CLAIMS

We Claim:

1. An apparatus for preparing a meat product A method of growing a cell mass, comprising:

an enclosure comprising a cavity; and

a substrate arranged within) grown the cavity and comprising one or more nested surfaces curved around a longitudinal axis and a surface configured to support growth of the meat product, the substrate configured to receive a fluid substantially parallel to the longitudinal axis.

2. The apparatus of claim 1cell mass on a substrate of an apparatus, wherein the enclosuresubstrate: is configuredspiral in shape or perpendicular to be placed on a ground surface, wherein the longitudinal axis is at an acute angle relative or planar and oriented to the ground surface.

3. The apparatus at an angle of claim 2, wherein the acute angle is at least about 85 degrees.°-90°; and

4. The apparatus of claim 1, further comprising a separator configured to separate the meat productb) separating the cell mass from the substrate in a continuous sheet of cells held together by one or more of cell-to-cell interactions and extracellular matrix generated by the cells.

5.

2. The apparatusmethod of claim 41, wherein the separator comprises one or more fluid nozzles configured to direct the fluid towards the substrate at a predetermined angle.

6. The apparatus of claim 5, wherein the separator is configured to rotate about a predetermined axis when the fluid is directed at the meat product.

7. The apparatus of claim 5, wherein the fluid comprises a linear velocity between about 0.003 m/sec and about 3.0 m/sec.

8. An apparatus for preparing a meat product, comprising:

an enclosure defining a cavity;

a substrate arranged within the cavity and configured to support growth of the meat product; and

a fluid diffuser coupled to the enclosure and configured to distribute fluid to the substrate in a predetermined flow pattern wherein a ratio of a diameter of the fluid diffuser to a diameter of the substrate is between about 3:4 and about 1:1.

9. The apparatus of claim 8, wherein the fluid diffuser is configured to enable a substantially uniform or laminar flow across a surface of the substrate.

10. The apparatus of claim 8, wherein the fluid diffuser comprises one or more openings.

11. The apparatus of claim 8, wherein the cavity comprises a headspace, and the fluid diffuser is disposed within the headspace of the enclosure.

12. The apparatus of claim 8, wherein the fluid diffuser comprises a tapered surface configured to distribute fluid to the substrate in a predetermined flow pattern.

13. The apparatus of claim 12, wherein the tapered surface comprises one or more of a concave shape, conical shape, frustum shape, stepped shape, and flared shape.

14. The apparatus of claim 12, wherein the tapered surface is angled up to about 80 degrees at 85° relative to the substrate. ground surface.

15. The apparatus of claim 12, wherein the fluid diffuser comprises a bicone comprising a first surface and a second surface opposing the first surface, wherein the first surface is configured to receive the fluid and the second surface is configured to receive the fluid from the first surface and distribute the fluid to the substrate.

3. The method of claim 1, wherein the substrate is curved around a longitudinal axis.

16. A method of preparing a comestible meat product, comprising:

growing the comestible meat product on a substrate of an apparatus; and

separating the comestible meat product from the substrate in a continuous sheet of cells held together by one or more of cell-to-cell interactions and extracellular matrix generated by the cells.

~~17. The method of claim 16, wherein separating the comestible meat product comprises directing a fluid at a predetermined angle relative to the substrate.~~

~~18.~~ 4. The method of claim ~~16~~3, wherein the ~~comestible meat product comprises a cell based meat product.~~ substrate is angled relative to the longitudinal axis by 5 or more degrees.

~~19.~~

5. The method of claim ~~17~~3, wherein growing the cell mass includes delivering fluid substantially parallel to the longitudinal axis.

6. The method of claim 1, further comprising delivering fluid between adjacent substrates.

7. The method of claim 1, wherein separating the cell mass comprises directing fluid at an angle relative to the substrate.

8. The method of claim 7, further comprising removing the fluid from the apparatus prior to separating the ~~comestible meat product~~cell mass from the substrate.

~~20. The method of claim 16, wherein the substrate comprises a spiral shape.~~

~~21. An apparatus for preparing a meat product, comprising:~~

~~an enclosure defining a cavity;~~

~~a fluid diffuser coupled to the enclosure, the fluid diffuser comprising a plurality of openings comprising a total area of at least about 700 μm^2; and~~

~~a plurality of substrates configured to grow the meat product, the substrates disposed within the cavity and coupled to the fluid diffuser.~~

~~22. The apparatus of claim 21, wherein the fluid diffuser comprises at least a first portion and a second portion, the first portion angled relative to the second portion between about 90 degrees and about 170 degrees.~~

~~23. The apparatus of claim 22, wherein each of the first portion and the second portion are angled relative to the plurality of substrates up to about 80 degrees.~~

24. The apparatus of claim 21, wherein the plurality of openings of the fluid diffuser are substantially equally spaced apart.

