amino Acid Residue -
Substituted Magainin II Analogues

Amino Acid Residue Substituted	% Effective Growth Inhibition Concentration in µg/ml		
	E. coli	P. aeruginosa	S. epidermidis
23	100 at 5	100 at 10	100 at 25
22	100 at 10	100 at 10	100 at 25
20	100 at 25	100 at 25	100 at 50
19	100 at 25	100 at 25	100 at 25
17	100 at 25	100 at 25	100 at 50
16	100 at 25	100 at 25	100 at 25
15	100 at 25	100 at 25	100 at >50
14	100 at 25	100 at >25	100 at >50
12	-	100 at 25	100 at 50
11	100 at 25	100 at 25	100 at 25
10	100 at 25	100 at 25	100 at 25
9	100 at 25	100 at 25	100 at 25
8	100 at 25	100 at 25	100 at 25
7	100 at 10	100 at 25	100 at 25
6	100 at 25	100 at 25	100 at 50

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Amino Acid Residue Substituted	E. coli	P. aeruginosa	S. epidermidis
5	100 at 25	100 at 25	100 at 50
4	100 at 25	100 at 25	100 at 50
2	100 at 25	100 at 25	100 at 50

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Example 21 - Magainin II Analogues with Glutamic Acid Deletions

In this example, analogues of Magainin II were synthesized, said analogues having amino acid residue 19 (glutamic acid) deleted from the peptide structure, and wherein one or more of the other amino acid residues was substituted with an amino acid residue different from the normal amino acid residue. Analogues of the following structures were then synthesized according to the method described in Example 1.

Analogue	Stucture	
1	GIGKFLHSAKKFWKAFVGIMNS	(comparative)
2	GIGKFLHSAKKFLKAFVGILNS	(comparative)
3	GILKFLHSAKKFLKAFVGILNS	(comparative)
4	GILKFLHSAKKFFKAFVKILNS	
5	GIGKFLHSAKKFFKAFVFILNS	(comparative)
6	GIGKFLHSAKKFGKAFVGIMKS	
7	GIGKFLHSAKKFGKAFVAIMKS	
8	GIGKFLHSAKKFGKAFVFIMNS*	(comparative)
9	GIGKFLHSAKKFAKAFVFIMNS	(comparative)
10	GIGKFLHSAKKFFKAFVFIMNS	(comparative)
11	GIGKFLKSAKKFGKAFVFIMNS	
12	GIGKFLHKAKKFAKAFVFIMNS	
13	GIGKFLKSAKKFAKAFVFIMNS	
14	GIGKFLHKAKKFFKAFVFIMNS	
15	GIGKFLKSAKKFFKAFVFIMNS	
16	GIGKFLHKAKKFAKAFVFIMNK	
17	GIGKFLKSAKKFAKFFVFIMNK	
18	GIGKFLKKAKKFGKAFVFIMKK	
19	GIGKFLHSAKKFGKAFVK**IMNS	
20	GIGKFLHSAKKFGKAFVKIMNS	
21	GIGKFLHKAKKFGKAFVKIMNS	

*D-Serine

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**-ε-F moc-lysine

Each of the peptides was then tested as hereinabove described for % effective growth inhibition of E. coli, P. aeruginosa, and S. epidermidis in μg/ml. The % effective growth inhibition of each of these analogues is given in Table XIII below.

TABLE XIII

Analogue	% Effective Growth Inhibition, Concentration in μg/ml		
	E. coli	P. aeruginosa	S. epidermidis
1	100 at 5	100 at 5	100 at 5
2	100 at 2.5	100 at 2.5	100 at 5
3	100 at 2.5	100 at 2.5	100 at 5
4	100 at 2.5	100 at 2.5	100 at 5
5	100 at 10	100 at 5	100 at 5
6	100 at 5	100 at 10	100 at 25
7	100 at 2.5	100 at 5	100 at 5
8	100 at 5	100 at 5	100 at 5
9	100 at 5	100 at 2.5	100 at 5
10	100 at 5	100 at 10	100 at 5
11	100 at 5	100 at 5	100 at 5
12	100 at 1.25	100 at 2.5	100 at 1.25
13	100 at 2.5	100 at 1.25	100 at 2.5
14	100 at 10	100 at 2.5	100 at 2.5
15	100 at 5	100 at 5	100 at 1.25
16	100 at 1.25	100 at 1.25	100 at 1.25
17	100 at 1.25	100 at 5	100 at 2.5
18	100 at 2.5	100 at 2.5	100 at 2.5
19	100 at 10	100 at 10	100 at 5
20	100 at 1.25	100 at 2.5	100 at 1.25
21	100 at 1.25	100 at 5	100 at 2.5

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Example 22

Amide (NH_2) - terminated Magainin II analogues wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substitued. The analogues are as follows:
Analogue 1 GIGKFLKKAKKFAKAFVKIINN-NH_2
Analogue 2 GIGKFLKKAAKFAKAFVKIINN-NH_2

The analogues were then tested as hereinabove described for % effective growth inhibition of E. coli, P. aeruginosa, and S. epidermidis. Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. coli, 100% at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S. epidermidis. Analogue 2 had % effective growth inhibitions of 100% at 1.25 µg/ml for P. aeruginosa and 100% at 1.25 µg/ml for S. epidermidis.

