CLAIMS

What is claimed is:

1 A method of provenance and/or lot-level identification of an item or product by means of a food compatible microbial tag comprising:

A identifying a food compatible microorganism having a cell wall and containing genomic DNA or plasmid DNA, wherein said genomic or plasmid DNA comprises one or more target nucleotide sequence of at least 10 base pairs in length, said food compatible microorganism and said target nucleotide sequence not being present in the item or product to be tagged;

B selecting at least one of said one or more target nucleotide sequence to serve as a tag, and saving the target nucleotide sequence or sequences selected to serve as a tag and associating it with the provenance and/or lot-level identity of the item or product to be tagged in a database;

C killing said food compatible microorganism to create at least one tag comprising the target nucleotide sequence or sequences selected to serve as a tag, wherein the cell wall of said food compatible microorganism is substantially intact after the step of killing;

D adding one or more of said at least one tag to an item in a predetermined amount;

E later confirming the provenance or lot-level identity of the tagged item by:

E1) extracting the nucleotide sequence or sequences from said item and adding primers for each target nucleotide sequence or sequences as recorded in the database;

E2) amplifying each of said target nucleotide sequence or sequences using polymerase chain reaction (PCR) techniques;

E3) sequencing each amplified target nucleotide sequence; and

E4) comparing each amplified target nucleotide sequence generated in step E3 to the nucleotide sequence saved for the target nucleotide sequence in step B and confirming that they match, thereby confirming a match to the recorded association, and returning the associated provenance or lot-level identity of the product.

2 The method of claim 1, wherein the food compatible microorganism is a probiotic bacterium.

3 The method of claim 1, wherein the food compatible microorganism is a bacterium selected from the group consisting of Firmicutes (lactobacillus), actinobacteria (bifidobacterial), and combinations thereof.

4 The method of claim 1, wherein the food compatible microorganism is a bacterium selected from the group consisting of *Bifidobacterium animalis* subsp. *Lactis* (BB12), *Bifidobacterium bifidum* (LMG 11041), *Bifidobacterium longum* (ATCC 15708), *Bifidobacterium longum subsp. Infantis* (LMG 8811), *Enterococcus faecium* (ATCC 6057), *Lactobacillus acidophilus* ATCC 4356), *Lactocaseibacillus casei* (ATCC 393), *Lb. delbrueckii subsp. Bulgaricus* (ATCC 11842), *Lactocaseibacillus paracasei* DSM 5622), *Lactiplantibacillus plantarum* (ATCC 8014), *Lactocaseibacillus rhamnosus* (ATCC 53103), *Ligilactobacillus salivarius* (ATCC 11741), *Lactococcus lactis* (ATCC 19435), *Lactobacillus reuteri* (LMG 9213), *Lactobacillus helveticus* (ATCC 15807), and combinations thereof.

5 The method of claim 1, wherein said one or more target nucleotide sequence is a nucleotide sequence of from 20 to 5000 base pairs in length.

6 The method of claim 1, wherein said one or more target nucleotide sequence comprises substantially all of said genomic DNA and/or plasmid DNA in said food compatible microorganism.

7 The method of claim 1, wherein the step of saving (step B) comprises saving the target nucleotide sequence or sequences selected to serve as a tag and the identity of the item to be tagged in a local or cloud-based database saved in non-transitory computer memory and the step of comparing (step E4) is performed using a basic local alignment search tools (BLAST) algorithm running on a computer or other microprocessor.

8 The method of claim 7, wherein said database is stored on a blockchain.

9 The method of claim 1, wherein the step of killing (step C) comprises incubation of said food compatible microorganism at a temperature of from 60°C to 138 °C for from 0.01 minutes to 30 minutes.

10 The method of claim 1, wherein the step of killing (step C) comprises irradiation of said food compatible microorganism with gamma radiation.

11 The method of claim 10, wherein the step of killing (step C) comprises irradiation of said food compatible microorganism with gamma radiation at from 5 kiloGray (kGy) to 50 kGy for from 15 seconds to 48 hours.

12 The method of claim 1, wherein the step of killing (step C) comprises irradiation of said food compatible microorganism with x-rays.

13 The method of claim 12, wherein the step of killing (step C) comprises irradiation of said food compatible microorganism with from 20 kiloGrays to 40 kiloGrays of x-rays.

14 The method of claim 1, wherein the step of adding (step D) comprises adding two or more different tags to the item.

15 The method of claim 1, wherein the step of extracting (step E1) is performed by ethanol precipitation and dissolution in Tris-EDTA (TE) buffer.

16 The method of claim 1, wherein the step of extracting (step E1) is performed using a spin column and eluting the DNA in elution buffer.

17 The method of claim 1, wherein the primers in said step of adding primers (step E2) are formed by solid phase oligonucleotide synthesis.

18 The method of claim 1, wherein the step of sequencing the amplified target nucleotide sequence (step E3) is performed using Sanger sequencing or targeted next generation sequencing (tNGS) techniques.

19 The method of claim 1, wherein the step of comparing (step E4) is performed using BLAST or a similar algorithm.

20 The method of claim 1, wherein said product is a food product, agricultural product, personal care, cosmetics, or pharmaceutical product.

