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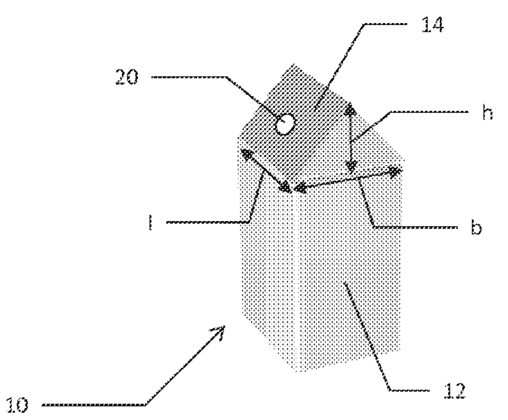

FIGURE 1

(57) Abstract: A method is provided for determining a minimum volume of headroom to leave in a package to sufficiently limit bricking of the package. It includes: determining, for a mass of contents packed in a first interior space of the package distinct from the headroom, a first volume of space located within the first interior space, which first volume of space is intermingled with but unoccupied by the mass of content; and determining the minimum volume of headroom to leave in the package to sufficiently limit bricking of the package such that the minimum volume is proportional to the first volume. Optionally, the method further includes determining a constant of proportionality based on a variation of exterior pressures the package is projected to be exposed to, such that the minimum volume of headroom is determined to be directly proportional to the first volume by the constant of proportionality.

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PACKAGE AND METHOD FOR FILLING TO LIMIT BRICKING

Reference to Related Applications

[0001] The present application claims priority to and the benefit of the filing date of U.S. Provisional Application No. 61/765,216, entitled "Package and Method for Filling to Limit Bricking," filed on February 15, 2013, the entire disclosure of which is incorporated herein by reference.

Field

[0002] The present inventive subject matter relates generally to the art of packaging. Particular but not exclusive relevance is found in connection with bags and/or flexible packages that have a one-way gas release valve, e.g., that provides a hermetic and/or other suitable seal but which still allows for the controlled expulsion of gas and related pressure from an interior of a bag, receptacle, container or other packaging. Accordingly, the present specification makes specific reference thereto. It is to be appreciated however that aspects of the present inventive subject matter are also equally amenable to other like applications.

Background

[0003] Various types of packaging options are available today and are often used by consumers, industries, and numerous retailers to store food and other consumables for later use or consumption. It is often desirable for specific food retailers to present a product that appears attractive to consumers, e.g., to increase product sales and promote a particular brand.

[0004] Coffee beans have a tendency to release a significant amount of gas following the roasting process, even after the coffee beans have already been placed in a sealed bag, container or other like packaging. The presence of excessive gas and/or pressure (e.g., produced by roasted coffee beans) within a sealed container or package may result in the container or package bulging and changing its shape or even bursting which can make the product unattractive to consumers and may impact the manufacturer by decreasing the amount of sales of those coffee beans.

[0005] Accordingly, one-way valves have heretofore been applied to packages containing roasted coffee beans in order to release generated excess gas from the interior of the container to the external environment, while inhibiting the flow of external gas and/or contaminates from the external environment into the otherwise sealed container or package. Such valves generally open in response to a pressure differential ΔP between the package interior and the external environment. That is to say, such valves generally remain open until the interior pressure is substantially equalized with the exterior pressure.

[0006] For example, roasted coffee beans are commonly packaged at a relatively low altitude which tends to have a higher ambient external pressure as compared to higher altitudes, e.g., at which airplanes shipping the packaged coffee may fly or shipping routes over mountain ranges. When the roasted coffee is initially packaged (e.g., at or near ground level), the pressure differential between the interior and exterior of the otherwise sealed packaging causes the valve to open and allow gas to escape the package. Accordingly, the pressure differential drops as the gas escapes and the pressure inside the packaging decreases. At some point, the pressure differential is no longer sufficient to keep the valve open, and the valve closes. Commonly, some gas remains trapped in the packaging at this point, and therefore some degree of interior pressure is retained. However, when the packaged coffee is trucked over mountains or even shipped by air freight, at the relatively higher altitude the external pressure experienced by the package may be relatively lower than the external pressure at which the coffee was initially packaged. In this case, the pressure differential may again exceed a threshold at which point the valve reopens, thereby allowing additional gas that remained in the package to again be expelled. Accordingly, the pressure inside the package is lowered yet further until the valve once again closes. Finally, when the package is again brought to a lower altitude with a correspondingly higher external pressure, the container or package may appear compressed or crushed (sometime referred to as “bricked”), e.g., due to the relatively lower interior pressure of the package that was achieved as a result of its shipping over a higher altitude route versus the exterior atmospheric pressure. In some instances, consumers may be displeased with the bricked appearance of the package and may therefore be less inclined to purchase the product. This can of course be undesirable from the view point of the coffee manufacturer and/or retailer. A further way pressure can increase is due to an increase in temperature during shipping and/or storage of the product. As explained by the Ideal Gas Law, pressure increases proportionally with temperature. When the pressure inside a package increases, the valve will open and release the increased pressure and after the package cools the pressure will proportionally decrease with less volume of gas creating a compressed (“bricked”) package.

[0007] Accordingly, a new and/or improved package and/or method for filling the same is disclosed which addresses the above-referenced problem(s) and/or others.

Brief Summary

[0008] This summary is provided to introduce concepts related to the present inventive subject matter. The summary is not intended to identify essential features of the claimed subject matter nor is it intended for use in determining or limiting the scope of the claimed subject matter. The embodiments described below are not intended to be exhaustive or to limit the invention to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may appreciate and understand the principles and practices of the present inventive subject matter.