Example 23

Amide (NH_2) -terminated analogues, which by virtue of their structures, may be analogues of Magainin I or Magainin II, were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and other amino acid residues were substituted. The analogues are as follows:
Analogue 1 GIGKFLKKAKKFGKAFVKIMKK-NH_2
Analogue 2 GIGKFLKKAKKFAKAFVKIMKK-NH_2
Analogue 3 GIGKFLKKAKKFAKAFVKIIKK-NH_2

The analogues were then tested for % effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. coli, 100% at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S. epidermidis. Analogue 2 had % effective growth inhibitions of 100% at 2.5 µg/ml for E. coli, 100 at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S. epidermidis. Analogue 3 had % effective growth inhibitions of 100% at 1.25 µg/ml for E. coli,

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100% at 2.5 µg/ml for P. aeruginosa, and 100% at 1.25 µg/ml for S. epidermidis.

Example 24

Amide (NH_2) terminated analogues of Magainin I were synthesized wherein at least amino acid residues 17-23 were deleted and amino acid residues 3, 7, and 8 were substituted with lysine residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAGKFGK-NH_2

Analogue 2 - GIKKFLKKAGKFGKAF-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for E. coli, 100% at 10 µg/ml for P. aeruginosa, and 100% at 10 µg/ml for S. epidermidis. Analogue 2 had % effective growth inhibitions of 100% of 2.5 µg/ml for E. coli, 100% at 5 µg/ml for P. aeruginosa, and 100% at 5 µg/ml for S. epidermidis.

Example 25

Amide (NH_2)-terminated analogues of Magainin II were synthesized wherein at least amino acid residues 16-23 were deleted and substitutions were made for other residues. The analogues had the following structures.

Analogue 1 - GIKKFLKKAKKFGKA-NH_2

Analogue 2 - GIKKFLKKAKKFAKA-NH_2

The analogues were then tested for effective growth inhibition. Analogue 1 had % effective growth inhibitions of 100% at 10 µg/ml for P. aeruginosa, and 100 at 5.0 µg/ml for S. epidermidis. Analogue 2 had % effective grwoth inhibitions of 100% of 5 µg/ml, for E. coli, 100% at 5 µg/ml for P. aeruginosa, and 100% at 5 µg/ml for S. epidermidis.

Example 26

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An amide (NH_2)-terminated analogue, which by virtue of its structure may be an analogue of Magainin I or Magainin II, was synthesized wherein amino acids 16-23 were deleted, amino acid residues 3,7, and 8 were substituted with lysine residues, and amino acid residue 10 and 13 were substituted with alanine residues. The analogue was of the following structure.

GIKKFLKKAAKFAKA-NH_2

The analogue was then tested for % effective growth inhibition. The analogue had % effective growth inhibitions of 100% at 5 µg/ml for E. Coli, 100% at 5 µg/ml for P.aeruginosa, and 100 at 5 µg/ml for S.epidermidis.

Example 27

Analogues of Magainin II were synthesized wherein amino acid residue 19 (glutamic acid) was deleted, and amino acids 1-4, or 3,5, and 6 were deleted and at least one of the remaining amino acid residues was substituted. The analogues were of the following structures:

Analogue 1: FLKSAKKFGKAFVGIMNS
Analogue 2: FLKSAKKFAKAFVGIMNS
Analogue 3: FLHSAKKFGKAFVFIMNS
Analogue 4: GIKHSAKKFAKAFKAIMNS

The analogues were then tested for % effective growth inhibition of E.coli, P.aeruginosa, and S.epidermidis. The % effective growth inhibition of each of these analogues is given in Table XIV below.

TABLE XIV

Analogue	% Effective Growth Inhibition, Concentration in ug/ml		
	E.Coli	P.aeruginosa	S.epidermidis
1	100 at 25	100 at 25	100 at 50
2	100 at 10	100 at 25	100 at 50

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3	100 at 25	100 at 25	100 at 10
4	100 at 10	100 at 25	100 at 5

Numerous modifications and variations of the present invention are possible in light of the above teachings, and, therefore, within the scope of the accompanying claims, the invention may be practiced other than as particularly described.