21 The method of claim 1, further comprising irradiating said food compatible microorganism to induce mutations in said genomic DNA.

22 The method of claim 21, wherein food compatible microorganism is irradiated with sunlight or ultraviolet light having a wavelength of about 254 nm.

23 The method of claim 1, wherein the step of sequencing (step E3) or the step of comparing each amplified target nucleotide sequence generated in step E3 to the nucleotide sequence

saved for the target nucleotide sequence in step B and confirming that they match (step E4) is performed using a microarray.

24 A method of provenance and/or lot-level identification of an item or product by means of a bacterial tag comprising:

A adding one or more tags to a product in a predetermined amount, each of said one or more tags comprising dead bacteria cells having at least one nucleotide sequence comprising a target sequence not otherwise present in said product;

B recording the identity of the product and the target sequence for later reference; and

C confirming the provenance or lot-level identity of the tagged product by:

C1) extracting the nucleotide sequence from said product; and adding primers for said target sequence;

C2) amplifying said target sequence using polymerase chain reaction (PCR) techniques;

C3) sequencing the amplified target sequence; and

C4) comparing that sequence to the target nucleotide sequence recorded for the product in step B to confirm a match to the recorded association, and return the associated provenance or lot-level identity of the product,

wherein the step of adding (step A) comprises:

A1) obtaining a plurality of food-compatible bacteria cells for use as a tag, said food-compatible bacteria cells comprising a target nucleotide sequence not otherwise present in the product;

A2) killing said bacteria cells while leaving the food-compatible bacteria cell walls and DNA substantially intact; and

A3) placing the dead food-compatible bacteria cells on or in said product, thereby producing a tagged product.

25 The method of claim 24, wherein the step of recording (step B) comprises saving the identity of the product and the target nucleotide sequence in non-transitory computer memory and the step of comparing (step C4) is performed using a computer or microprocessor running a sequence analysis algorithm.

26 The method of claim 24, wherein the step of recording (step B) comprises saving the identity of the product and the target nucleotide sequence to a database stored on a blockchain.

27 The method of claim 24, wherein the plurality of bacteria cells comprise bacteria selected from the group consisting of Firmicutes (lactobacillus), actinobacteria (bifidobacteria), and combinations thereof.

28 The method of claim 24, wherein the plurality of bacteria cells comprise bacteria selected from the group consisting of *Bifidobacterium animalis* subsp. *Lactis* (BB12), *Bifidobacterium bifidum* (LMG 11041), *Bifidobacterium longum* (ATCC 15708), *Bifidobacterium longum subsp. Infantis* (LMG 8811), *Enterococcus faecium* (ATCC 6057), *Lactobacillus acidophilus* ATCC 4356), *Lactocaseibacillus casei* (ATCC 393), *Lb. delbrueckii subsp. Bulgaricus* (ATCC 11842), *Lactocaseibacillus paracasei* DSM 5622), *Lactiplantibacillus plantarum* (ATCC 8014), *Lactocaseibacillus rhamnosus* (ATCC 53103), *Ligilactobacillus salivarius* (ATCC 11741), *Lactococcus lactis* (ATCC 19435), *Lactobacillus reuteri* (LMG 9213), Lactobacillus helveticus (ATCC 15807), and combinations thereof.

29 The method of claim 24, wherein the step of killing (step A2) is performed by at least one of heat treatment, x-ray treatment, and sonication.

30 The method of claim 24, wherein said target sequence is from 10 to 5000 base pairs in length.

31 The method of claim 24, wherein the step of sequencing the amplified target sequence (step C3) is performed using Sanger sequencing or targeted next generation sequencing (tNGS) techniques.

32 The method of claim 24, wherein said product is a food product, agricultural product, personal care, cosmetics, or pharmaceutical product.

33 The method of claim 24, wherein two or more different tags are added to a product.

34 The method of claim 24, wherein said step of recording further comprises tracking the origins of different components of a mixture, with each component individually tagged and distinguishable.

35 A method of provenance and/or lot-level identification of an item or product by means of a bacterial tag comprising:

A adding one or more tags to a product in a predetermined amount, each of said one or more tags comprising dead bacteria cells having at least one nucleotide sequence comprising a target sequence not otherwise present in said product;

B recording the identity of the product and the target sequence in a database for later reference; and

C confirming the provenance or lot-level identity of the tagged product by:

C1) extracting and then sequencing the DNA found in the tagged product using NGS techniques; and

C2) comparing the DNA sequences generated in step C1 to the target nucleotide sequence recorded in step B for the product to confirm a match to the recorded association, and return the associated provenance or lot-level identity of the product,

wherein the step of adding (step A) comprises:

A1) obtaining a plurality of food-compatible bacteria cells for use as a tag, said food-compatible bacteria cells comprising a target nucleotide sequence not otherwise present in the product;

A2) killing said bacteria cells while leaving the food-compatible bacteria cell walls and DNA substantially intact; and

A3) placing the dead food-compatible bacteria cells on or in said product, thereby producing a tagged product.