Claims

1. A modified norovirus VP1 protein comprising an amino acid sequence derived from an amino acid sequence of a wild type norovirus VP1 protein, the modified norovirus VP1 protein comprising,

one or more than one amino acid substitution in the amino acid sequence of the wild type norovirus VP1 at a position selected from amino acids in sequence alignment with amino acids 43, 57, 84 and 94 of norovirus VP1 genotype GI.1 (SEQ ID NO:1), and

wherein the wild type norovirus VP1 protein is not a GI.1 genotype.

2. The modified norovirus VP1 protein of claim 1, wherein the wild type norovirus VP1 is selected from a group consisting of genotypes GI.3. GI.5, GI.7, GII.2, GII.3, GII.4, GII.6, GII.12 and GII.17.

3. The modified norovirus VP1 protein of claim 1 or claim 2, wherein:

the one or more than one substitution at the position in sequence alignment with amino acid 43 is to valine, isoleucine, leucine, methionine, threonine, aspartic acid, glutamic acid, asparagine, glutamine, lysine, or histidine;

the one or more than one substitution at the position in sequence alignment with amino acid 57 is to isoleucine, leucine, valine, alanine, glycine, serine, threonine, asparagine, glutamine, lysine, or histidine;

the one or more than one substitution at the position in sequence alignment with amino acid 84 is to serine, asparagine, cysteine, threonine, alanine, lysine or histidine; and/or

the one or more than one substitution at the position in sequence alignment with amino acid 94 is to leucine, isoleucine, methionine, valine, threonine, aspartic acid, glutamic acid, asparagine, glutamine, lysine, or histidine.

4. A recombinant polynucleotide encoding the modified norovirus VP1 protein of any one of claims 1 to 3.

5. The recombinant polynucleotide of claim 4, wherein the codon usage of the nucleotide sequence is optimized to human codon usage, increased GC content, or a combination thereof, and/or wherein the polynucleotide comprises a vector.

6. A virus-like particle (VLP) comprising the norovirus VP1 of any one of claims 1 to 3.

7. The VLP of claim 6, further comprising a norovirus VP2 protein.

8. A method of producing a norovirus VP1 protein, or a VLP comprising the norovirus VP1 protein, in a plant, portion of a plant or a plant cell, the method comprising:

introducing the recombinant polynucleotide of claim 4 or claim 5 into the plant, portion of the plant or plant cell; and

incubating the plant, portion of the plant or the plant cell under conditions that permit expression of the norovirus VP1 protein.

9. The method of claim 8, wherein in the step of introducing, a second polynucleotide encoding a norovirus VP2 protein is introduced into the plant, the portion of the plant or the plant cell, and in the step of incubating, the conditions permit co-expression and co-production of both the norovirus VP1 protein and the norovirus VP2 protein in the plant, portion of the plant, or the plant cell.

10. The method of claim 8 or 9, wherein the method further comprises a step of harvesting the plant, the portion of the plant or the plant cell.

11. The method of claim 10, wherein the method further comprises a step of:

extracting, purifying, or both extracting and purifying the norovirus VP1 protein, or both the norovirus VP1 protein and the norovirus VP2 protein, from the plant, the portion of the plant or the plant cell, or

extracting, purifying or both extracting and purifying the virus-like particle (VLP) from the plant, the portion of the plant or the plant cell, wherein the VLP comprises the norovirus VP1 protein or both the norovirus VP1 protein and the norovirus VP2 protein.

12. A plant, portion of the plant, plant cell comprising the norovirus VP1 protein of any one of claims 1 to 3, the recombinant polynucleotide of claim 4 or claim 5, or the VLP of claim 6 or 7.

13. A composition for inducing an immune response comprising, an effective dose of the norovirus VP1 protein of any one of claims 1 to 3 or the VLP of claim 6 or 7, and a pharmaceutically acceptable carrier, adjuvant, vehicle or excipient.

14. A vaccine comprising an effective dose of the norovirus VP1 protein of any one of claims 1 to 3 or the VLP of claim 6 or 7, for inducing an immune response.

15. An antibody or antibody fragment that binds to the norovirus VP1 protein of any one of claims 1 to 3 or binds to the VLP according to claim 6 or 7.

16. The norovirus VP1 protein of any one of claims 1 to 3 or the VLP of claim 6 or 7, for use in inducing immunity to a norovirus infection in a subject.

17. The norovirus VP1 protein or VLP for use according to claim 16, wherein the norovirus VP1 protein or VLP is administered to the subject orally intranasally, intramuscularly, intraperitoneally, intravenously, subcutaneously, rectally, or intravaginally.

18. Use of the norovirus VP1 protein of any one of claims 1 to 3 or the VLP of claim 6 or 7, in the manufacture of a medicament for inducing immunity to a norovirus infection in a subject.

19. The use according to claim 18, wherein the norovirus VP1 protein or VLP is for administration to the subject orally intranasally, intramuscularly, intraperitoneally, intravenously, subcutaneously, rectally, or intravaginally.