[0009] In accordance with one embodiment, a package is provided including: a first interior space sized to accommodate a mass of contents packed into the first interior space, the mass of contents when packed into the first interior space defining a first volume of space intermingled with but unoccupied by the mass of content; and a second interior space distinct from the first interior space. In practice, the second interior space is sized such that a second volume of the second interior space is at least proportional to the first volume.

[0010] In one suitable embodiment, the second volume is at least directly proportional to the first volume.

[0011] In accordance with a further embodiment, there is provided a method for making the package by providing one or more flexible walls defining the first and second interior spaces.

[0012] In one suitable embodiment of the package, the first space is generally a rectangular cuboid in shape and the second space is generally a triangular prism in shape.

[0013] In another suitable embodiment, the package may further include a valve that selectively opens to vent gas from an interior of the package in response to a pressure differential between an exterior and the interior of the package.

[0014] In yet another suitable embodiment, a package includes: one or more flexible walls defining a first interior space and a second interior space distinct from the first interior space; a valve arranged on at least one of the flexible walls that selectively opens to vent gas from an interior of the package in response to a pressure differential between an exterior and the interior of the package; a mass of contents packed into the first interior space; and a first volume of space located within the first interior space and intermingled with but unoccupied by the mass of content. Suitably, the second interior space is sized such that a second volume of the second interior space is at least proportional to the first volume. Optionally, the contents may be roasted coffee beans.

[0015] In accordance with another embodiment, a method is provided for filling a package with contents. The method includes: placing a mass of contents into a first interior space of a package such that there is a first volume of space located within the first interior space which is intermingled with but unoccupied by said mass of content; sizing a second interior space of the package, which second interior space is distinct from the first interior space, such that a second volume of the second interior space is at least directly proportional to the first volume; and leaving the second interior space of the package free of the contents.

[0016] In accordance with still another embodiment, a method is provided for determining a minimum volume of headroom to leave in a package to sufficiently limit bricking of the package. The method includes: determining, for a mass of contents packed together in a first interior space of the package which first interior space is distinct from the headroom, a first volume of space located within the first interior space, which first volume of space is intermingled with but unoccupied by the mass of content; and determining the minimum volume of headroom to leave in the package to sufficiently limit bricking of the package such that the minimum volume is proportional to the first volume. Optionally, the method further includes determining a constant of proportionality based on a variation of exterior pressures the package is projected to be exposed to, such that the minimum volume of headroom is determined to be directly proportional to the first volume by the constant of proportionality.

[0017] Numerous advantages and benefits of the inventive subject matter disclosed herein will become apparent to those of ordinary skill in the art upon reading and understanding the present specification. It is to be understood, however, that the detailed description of the various embodiments and specific examples, while indicating preferred and other embodiments, are given by way of illustration and not limitation. Many changes and modifications within the scope of the present invention may be made without departing from the spirit thereof, and the invention includes all such modifications.

Brief Description of the Drawings

[0018] The following detailed description makes reference to the figures in the accompanying drawings. However, the inventive subject matter disclosed herein may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating exemplary, preferred and/or other embodiments and are not to be construed as limiting. Further, it is to be appreciated that the drawings may not be to scale.

[0019] FIGURE 1 is a diagrammatic illustration showing an exemplary bag or package in accordance with aspects of the present inventive subject matter.

[0020] FIGURE 2 is a diagrammatic illustration showing an exemplary experimental setup for measuring a combined volume of packed coffee beans and their associated excluded air in accordance with aspects of the present inventive subject matter.

[0021] FIGURE is a diagrammatic illustration showing another exemplary experimental setup for measuring a combined volume of coffee beans alone along with the volume of a disk used to submerge the coffee beans in accordance with aspects of the present inventive subject matter.

[0022] FIGURE 4 is a graph showing experimentally determined data relating the mass of roasted coffee beans to the combined volume of the roasted coffee beans packed together plus the volume of their associated excluded air, and showing a linear curve fit to the experimentally determined data.

[0023] FIGURE 5 is a graph showing experimentally determined data relating the volume of excluded air associated with an amount of packed together roasted coffee beans to the mass of those roasted coffee beans, and showing a quadratic curve fit to the experimentally determined data.

[0024] FIGURE 6 is a graph showing experimentally determined data relating the volume of excluded air associated with an amount of packed together roasted coffee beans to the mass of those roasted coffee beans, and showing a linear curve fit to the experimentally determined data.

Detailed Description

[0025] The apparatuses and methods disclosed in the present specification are described in detail by way of examples and with reference to the figures. Unless otherwise specified, like numbers in the figures indicate references to the same, similar or corresponding elements throughout the figures. It will be appreciated that modifications to disclosed and described examples, arrangements, configurations, components, elements, apparatuses, methods, materials, etc. can be made and may be desired for a specific application. In this disclosure, any identification of specific shapes, materials, techniques, arrangements, etc. are either related to a specific example presented or are merely a general description of such a shape, material, technique, arrangement, etc. Identifications of specific details or examples are not intended to be, and should not be, construed as mandatory or limiting unless specifically designated as such. Selected examples of apparatuses and methods are hereinafter disclosed and described in detail with reference made to the figure.

[0026] The present inventive subject matter relates generally to a bag and/or other like flexible-walled package including a fluid control device or one-way valve that allows for the expulsion of air, gas and/or other unwanted components from an interior of the otherwise sealed bag or package, while providing a protective seal that prevents or inhibits unwanted air, gas, moisture and/or other components or contaminates found in an exterior of the bag or package from entering the interior thereof. Suitably, the protective seal provided by the control device or one-way valve may be a hermetic or water resistant seal which permits fluid and/or gas flow therethrough in one direction (e.g., from an interior to an exterior of a package), while preventing or inhibiting fluid and/or gas flow therethrough in an opposite direction (e.g., from an exterior to an interior of a package). Accordingly, the outlet of gas from an interior of the bag or package fitted with such a valve protects against an undesirable build-up of excessive pressure inside the otherwise sealed bag or package.