25. The apparatus of claim 21, wherein each of the plurality of openings comprises a diameter of at least about 30 μm.

26. The apparatus of claim 22, wherein the fluid diffuser comprises an interface between the first portion and the second portion, wherein the interface comprises one or more of the plurality of openings.

27. The apparatus of claim 21, wherein the fluid diffuser is coupled to a proximal end of the plurality of substrates.

28. The apparatus of claim 21, wherein the fluid diffuser comprises one or more of stainless steel, a ceramic, and a polymer.

29. The apparatus of claim 22, wherein the first portion and the second portion are substantially flat.

30. The apparatus of claim 21, wherein the enclosure and the fluid diffuser are substantially circular and each comprise an inner diameter and an outer diameter, and the outer diameter of the fluid diffuser is substantially equal to the inner diameter of the enclosure.

31. The apparatus of claim 21, wherein the fluid diffuser is configured to output a substantially uniform and laminar flow to the plurality of substrates.

32. The apparatus of claim 21, wherein the fluid diffuser is configured to releasably engage to the enclosure.

33. The apparatus of claim 21, wherein the fluid diffuser is at least partially disposed in the cavity.

34. The apparatus of claim 21, comprising a plurality of fluid channels.

35. The apparatus of claim 34, wherein at least one of the fluid channels is associated with at least one of the plurality of substrates.

36. The apparatus of claim 34, wherein one or more of the fluid channels is planar.

37. The apparatus of claim 34, wherein each of the fluid channels is between adjacent substrates.

38. The apparatus of claim 34, wherein fluid is configured to flow in one direction through the plurality of fluid channels.

39. The apparatus of claim 34, wherein the plurality of fluid channels are substantially parallel to each other.

40. The apparatus of claim 21, wherein the fluid channel comprises a space between adjacent substrates between about 0.3 mm and about 5.0 cm.

41. The apparatus of claim 21, wherein the plurality of substrates are parallel to each other.

42. The apparatus of claim 21, wherein one or more of the substrates are planar.

43. The apparatus of claim 21, wherein one or more of the substrates are non-planar.

44. The apparatus of claim 21, wherein the plurality of substrates comprise one or more of stainless steel, a ceramic, and a polymer.

45. The apparatus of claim 21, wherein the apparatus comprises up to about 1000 substrates.

46. The apparatus of claim 21, wherein the plurality of substrates comprises one or more of a plate, rectangle, rod, bead, and disk shape.

47. The apparatus of claim 21, wherein each substrate comprises a width between about 10 cm and about 40 cm.

48. The apparatus of claim 21, wherein each substrate comprises an area between about 430 cm^2 and about 8000 cm^2.

49. The apparatus of claim 21, wherein the plurality of substrates are configured to releasably engage to the enclosure.

50. The apparatus of claim 21, wherein one or more of the substrates are configured to grow the meat product on opposite sides of the substrate.

51. The apparatus of claim 21, further comprising at least one collector coupled to the enclosure.

52. The apparatus of claim 31, wherein the collector comprises a plurality of openings comprising a total area of at least about 25 μm^2.

53. The apparatus of claim 31, wherein the collector is coupled to a distal end of the plurality of substrates.

54. The apparatus of claim 31, wherein the collector comprises one or more of stainless steel, a ceramic, and a polymer.

55. The apparatus of claim 31, wherein the collector is configured to receive the meat product separated from the plurality of substrates.

56. The apparatus of claim 21, wherein the collector is configured to releasably engage to the enclosure.

57. The apparatus of claim 21, wherein the enclosure comprises one or more inlets configured to receive fluid.

58. The apparatus of claim 57, wherein the enclosure comprises one or more outlets configured to output the fluid.

59. The apparatus of claim 58, wherein the one or more inlets are disposed on a first side of the enclosure, and the one or more outlets are disposed on a second side of the enclosure, opposite the first side of the enclosure.

60. The apparatus of claim 21, wherein the enclosure comprises a volume between about 25 L and about 4000 L.

61. The apparatus of claim 57, wherein the one or more outlets comprise a diameter configured to output a meat product separated from the plurality of substrates.

62. The apparatus of claim 21, wherein the enclosure comprises a substantially cylindrical shape.

63. The apparatus of claim 21, further comprising a rotator coupled to the enclosure and configured to rotate the enclosure about a lateral axis of the enclosure.

64. A system for preparing a meat product, comprising:

an apparatus comprising a plurality of substrates;

a fluid pump coupled to the apparatus;

a fluid source coupled to the fluid pump; and

a controller coupled to the fluid pump, the controller configured to:

generate a first fluid pump signal to grow the meat product on the substrates; and

generate a second fluid pump signal to separate the meat product from the substrates.

