without departing from the spirit and scope of the invention. Specifically, the invention is not limited to irradiating any specific type of fluent food product, nor is the invention limited to any specific type of radiation energy. All patents, patent applications and publications created herein are incorporated by reference in their entirety.

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~~[00124] This application claims priority benefit of U.S. Provisional Ser. No.60/651, 796, filed February 10, 2005, the entire disclosure of which is incorporated herein by reference.~~

WHAT IS CLAIMED IS:

~~1. An apparatus for radiation processing of fluent food products comprising:~~

~~a radiation source;~~

~~a first wall having a convex surface, the first wall being transmissive to radiation energy produced by the radiation source;~~

~~a second wall having a surface that opposes the convex surface of the first wall so as to form a product flow cavity therebetween, wherein the product flow cavity has a substantially constant depth;~~

~~an inlet forming a passageway into the product flow cavity;~~

~~an outlet forming a passageway out of the product flow cavity;~~

~~a sensor means in the product flow cavity for measuring a characteristic of the radiation energy emitted by the radiation source; and~~

~~a flow cavity adjusting means for adjusting the substantially constant depth of the product flow cavity;~~

~~wherein the first wall is positioned between the radiation source and the product flow cavity so that when the radiation source emits radiation energy, the radiation energy passes through the first wall and into the product flow cavity; and~~

~~wherein the radiation source is selected from the group consisting of an electron beam source, a gamma ray source, and an x-ray source.~~

1. An apparatus for radiation processing of fluent food products comprising:

a radiation source for emitting a radiation energy;

a radiation chamber defining a product flow path and having an inlet, an outlet, a first wall, and a second wall with the first wall being positioned between the radiation source and the second wall, at least a portion of the first wall being transmissive to at least a fraction of the radiation energy emitted by the radiation source to permit the radiation energy to pass into the product flow path,

wherein the transmissive portion of the first wall extends about the radiation source at an angle of less than 360° and has an inner surface configured in a way that the radiation source is an equidistance from substantially the entirety of the inner surface of the transmissive portion.

~~2. The apparatus of claim 1 wherein the surface of the second wall that opposes the convex surface of the first wall is a concave surface.~~

2. The apparatus of claim 1 wherein the transmissive portion of the first wall is semi-cylindrical in shape.

3. The apparatus of claim 2 wherein the product flow path has a substantially constant depth.

~~3~~4. The apparatus of claim ~~1~~ 3 wherein the substantially constant depth is approximately 3 inches (0.0762 meter) or less.

5. The apparatus of claim 2, wherein the transmissive portion of the first wall is a half cylinder.

~~4. The apparatus of any one of claims 1 to 3, further comprising a third wall forming a second cavity with the second wall, the second cavity filled with a cooling fluid.~~

~~5~~6. The apparatus of ~~any one of claims 1 to 4~~claim 1, further comprising a source of fluent food product operably connected to the inlet.

~~6~~7. The apparatus of claim ~~5~~ 6 wherein the fluent food product is selected from the group consisting of pastes, liquids, powders, granular materials, gels, ~~or~~ and semisolids.

~~7~~8. The apparatus of claim ~~6~~ 7 wherein the fluent food product is powder infant formula.

9. The apparatus of claim 1, further comprising a sensor means in the product flow path for measuring a characteristic of the radiation energy emitted by the radiation source.

~~8~~10. The apparatus of claim ~~1~~ 9 wherein the characteristic ~~of the radiation energy~~ is selected from the group consisting of radiation power, radiation dose, radiation intensity, and radiation energy.

~~9~~11. The apparatus of claim ~~8~~ 10 wherein the sensor means is embedded in, secured to, or positioned at or near the surface of the second wall.

~~10~~12. The apparatus of ~~any one of claims 1 to 9~~claim 1, wherein the transmissive portion of the first wall transmits the radiation energy produced by the radiation source without a significant loss in energy.

~~11~~13. The apparatus of claim ~~10wherein~~ 12 wherein the transmissive portion of the first wall is constructed of a material selected from the group consisting of quartz, glass, synthetic polymers, laminates, heavy metal plates, and heavy metal foils.

~~12~~14. The apparatus of ~~any one of claims 1 to 11~~claim 1, wherein the first wall is semi-cylindrical in shape having a central axis located outside of the product flow ~~cavity~~path, the radiation source being positioned along the central axis.

~~13~~15. The apparatus of ~~any one of claims 1 to 11~~claim 1, wherein the transmissive portion of the first wall is semi-spherical in shape having a center point located outside of the product flow cavity, the radiation source being positioned at or near the center point.

~~14~~16. The apparatus of ~~any one of claims 1 to 13~~claim 1, further comprising means for controlling flow rate of fluent food product through the product flow ~~cavity~~path.

~~15~~17. The apparatus of claim ~~14~~ 16 wherein the flow rate control means is operably coupled to either the inlet or the outlet.

~~16~~18. The apparatus of ~~any one of claims 1 to 15~~claim 1, further comprising means for facilitating flow of fluent food product through the product flow ~~cavity~~ path via the inlet and outlet.

~~17~~19. The apparatus of claim ~~16~~ 18 wherein the means for facilitating flow of fluent food product comprises a pump adapted to create a pressure or vacuum differential between the inlet and the outlet.

~~18. The apparatus of any one of claims 1 to 17, wherein the surface of the second wall is a concave surface that is generally concentric to the convex surface.~~

20. The apparatus of claim 1, wherein the radiation source is selected from a group consisting of an electron beam source, a gamma ray source, and an x-ray source.