[0027] In practice, the bag or package is generally used to hold or contain roasted coffee therein. However, to like or otherwise similar benefit, it is equally amenable to holding other contents with similar off-gassing and/or other properties. Suitably, other than the valve, the bag or package may be sealed shut after filling of the same to a designated level.

[0028] Suitably, the valve only opens (e.g., to release gas from an interior of the package) when the pressure differential (ΔP) between the package's internal pressure (P_i) and the ambient external pressure (P_e) exceeds a given opening threshold (T_o). That is to say, the valve only opens when $\Delta P = P_i - P_e > T_o$, thereby allowing gas to flow out through the valve from an interior of the otherwise sealed package to an exterior thereof. The pressure differential (ΔP) at which the valve opens shall be referred to herein as the opening pressure (ΔP_o). Conversely, when the pressure differential (ΔP) between the package's internal pressure (P_i) and the ambient external pressure (P_e) falls below a given closing threshold (T_c), then the value may again close. That is to say, the valve closes when $\Delta P = P_i - P_e < T_c$, thereby inhibiting further gas flow through the valve. The pressure differential (ΔP) at which the valve closes shall be referred to herein as the closing pressure (ΔP_c).

[0029] In one embodiment, suitably the bag or package is arranged or sized and/or an amount to which the bag or package is filled is adjusted so that a sufficient headroom or headspace remains in the bag or package to effectively limit bricking (i.e., a crushed or compressed appearance) of the bag or package due to the bag or package experiencing a variation of external pressures (P_e) or other variations in the pressure differential (ΔP). Headroom or headspace as used herein generally refers to an interior portion, space or volume of the bag or package that is above a designated fill-level or outside a designated fill-volume of the bag or package.

[0030] Referring now to the figures and initially to FIGURE 1, there is shown an exemplary bag or package 10 suitable for practicing aspect of the present inventive subject matter, equipped and/or otherwise provisioned with a suitable valve 20 as described above. As shown, the package 10 includes: a first volume or space 12 defining a fill-volume or space which is intended to be filled with roasted coffee beans or other like contents; and a second volume or space 14 defining a headroom or headspace which is intended to remain substantially free of roasted coffee beans or other like contents (i.e., the headroom remains generally unfilled). As shown, the first fill-volume or space 12 has a generally rectangular cuboid shape, and the headroom or second space 14 has a generally triangular prism shape. For a headroom so shaped, the volume of the space 14 can be calculated as:

$$V_h = (1/2)\ l\ b\ h \qquad (1),$$

where V_h is the headroom volume of the triangular prism, l is the length of the triangular prism, b is the length of the base of the triangular prism, and h is the height of the triangular prism measured perpendicular from the base.

[0031] In one suitable embodiment, the bag or package 10 is sized or otherwise provided and/or filled so as to maintain a minimally sufficient volume of headroom to effectively limit bricking under varying pressure and/or other conditions which would otherwise tend to cause bricking of the bag or package 10. By minimally sizing the headroom to that volume which is still sufficient to effectively limit bricking, material used to construct the bag or package 10 can be conserved while still guarding against the potential for bricking should conditions be encountered which would otherwise tend to result in such bricking.

[0032] Notably, roasted coffee beans and other similar solid contents tend to be irregular in shape. Accordingly, even when closely packed together (e.g., in the fill-space 12 of the bag or package 10) there remains some space or spaces in-between the beans, granules, etc. which are unoccupied by the beans, granules, etc. Generally, this space in-between and unoccupied by the beans or other solid contents, while otherwise located in the so-called filled-space 12 of the bag or package 10, is taken up by air and/or other gases. Within the space 12 of the bag or packaging 10 which is nominally filled with roasted coffee beans or other contents, the air and/or gas in-between the unoccupied spaces of the packed together beans or other contents shall be referred to herein as excluded air.

[0033] Accordingly, a packing density (D) of a mass (m) of packed together roasted coffee beans or other like contents can be defined as follows:

$$D = m / (V_c + V_0) \quad (2),$$

where V_c represents the actual volume of the roasted coffee beans or other solid contents, and V_0 represents the volume of excluded air therebetween. Therefore, to accommodate a mass (m) of roasted coffee beans or other like solid contents packed within the space 12 of the bag or package 10, the volume (V_{fill}) of the space 12 can be determined as:

$$V_{fill} = V_c + V_0 \quad (3).$$

[0034] The total volume (V_b) of the bag or package 10 is therefore given by:

$$V_b = V_h + V_c + V_0 \quad (4).$$

[0035] It is to be appreciated that the headroom space 14 is generally also taken up for the most part entirely by air and/or gas. That is to say, the headroom space 14 is generally not filled with roasted coffee beans or other like contents. While the headroom volume (V_h) and the excluded air volume (V_0) are generally taken by up compressible air and/or gas, the roasted coffee beans and/or other like contents are solid and tend to be largely uncompressible. Accordingly, a compressible volume (V_{comp}) inside the bag or package 10 can be given by:

$$V_{comp} = V_h + V_0 \quad (5).$$

[0036] For purposes of illustration and not limitation, two example cases will now discussed. In each case, it is assumed that roasted coffee beans or the like are packed, for example, in a bag or package such as the bag or package 10 at a first altitude (A1), where the ambient external pressure (P_e) is a value (P1). During shipping or otherwise, the bag or package 10 is then taken to a second altitude (A2), where the ambient external pressure (P_e) is a second value (P2) which is less than

P1. Finally, the bag or package 10 comes to rest at a third altitude (A3) where the ambient external pressure (P_e) is a third value (P3), for example, which is greater than both P2 and P1.