65. The system of claim 64, wherein the first fluid pump signal is configured to provide a substantially uniform and laminar flow of the fluid to the plurality of substrates using the fluid pump.

~~66. The system of claim 64, wherein the first fluid pump signal comprises a first flow rate and the second fluid pump signal comprises a second flow rate higher than the first flow rate.~~

~~67. The system of claim 64, further comprising one or more sensors configured to measure one or more parameters of the fluid.~~

~~68. The system of claim 64, wherein the first fluid pump signal comprises a flow rate of up to about 0.3 meters per second.~~

~~69. The system of claim 64, wherein the second fluid pump signal corresponds to a linear velocity within the apparatus of up to about 10 meters per second.~~

~~70. The system of claim 64, wherein the fluid source comprises growth media.~~

~~71. The system of claim 64, wherein the growth media comprises cells.~~

~~72. The system of claim 64, wherein the system is configured to grow the meat on the substrate for at least about 1 day.~~

~~73. A method of preparing a meat product, comprising:~~

~~applying a plurality of non-human cells to at least one substrate of an apparatus;~~

~~culturing the cells on the substrate using a first fluid comprising growth media thereby generating the meat product; and~~

~~separating the meat product from the substrate using the first fluid or a second fluid flowing through the apparatus.~~

~~74. The method of claim 73, wherein culturing the cells comprises providing a substantially uniform and laminar first fluid to the substrate.~~

~~75.~~

9. The method of claim ~~73, wherein about 5,000 cells/cm^2 and about 100,000 cells/cm^2 are applied to the cells~~1, further comprising delivering fluid through a fluid diffuser.

76.10. The method of claim 739, wherein the cells comprise myoblasts. fluid diffuser is configured to deliver a substantially uniform or laminar flow across a surface of the substrate.

77.

11. The method of claim 739, wherein the cells comprise fibroblasts. fluid diffuser comprises one or more openings.

12.78. The method of claim 73, further comprising recirculating9, wherein delivering the first fluid in includes distributing the apparatus at fluid to the substrate in a rate between about 0.0001 meters per second and about 0.3 meters per second.

79. The methodpredetermined flow pattern using a tapered surface of claim 73, wherein the first fluid flows through the apparatus from a first elevation to a second elevation lower than the first elevationfluid diffuser.

13.80. The method of claim 73, further comprising culturing the cells on the substrate for at least 1 day12, wherein the tapered surface comprises a conical shape.

14.81. The method of claim 1, wherein the substrate includes one or more channels, one or more grooves, one or more recessions, or a combination thereof.

15. The method of claim 1, wherein the substrate includes a coating to improve cell behavior including adhesion, proliferation, differentiation, and maturation.

16.73 The method of claim 1, wherein the first fluid comprises a planar flow over the substratesubstrate is textured, coated, porous, circular, nested, comprised of a plurality of turns, or some combination thereof.

17.82. The method of claim 731, wherein the meat product is held together by an extracellular matrix secreted by the cellssubstrate comprises a three-dimensional lattice.

83. The method of claim 73, wherein the cells comprise one or more of myoblasts, mesangioblasts, myofibroblasts, mesenchymal stem cells, hepatocytes, fibroblasts,

pericytes, adipocytes, epithelial, chondrocytes, osteoblasts, osteoclasts, pluripotent cells, somatic stem cells, and endothelial cells.

84.

18. The method of claim 73, wherein the cells comprise one or more cells from livestock, poultry, game, and aquatic animal species1, wherein the cell mass comprises a comestible, cell-based meat product.

85.

19. The method of claim 731, wherein culturing the cellscell mass comprises aligning the substrate substantially perpendicular to a ground surfacebovine, porcine, ovine, caprine, poultry, aquatic cells, or some combination thereof.

86. The method of claim 73, wherein applying the one or more cells to the substrate comprises rotating the apparatus such that the substrate is parallel to ground.

87. The method of claim 73, further comprising receiving the separated meat product in a collector.

88. The method of claim 73, wherein the collector is disposed in a cavity of the apparatus.

89. The method of claim 73, wherein the collector is coupled externally to the apparatus.

90. The method of claim 73, wherein the meat product of the substrate comprises a volume between about 0.0001 m3 and about 0.1 m3.

91. The method of claim 73, further comprising sterilizing the substrate after separating the meat product.

92. The method of claim 91, further comprising culturing and separating another meat product after sterilizing the substrate.

93. The method of claim 91, wherein sterilizing the substrate comprises steaming the apparatus.

94. The method of claim 73, further comprising detaching at least one of the substrates from the apparatus.

95. A method of preparing a meat product comprising any of the apparatuses of claims 1-63.

96. The method of claim 95, further comprising detaching the fluid diffuser from the apparatus.

97. The method of claim 95, further comprising detaching the collector from the apparatus.

98. A cell-based meat product generated by the method of claims 73-97.