21. The apparatus of claim 15, wherein the transmissive portion of the first wall is a half sphere.

~~19~~22. The apparatus of ~~any one of claims 1 to 18~~claim 1, wherein the second wall is substantially non-transmissive to radiation energy produced by the radiation source.

~~20. The apparatus of any one of claims 1 to 19, further comprising:~~

~~means to adjust the depth of the product flow cavity by either expanding the second wall and/or retracting the first wall;~~

~~a source of fluent food product operably connected to the inlet; a sensor means for measuring radiation energy levels in the product flow cavity, the sensor means embedded within, secured to, or positioned at or near the surface of the second wall;~~

~~means for facilitating flow of fluent food product through the product flow cavity;~~

~~means for controlling flow rate of the fluent food product through the product flow cavity;~~

~~wherein the surface of the second wall is a concave surface and the product flow cavity has a substantially constant depth of approximately 3 inches (0.0762 meter) or less;~~

~~wherein the first wall transmits the radiation energy produced by the radiation source without a significant loss in energy;~~

~~wherein the first wall is a semi-spherical shape having a center point that is outside of the product flow cavity, the radiation source being positioned at or near the center point;~~

~~wherein the radiation source is an electron beam source;~~

~~wherein the inlet forms a vertical passageway into a top of the product flow cavity; and wherein the outlet forms a vertical passageway out of a bottom of the product flow cavity;~~

~~wherein the concave surface is generally concentric to the convex surface;~~

~~wherein a distance separates the radiation source from the first wall; and~~

~~wherein the inlet is positioned to introduce the fluent food product into the product flow cavity in contact with the convex surface of the first wall.~~

23. The apparatus of claim 1, further comprising:

means to adjust the depth of the product flow path by either expanding the second wall and/or retracting the first wall;

a source of fluent food product operably connected to the inlet;

a sensor means for measuring radiation energy levels in the product flow path, the sensor means embedded within, secured to, or positioned at or near the surface of the second wall;

means for facilitating flow of fluent food product through the product flow path; and

means for controlling flow rate of the fluent food product through the product flow path;

wherein the second wall is concave and the product flow path has a substantially constant depth of approximately 3 inches (0.0762 meter) or less;

wherein the transmissive portion of the first wall transmits the radiation energy produced by the radiation source without a significant loss in energy;

wherein the first wall is a semi-spherical shape having a center point that is outside of the product flow path, the radiation source being positioned at or near the center point;

wherein the radiation source is an electron beam source;

wherein the inlet forms a vertical passageway into a top of the product flow path; and wherein the outlet forms a vertical passageway out of a bottom of the product flow path;

wherein the concave surface is generally concentric to the convex surface;

wherein a distance separates the radiation source from the first wall; and

wherein the inlet is positioned to introduce the fluent food product into the product flow path in contact with the inner surface of the transmissive portion of the first wall.

~~21. A method of radiation processing fluent food products comprising:~~

~~providing an apparatus comprising a radiation source, a first wall having a convex surface, a second wall, and a sensor means in the product flow cavity for measuring a characteristic of the radiation energy emitted by the radiation source, wherein the surface of the second wall opposes the convex surface of the first wall so as to form a product flow cavity therebetween, wherein the first wall is transmissive to the radiation energy emitted by the radiation source, and wherein the first wall is positioned between the radiation source and the product flow cavity;~~

~~introducing a fluent food product into the product flow cavity via an inlet to the product flow cavity;~~

~~flowing the fluent food product through and out of the product flow cavity via an outlet; and~~

~~exposing the fluent product to radiation energy emitted by the radiation source, the radiation energy being emitted by the radiation source, passing through the first wall into the product flow cavity, and contacting the fluent food product moving through the product flow cavity~~

~~wherein the radiation source is selected from the group consisting of an electron beam source, a gamma ray source, and an x-ray source.~~

22. The method of claim 21 wherein the fluent food product is flowed through the product flow cavity at a rate that results in the fluent food product being exposed to at least a desired dose of the radiation energy.

23. The method of claim 21 or 22:

wherein the surface of the second wall is a concave surface that is generally concentric to the convex surface;

wherein the first wall is a semi-spherical shape having a center point that is located outside of the product flow cavity, the radiation source being positioned at or near the center point;

wherein the radiation source is an electron beam source adapted to operate at a maximum energy of approximately 10 MeV;

wherein the product flow cavity has a substantially constant depth of approximately 3 inches (0.0762 meter) or less;

wherein the fluid food product contains one or more biological contaminants or pathogens, the fluent food product being flowed through the product flow cavity at a rate that results in the fluent food product being exposed to at least a dose of the radiation energy that is sufficient to effectively reduce levels of the one or more biological contaminants or pathogens;

wherein the fluent food product is infant formula and the one or more biological contaminants or pathogens comprise *Enterobacter sakazakii*, the desired dose of the radiation energy being no more than approximately 5.0 kGy;

24. A method of irradiating a fluent food product comprising:

providing an apparatus comprising a radiation source, a first wall having a convex surface, and a sensor means for measuring a characteristic of the radiation energy emitted by the radiation source, wherein the first wall is transmissive to radiation energy emitted by the radiation source, and wherein the radiation source is positioned on a side of the first wall that is opposite of the convex surface;

flowing a fluent food product onto the convex surface of the first wall; and

exposing the fluent product to radiation energy emitted by the radiation source, the radiation energy being emitted by the radiation source, passing through the first wall, and contacting the fluent food product,

wherein the radiation source is selected from the group consisting of an electron beam source, a gamma ray source, and an x-ray source.