[0037] In example case 1, it is assumed that the valve 20 did not open to equalize pressure and/or release gas from within the bag or package 10 as it was taken from A1 to A3. In example case 2, it is assumed that the valve 20 did open to equalize pressure and/or release gas from within the bag or package 10 as it was taken from A1 to A3, for example, at A2.

[0038] According to the ideal gas law, the initial volume of compressible air and/or gas in the bag or package 10 (i.e., the initial compressible volume) multiplied by the initial applied pressure (i.e., the initial ambient external pressure) is equal to the final volume of compressible air and/or gas in the bag or package 10 multiplied by the final applied pressure (i.e., the final ambient external pressure).

[0039] In case 1, the foregoing equality can be represented by the equation:

$$V_{comp}\ P1 = V_f\ P3 \qquad (6);$$

or

$$(V_h + V_0)\ P1 = V_f\ P3 \qquad (7),$$

where V_f represent the final volume of compressible air and/or gas within the bag or package 10.

[0040] In case 2, it is to be appreciated that at A2, for example, the valve 20 opens for a time to equalize pressure and/or release gas from within the bag or package 10. This has in essence the effect of altering the “initial” amount and/or volume of compressible air and/or gas within the bag or package 10. In other words, the internal pressure (P_i) is substantially equalized to the ambient external pressure at A2 (i.e., P2) plus the closing pressure (ΔP_c) of the valve 20. Accordingly, the equation can take the form:

$$V_{comp}\ (P2 + \Delta P_c) = V_f\ P3 \qquad (8);$$

or

$$(V_h + V_0)\ (P2 + \Delta P_c) = V_f\ P3 \qquad (9).$$

[0041] In either case, by solving for V_f, the foregoing equations can be rewritten as:

$$V_f = R\,(V_h + V_0) \quad (10),$$

where in case 1, R represents the ratio of P1 to P3 (i.e., R = P1/P3), and in case 2, R represents the ratio of P2 plus the closing pressure (ΔP_c) to P3 (i.e., R = (P2 + ΔP_c)/P3).

[0042] As can be appreciated from the foregoing equations, in a bag or package without any headspace ($V_h = 0$), the final volume (V_f) is a fraction of the initial volume of the excluded air (V_0). Accordingly, the bag or package is closed in on, pressed and/or collapsed around the coffee beans or other contents and the bag or package appears bricked or crushed. However, when there is a sufficient headspace present in the bag or package 10, the resulting reduction in the air/gas volume is offset by the headspace as opposed to the region of the bag or package 10 around the actual coffee or other contents. That is to say, the resulting reduction of air/gas volume within the bag and/or package 10 tends to collapse the headroom space 14 of the bag/package 10 instead of the fill-space 12 which contains and/or surrounds the roasted coffee beans and/or other contents.

[0043] Accordingly, bricking is likely to be sufficiently limited if the headspace is greater or equal to the resulting reduction in air/gas volume. Suitably, minimizing the headspace volume while maintaining it greater than or equal to the resulting reduction in air/gas volume has a further benefit of minimizing the amount of material that has to be used to construct the bag or package 10. Accordingly to sufficiently limit bricking, the foregoing condition may be expressed as follows:

$$V_h \geq |\, V_f - (V_h + V_0) \,| \quad (11).$$

Substituting for V_f from the foregoing equation and solving for the headroom or headspace volume, the following equation can be derived:

$$V_h \geq k\, V_0 \quad (12),$$

where k is given by (1/R) - 1.

[0044] From the foregoing equation, it is noted that a minimum headroom or headspace volume which sufficiently limits bricking is proportional to the initial volume of excluded air. More specifically, V_h is directly proportional to V_0 by a proportionality constant k = (1/R) - 1.

[0045] Accordingly, to determine a suitable headroom volume which effectively achieves the desired limitation on bricking, it becomes useful to determine the volume of excluded air (V_0) which accompanies a mass (m) of roasted coffee beans or other like contents packed in a bag or package such as the bag or package 10.

[0046] Suitably, the volume of excluded air (V_0) which accompanies a mass (m) of roasted coffee beans or other like contents packed in a bag or package such as the bag or package 10 can be experimentally determined and/or extrapolated from experimental data.

[0047] In one example, the volume of excluded air (V_0) has been experimentally determined for roasted coffee beans having an array of different masses (m), namely, 1 ounce (oz), 2 oz, 3 oz, 4 oz and 5 oz. With reference now to FIGURE 2, in a first instance, each mass of roasted coffee beans 100 was packed in a thin walled container 102 and the container 102 was submerged in a cylinder of water 106 until the upper level 104 of the roasted coffee beans 100 was even with the water level. In one example, the cylinder of water 106 had a diameter of 14 cm. As the container 102 was submerged, the water level rose. From the change in the height of the water 106 experienced as a result of submerging the container 102 therein, the volume of displaced water ($V1_{dw}$) was calculated and in turn this volume of displaced water 106 was used to closely approximate the volume of the mass of roasted coffee beans 100 plus the associated volume of excluded air (V_0) (e.g., discounting the relatively insignificant volume added by the relatively thin walls of the container 102). In other words, $V1_{dw} = V_c + V_0$.

[0048] With reference now to FIGURE 3, in a second instance, each mass of coffee beans 100 was again submerged under the cylinder water 106, this time without the container 102. A disk 108 was used to push and/or hold the beans 100 below a surface of the water 106 thereby ensuring complete submersion of the beans 100 and the disk 108. Again, submersion of the beans 100 and the disk 108 resulted in the water level rising by a given amount. From the change in height of the water level, the volume of displaced water ($V2_{dw}$) was calculate and in turn this volume of displaced water was used to closely approximate the volume of the mass of beans 100 plus the volume of the disk 108 (e.g., discounting any water absorption by the beans 100 or disk 108 which was deemed to be relatively insignificant). In other words, $V2_{dw} = V_c + V_d$, where V_d is the volume of the disk 108.

