Claims

1. A method of thawing a frozen sample in a bag-format vessel, the method comprising:

measuring a plurality of first temperatures of the bag-format vessel in contact with a first surface and a second surface, each first temperature of the plurality of first temperatures measured by a different sensor of a plurality of sensors, each sensor of the plurality of sensors configured to measure temperature at a different location of the bag-format vessel;

comparing each first temperature of the plurality of first temperatures to a first threshold;

determining a subset of the plurality of sensors using the comparison, wherein each sensor of the subset of the plurality of sensors measured a first temperature below the first threshold;

heating the frozen sample using a first heater bank and concurrently heating the frozen sample using a second heater bank;

measuring a plurality of second temperatures of the bag-format vessel, using the subset of the plurality of sensors;

upon a second temperature of the plurality of second temperatures exceeding a second threshold, the second threshold indicating that a partially thawed sample is in the bag-format vessel:

heating the partially thawed sample using the first heater bank, and

terminating heating of the partially thawed sample using the second heater bank; and

terminating the heating of the partially thawed sample using the first heater bank after the partially thawed sample has been heated using the first heater bank for a duration.

2. The method of claim 1, wherein when the heating of the partially thawed sample using the first heater bank is terminated, a majority of the partially thawed sample is an aqueous solution and a solid phase remains in the partially thawed sample.

3. The method of claim 2, wherein:

terminating the heating of the partially thawed sample occurs at a predetermined time, and

the predetermined time is calculated using an empirically-derived phase change duration.

4. The method of claim 2, further comprising:

measuring a plurality of third temperatures of the bag-format vessel using the subset of the plurality of sensors,

wherein terminating the heating of the partially thawed sample using the first heater bank is upon a third temperature of the plurality of third temperatures exceeding a third threshold.

5. The method of claim 4, wherein the third threshold is determined empirically.

6. The method of claim 1, further comprising:

measuring a plurality of third temperatures of the bag-format vessel using the subset of the plurality of sensors, and

comparing the plurality of third temperatures to a reference temperature profile,

wherein terminating the heating of the partially thawed sample using the first heater bank is upon a third temperature of the plurality of third temperatures significantly deviating from the reference temperature profile.

7. The method of claim 1, further comprising:

disposing the bag-format vessel in contact with the first surface and the second surface, such that:

a port of the bag-format vessel is proximate to a first end of the first surface and a first end of the second surface; and

the port of the bag-format vessel is disposed nearer to the first heater bank than the second heater bank.

8. The method of claim 1, further comprising:

disposing the bag-format vessel such that:

the bag-format vessel overlaps the first surface at a first portion of the first surface and to not overlap the first surface at a second portion of the first surface; and

the bag-format vessel overlaps the second surface at a first portion of the second surface and not overlap the second surface at a second portion of the second surface,

the first heater bank being disposed closer to the first portion of the first surface and the first portion of the second surface than the second portion of the first surface and the second portion of the second surface,

the second heater bank being disposed closer to the second portion of the first surface and the second portion of the second surface than the first portion of the first surface and the first portion of the second surface,

the bag-format vessel having a surface area smaller than a surface area of the first surface,

the bag-format vessel having a surface area smaller than a surface area of the second surface.

9. The method of claim 8, wherein the surface area of the bag-format vessel is 30% or less of the surface area of the first surface.

10. The method of claim 1, further comprising:

disposing the bag-format vessel such that a line perpendicular to the first surface extends through the second heater bank and does not extend through the bag-format vessel.

11. The method of claim 1, further comprising:

receiving a user input specifying the size of the bag-format vessel, and

based on the size of the bag-format vessel, excluding sensors from the subset of the plurality of sensors.

12. The method of claim 11, further comprising:

receiving a user input specifying the type of media in the bag-format vessel.

13. The method of claim 1, wherein:

the step of measuring the plurality of first temperatures of the bag-format vessel in contact with the first surface and the second surface includes measuring the plurality of first temperatures at five locations unevenly spaced across the first surface and the second surface.

14. The method of claim 1, wherein the subset of the plurality of sensors comprises fewer sensors than the plurality of sensors.

15. The method of claim 1, wherein:

the frozen sample is a first frozen sample, and

the bag-format vessel is a first bag-format vessel characterized by a first size,

the method further comprising:

thawing a second frozen sample in a second bag-format vessel in contact with the first surface and the second surface, wherein the second bag-format vessel is characterized by a second size different from the first size.

16. The method of claim 1, wherein the first threshold is lower than a temperature of the bag-format vessel measured when the bag-format vessel initially contacts the first surface and the second surface.

17. The method of claim 1, wherein:

heating the frozen sample using the first heater bank comprises targeting a temperature set point in the range of 37 °C to 45 °C for the first heater bank, and

heating the frozen sample using the second heater bank comprises targeting the temperature set point for the second heater bank.

18. The method of claim 1, wherein heating the partially thawed sample using the first heater bank comprises targeting a temperature set point in the range of 37 °C to 45 °C for the first heater bank.

19. The method of claim 1, further comprising:

contacting a bag-format vessel with the first surface,

contacting the bag-format vessel with the second surface, and

clamping the bag-format vessel between the first surface and the second surface.

20. The method of claim 19, further comprising:

loading the bag-format vessel into a drawer of a device, and

removing the bag-format vessel from the device after terminating heating of the partially thawed sample using the first heater bank.

21. A thawing system for thawing a frozen sample in a bag-format vessel, the thawing system comprising:

a thawing device comprising:

a first surface,

a second surface,

a plurality of temperature sensors,

a first heater bank, and

a second heater bank; and

a computer system comprising instructions that when executed control the thawing device to perform the method of claim 1.

22. The thawing system of claim 21, wherein the first surface is a first plate, and the second surface is a second plate.

23. The thawing system of claim 21, wherein the plurality of sensors are distributed unevenly across the first surface and the second surface.

24. The thawing system of claim 21, wherein the first heater bank is disposed nearer to a first end of the first surface and a first end of the second surface than the second heater bank is disposed to the first end of the first surface and the first end of the second surface.

25. The thawing system of claim 21, wherein when a bag-format vessel containing a frozen sample is placed between the first surface and the second surface for thawing, a line perpendicular to the first surface extends through the second heater bank and does not extend through the bag-format vessel.