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WHAT IS CLAIMED IS:

1. A compound having antimicrobial, antiviral or antitumor activity, comprising an analogue of Magainin I peptide or Magainin II peptide in an amide or carboxy terminated form, wherein Magainin I is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A G K F G K A F V G E I M K S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

and Magainin II is represented by the following structural formula using the single letter amino acid code and the numbers below each amino acid residue refer to the position of the residue in the peptide:

G I G K F L H S A K K F G K A F V G E I M N S
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

said analogue being characterized in that any of amino acid residues 15-23 of Magainin I peptide or Magainin II peptide is optionally omitted, and one to seven of the remaining amino acid residues of said Magainin peptide is substituted by another amino acid residue, at least one of amino acid residues 3, 7, 8, 10, 18-21 and 23 (in the case of Magainin I) or at least one of amino acid residues 1-3, 5-8, 12, 13, and 15-23 (in the case of Magainin II) being substituted by Lys and any further substitutions being as shown in the following table, provided that residue 18 may be substituted by Phe only if one of residues 15 to 17 or 19 to 23 is omitted:

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Residue No.	Substituent
1	Lys, Ala
2	Lys, Ala, D-Ile, Arg, Leu, Val, His, Met
3	Lys, Ala, Trp, Arg, His
4	D-Lys, Ala, Arg, His
5	D-Phe, Ala, Lys, Trp, Leu, Ile, Val, Met
6	D-Leu, Lys, Ala, Ile, Val, Met
7	Lys, D-His, Ala, Arg, Ile, Val, Met
8	Ala, Lys, D-Ser, Trp, Met, Ile, Arg, His, Thr, Leu, Val
9	Lys, D-Ala, Trp, Arg, His, Leu, Ile, Val
10	D-Lys, Lys Ala, Trp, Arg, His, Leu, Ile, Val
11	D-Lys, Arg, His
12	D-Phe, Lys, Trp, Arg, His
13	Ala, Lys, Trp, Met, Arg, His, Phe, Leu, Ile, Val
14	Ala, D-Lys, Arg, His
15	Lys, Trp, D-Ala, Arg, His, Phe
16	Ala, Lys, D-Phe, Ile, Val, Met, Leu
17	Ala, Lys, D-Val, Trp, Arg, His, Met, Leu
18	Ala, Lys, Trp, Arg, His, Leu, Met, Phe
19	Ala, Lys, D-Glu, Gly, Arg, His, Leu, Ile, Phe, Asn
20	D-Ile, Ala, Lys
21	Lys, Pro, Ala, His, Leu, Arg, Ile, Phe
22	Lys, Ala, D-Asn, Gln, Arg, His
23	D-Ser, Lys, Ala, Thr, Gly, Leu, Ile, Gln, Asn

* C L M S *

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2. A compound according to claim 1 wherein amino acid residue 19 is omitted, provided that at least one of amino acid residues 3, 7, 8, 10, 13, 15, 16, 18, 21, 22 or 23 is substituted as shown in the following table:

Residue number	Substituent
3	Lys
7	Lys
8	Lys, Ala
10	Lys, Ala
13	Trp, Leu, Phe, Ala
15	Phe
16	Ala
18	Lys, Ala, Phe
21	Lys, Ile
22	Lys
23	Lys, D-Ser

3. A compound according to claim 1, wherein at least one of amino acid residues 15-23 is omitted.

4. A compound according to any of claims 1 to 3, which is an analogue of Magainin II peptide.

5. The compound of claim 1 wherein said analogue of Magainin I peptide or Magainin II peptide is selected from:

GIGKKLHKKGKFGKFKGAILKA;
GIKKFLKKAGKFGKA;
GIGKFLKKAKKFAKAFVKIINN-NH_2;
GIGKFLKKAAKFAKAFVKIINN-NH_2;
GIGKFLKKAKKFGKAFVKIMKK-NH_2;
GIGKFLKKAKKFAKAFVKIMKK-NH_2;
GIGKFLKKAKKFAKAFVKIIKK-NH_2;
GIKKFLKKAGKFGK-NH_2;
GIKKFLKKAGKFGKAF-NH_2;
GIKKFLKKAKKFGKA-NH_2;

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* C L M S *

GIKKFLKKAKKFAKA-NH_2; and
GIKKFLKKAAKFAKA-NH_2.

6. A process comprising administering to a host an effective spermicidal amount of the compound of any of claims 1 to 5.

7. The use of a compound according to any of claims 1 to 5 in the manufacture of a medicament for treating microbial infections.

8. The use of a compound according to any of claims 1 to 5 in the manufacture of a medicament for treating viral infections.

9. The use of a compound according to any of claims 1 to 5 in the manufacture of a medicament for treating tumors.

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