[0049] Additionally, the disk 108 was separately submerged under the water 106 without the roasted coffee beans. Again, submersion of the disk 108 resulted in the water level rising by a given amount. From the change in height of the water level, the volume of displaced water ($V3_{dw}$) was calculate and in turn this volume of displaced water 106 was used to closely approximate the volume of the disk 108 alone (e.g., discounting any water absorption by the disk 108 which was deemed to be relatively insignificant). In other words, $V3_{dw} = V_d$.

[0050] Accordingly, for each given mass (m) of roasted coffee, the volume of excluded air (V_0) associated therewith was calculated as:

$$V_0 = V1_{dw} - (V2_{dw} - V3_{dw}) \quad (13).$$

[0051] The following tables show the respective values obtained in one such experiment.

Table 1

Mass of beans (oz)	Initial height of water (cm)	Height of water after immersion of container containing coffee beans (cm)	Change in height (cm)	Volume $V1_{dw}$ (cc)
1	10	10.6	0.6	92.316
2	10	11.3	1.3	200.018
3	10	12	2	307.72
4	10	12.6	2.6	400.036
5	10	13.4	3.4	523.124

[0052] Table 1 shows the values used and/or results obtained in the first instance, e.g., as shown in FIGURE 2.

Table 2

Mass of beans (oz)	Initial height of water (cm)	Height of water after immersion of just coffee beans and disk (cm)	Change in height (cm)	Volume $V2_{dw}$ (cc)
1	9.4	9.8	0.4	61.544
2	9.4	10.2	0.8	123.088
3	9.4	10.6	1.2	184.632
4	9.4	10.9	1.5	230.79
5	9.4	11.2	1.8	276.948

[0053] Table 2 shows the values used and/or results obtained in the second instance, e.g., as shown in FIGURE 3.

[0054] Additionally, to determine the volume of the disk 108 alone, the cylinder of water 106 was provided with an initial height of 10.3 centimeters (cm) and after immersion of the disk 108 alone the height of the water rose to 10.4 cm, giving a difference of 0.1 cm in water height and a displaced water volume ($V3_{dw}$) of 15.386 cubic centimeters (cc).

Table 3

Mass of beans (oz)	Volume $V1_{dw}$ (cc)	Volume $V2_{dw}$ (cc)	Volume $V3_{dw}$ (cc)	Volume V_0 (cc)
1	92.316	61.544	15.386	46.158
2	200.018	123.088	15.386	92.316
3	307.72	184.632	15.386	138.474
4	400.036	230.79	15.386	184.632
5	523.124	276.948	15.386	261.562

[0055] Table 3 shows the resulting volume of excluded air (V_0) associated with each mass (m) of roasted coffee beans.

[0056] FIGURE 4 shows the mass (m) of the roasted coffee beans (along the y- or vertical axis) plotted against the volume ($V1_{dw}$) (i.e., the volume of the roasted coffee beans (V_c) plus the volume of the excluded air (V_0)) (along the x- or horizontal axis). Again, it is assumed that the roasted coffee beans are sufficiently non-porous and/or the water does not significantly penetrate or absorb into the beans. Notably, the slope of a straight line fit to the data and passing through the origin gives the "packing density" (D) of the roasted coffee beans, e.g., in this case the slope or packing density (D) is 0.0098 oz/cc.

[0057] FIGURE 5 shows the volume of excluded air (V_0) (along the y- or vertical axis) plotted against the mass (m) of the roasted coffee beans (along the x- or horizontal axis). Notably, a curve or trendline in the form of a quadratic equation may be fit to the data. For example, in the case, the quadratic equation or trendline takes the form $y = 2.3891\, x^2 + 39.182\, x$. Accordingly, assuming the same or a common packing density (D), the fitted quadratic curve or trendline can be used to extrapolate volumes of excluded air (V_0) associated with masses (m) of roasted coffee beans other than those determined experimentally.

[0058] Accordingly, a minimum headroom or headspace volume that sufficiently limits bricking may be calculated or otherwise determined as follows. For example, assume from case 1 and 2 described above, that: (i) the roasted coffee beans are packaged in the bag or package 10 at a first altitude of 4500 feet (ft) above sea level (i.e., A1 = 4500 ft), where the initial ambient external pressure is 12.5 pounds per square inch (psi) (i.e., P1 = 12.5 psi); (ii) the package of roasted coffee beans travels over an elevation of 7300 ft above sea level (i.e., A2 = 7300 ft), where the ambient external pressure is 11.1 psi (i.e., P2 = 11.1 psi); and (iii) the package of roasted coffee beans comes to rest at sea level (i.e., A3 = 0 ft), where the final ambient external pressure is 14.7 psi (i.e., P3 = 14.7 psi).

[0059] In the foregoing example, the headroom volume which sufficiently limits bricking may be determined from equation (12) above. In other words, given case 1 where the valve 20 does not open, from equation (12) above the headroom volume is given by $V_h \geq 0.176\, V_0$ (i.e., k = 0.176); and given case 2 where the valve 20 does open at A2 and has a closing pressure (ΔP_c) of 0.05 psi, from equation (12) above the headroom volume is given by $V_h \geq 0.316\, V_0$ (i.e., k = 0.316).

[0060] Substituting from equation (1) for V_h is equation (12), and solving for the minimum height (h) of the headroom space 14, the following equation is achieved:

$$h \geq [(2\ k) / (l\ b)]\ V_0 \qquad (14).$$

[0061] As shown in equation (14), assuming a triangular prism shaped headspace 14 with fixed and/or otherwise known dimensions for l and b, the height (h) of the headroom space 14 which is minimally sufficient to limit undesired bricking (i.e., the lower limit of h) is a function of the excluded air volume (V_0).

[0062] Using experimentally determined and/or extrapolated data from the example of FIGURE 5, the following Table 4 shows the resulting height (h) of the headroom space 14 (e.g., given dimensions of l and b as 10 cm and 8 cm) which is minimally sufficient to suitably limit bricking for a variety of different masses (m) of roasted coffee beans packed in a bag or package such as the bag or package 10, in both case 1 (where the valve 20 does not open) and case 2 (where the valve 20 has a closing pressure (ΔP_c) of 0.05 psi and does open, e.g., at A2) assuming the foregoing history of altitude and/or ambient external pressure experienced by the bag or package.

Table 4

Mass (m) of beans (oz)	Volume of excluded air (V_0) (cc)	Case 2 headspace volume (V_h) (cc)	Case 2 headspace height (h) (cm)	Case 1 headspace volume (V_h) (cc)	Case 1 headspace height (h) (cm)
2.00	87.92	27.78	0.69	15.47	0.39
4.00	194.95	61.61	1.54	34.31	0.86
6.00	321.10	101.47	2.54	56.51	1.41
8.00	466.36	147.37	3.68	82.08	2.05
9.00	546.16	172.59	4.31	96.12	2.40
12.00	814.21	257.29	6.43	143.30	3.58
16.00	1238.52	391.37	9.78	217.98	5.45

[0063] FIGURE 6 again shows the volume of excluded air (V_0) (along the y- or vertical axis) plotted against the mass (m) of the roasted coffee beans (along the x- or horizontal axis). In this embodiment, instead of a quadratic fit as used in FIGURE 5, a straight line or linear trendline is fit to the data. For example, in the case, the line or trendline takes the form y = 48.955 x. Again, assuming the same or a common packing density (D), the fitted line or linear trendline can be used to extrapolate volumes of excluded air (V_0) associated with masses (m) of roasted coffee beans other than those determined experimentally.

[0064] Using experimentally determined and/or extrapolated data from the example of FIGURE 6, the following Table 5 shows the resulting height (h) of the headroom space 14 (e.g., given dimensions of l and b as 10 cm and 8 cm) which is minimally sufficient to suitably limit bricking for a variety of different masses (m) of roasted coffee beans packed in a bag or package such as the bag or package 10, in both case 1 (where the valve 20 does not open) and case 2 (where the valve 20 has a closing pressure (ΔP_c) of 0.05 psi and does open, e.g., at A2) assuming the foregoing history of altitude and/or ambient external pressure experienced by the bag or package.

Table 5

Mass (m) of beans (oz)	Volume of excluded air (V_0) (cc)	Case 2 headspace volume (V_h) (cc)	Case 2 headspace height (h) (cm)	Case 1 headspace volume (V_h) (cc)	Case 1 headspace height (h) (cm)
2.00	97.91	30.94	0.77	17.23	0.43
4.00	195.82	61.88	1.55	34.46	0.86
6.00	293.73	92.82	2.32	51.70	1.29
8.00	391.64	123.76	3.09	68.93	1.72
9.00	440.60	139.23	3.48	77.54	1.94
12.00	587.46	185.64	4.64	103.39	2.58
16.00	783.28	247.52	6.19	137.86	3.45

[0065] While the bag or package 10 and the spaces 12 and 14 and the valve 20 have been shown in particular shapes, it should be understood that other configurations and/or shapes are acceptable. Likewise, while the valve 20 has been shown arranged on the headroom portion 14 of the bag or package 10, it could likewise be arranged on the fill-portion 12 of the bag or package 10. Furthermore, while a single valve 20 has been illustrated, it is to be appreciated that more valves or no valve may be employed on the bag or package 10.

[0066] Additionally, the bag or package 10 has been described for use in connection with the packing of roasted coffee beans and/or the like therein. However, it is to be appreciated that the bag or package 10 and/or the disclosed method for filling the same and/or determining an amount of headroom to provide or leave to limit bricking may be used in other applications and/or with packaging for other materials which may experience relative interior and/or exterior pressure changes or variations, for example, during shipping or other transportation.

[0067] In short, while aspects of the inventive subject matter herein have been described in connection with exemplary and/or other embodiments, it will be apparent to those of ordinary skill in the art that the invention is not to be limited to the disclosed embodiments, and that many modifications and equivalent arrangements may be made thereof within the scope of the invention, which scope is to be accorded the broadest interpretation of the appended claims so as to encompass all equivalent structures and products.

[0068] The inventors hereby state their intent to rely on the Doctrine of Equivalents to determine and assess the reasonably fair scope of their invention as it pertains to any apparatus, system, method or article not materially departing from but outside the literal scope of the invention as set out in the following claims.

Claims

What is claimed is:

1. A package comprising:

a first interior space sized to accommodate a mass of contents packed into said first interior space, said mass of contents when packed into said first interior space defining a first volume of space intermingled with but unoccupied by said mass of content; and

a second interior space distinct from the first interior space;

wherein said second interior space is sized such that a second volume of said second interior space is at least proportional to said first volume.

2. The package of claim 1, wherein the second volume is at least directly proportional to the first volume.

3. The package of claim 2, further comprising one or more flexible walls defining the first and second interior spaces.

4. The package of claim 3, further comprising a valve that selectively opens to vent gas from an interior of the package in response to a pressure differential between an exterior and the interior of the package.

5. The package of claim 4, wherein the first space is generally a rectangular cuboid in shape and the second space is generally a triangular prism in shape.

6. A package comprising:

one or more flexible walls defining a first interior space and a second interior space distinct from the first interior space;

a valve arranged on at least one of the flexible walls that selectively opens to vent gas from an interior of the package in response to a pressure differential between an exterior and the interior of the package;

a mass of contents packed into said first interior space; and

a first volume of space located within the first interior space and intermingled with but unoccupied by said mass of content;

wherein said second interior space is sized such that a second volume of said second interior space is at least proportional to said first volume.

7. The package of claim 6, wherein the contents is roasted coffee beans.

8. A method for filling a package with contents:

placing a mass of contents into a first interior space of a package such that there is a first volume of space located within the first interior space which is intermingled with but unoccupied by said mass of content;

sizing a second interior space of the package, which second interior space is distinct from said first interior space, such that a second volume of said second interior space is at least directly proportional to said first volume; and

leaving the second interior space of the package free of the contents.

9. A method for determining a minimum volume of headroom to leave in a package to sufficiently limit bricking of said package, said method comprising:

determining, for a mass of contents packed together in a first interior space of said package which first interior space is distinct from said headroom, a first volume of space located within the first interior space, which first volume of space is intermingled with but unoccupied by said mass of content; and

determining the minimum volume of headroom to leave in the package to sufficiently limit bricking of said package such that said minimum volume is proportional to the first volume.

10. The method of claim 9, further comprising:

determining a constant of proportionality based on a variation of exterior pressures the package is projected to be exposed to, such that said minimum volume of headroom is determined to be directly proportional to the first volume by said constant of proportionality.

11. A method of making the package of claim 1, said method comprising:

providing one or more flexible walls defining the first and second interior spaces.

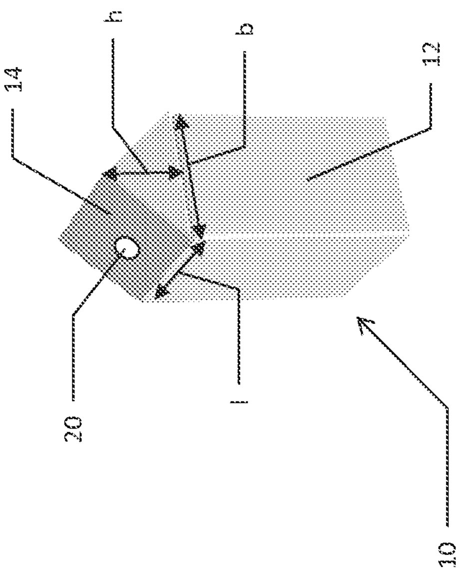

FIGURE 1

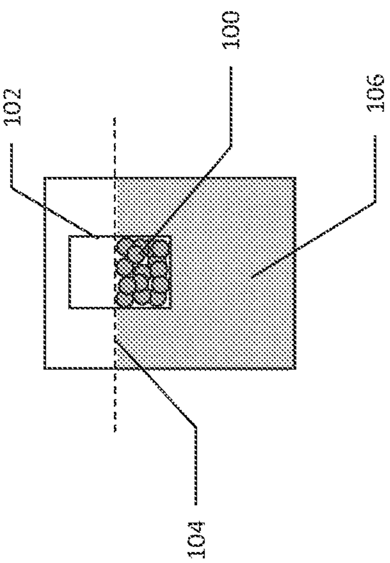

FIGURE 2

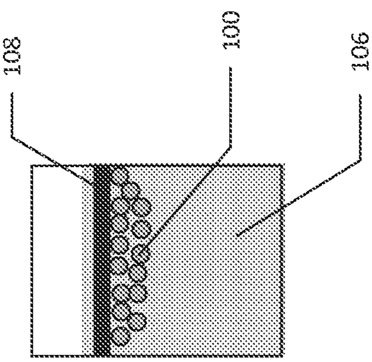

FIGURE 3

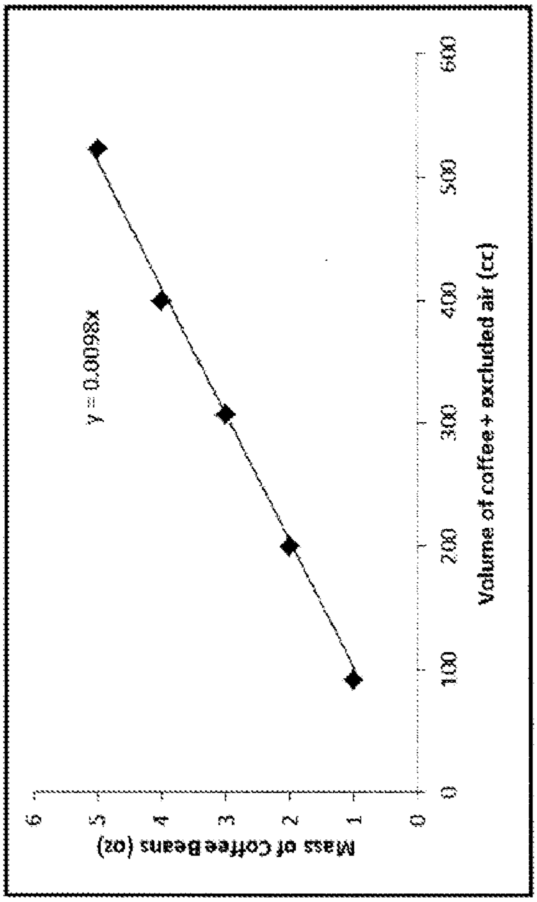
Mass of Coffee Beans (oz)
0
1
2
3
4
5
6
Volume of coffee + excluded air (cc)
0
100
200
300
400
500
600
y = 0.0098x

FIGURE 4

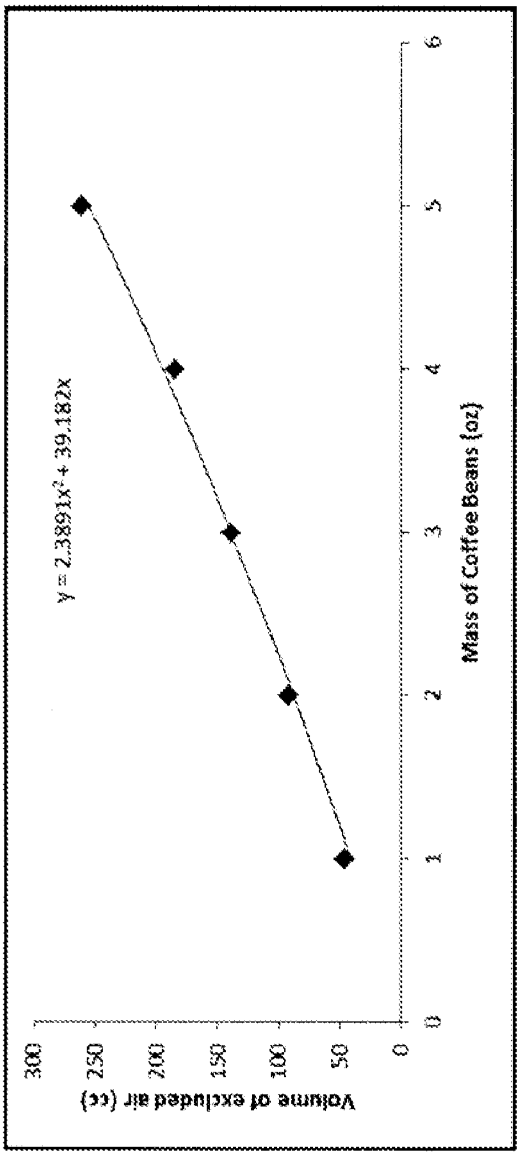
y = 2.3891x^2 + 39.182x
Volume of excluded air (cc)
300
250
200
150
100
50
0
0
1
2
3
4
5
6
Mass of Coffee Beans (oz)

FIGURE 5

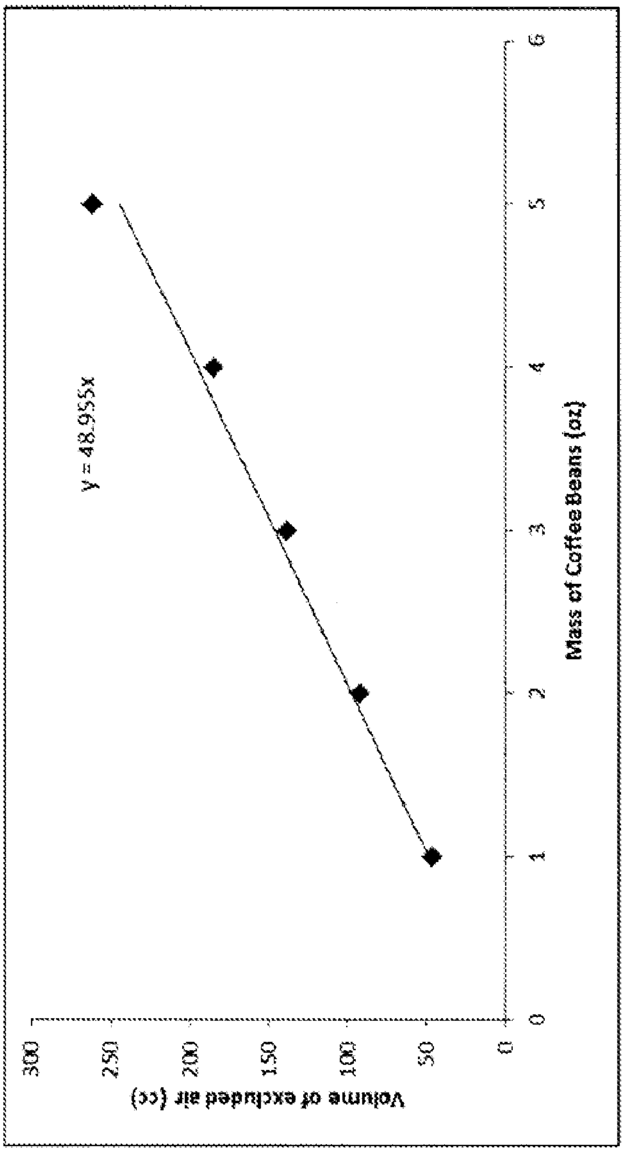
y = 48.955x
Volume of excluded air (cc)
300
250
200
150
100
50
0
0
1
2
3
4
5
6
Mass of Coffee Beans (oz)

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US14/16437

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B64D 33/01, 81/20, 90/36 (2014.01)
USPC - 206/524.8; 220/89.1; 383/100
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) Classification(s): B64D 33/01, 81/20, 90/36 (2014.01)
USPC Classification(s): 206/524.8, 220/89.1, 383/100

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); IP.com; Google/Google Scholar; DialogPRO; Searched Terms Used: roasted, coffee, bean, package, valve, bricking, atmosphere, exterior, proportion, constant, pressure, external,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,992,634 A (WALTERS WJ) November 30, 1999; figure 1; column 4, lines 15-30	1-11
A	US 2010/0183777 A1 (SAGY A et al.) July 22, 2010; figure 1; paragraph [0030]	1-11
A	US 6,663,284 B2 (BUCKINGHAM R et al.) December 16, 2003; figure 1; column 4, lines 25-50	1-11

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 May 2014 (21.05.2014)	03 JUN 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774