PACKAGING SYSTEMS FOR THE CONTROL OF RELATIVE HUMIDITY OF FRESH FRUITS, VEGETABLES AND FLOWERS WITH SIMULTANEOUS REGULATION OF CARBON DIOXIDE AND OXYGEN

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ABSTRACT

A water permeable sealed container for preservation of produce such as fruit, vegetables and flowers made out of three layer laminate corrugated to form, further three to five layer construct. The layers also include a layer of Kraft paper fluting and layer of polymer which is enclosed between two layers of Kraft paper. The container has a lid, which absorbs water vapor and transmits water vapor from the interior of the container to the exterior through micro perforations. The container can also regulate relative humidity within a range of 75% to 85% for some foods by removing moisture from the food generated from respiration and suppressing product decay due to microorganisms. The laminate may be die cut to be formed into a range of box designs for vertical profiles that provide ventilation spaces between containers in a vertical stack and to provide airflow channels within a stack.
FIG. 3

FIG. 3a Top view of the lid for container in FIG. 1
FIG. 3b Side view of the lid in place with container in FIG. 1
FIG. 3c Cross section of lid in perspective with container in FIG. 1
FIG. 3d Perspective view of the lid
FIG. 4a  Top view of the lid for container in FIG. 2
FIG. 4b Side view of the lid in place with container in FIG. 2
FIG. 4c Cross section of lid in perspective with container in FIG. 2
FIG. 4d Perspective view of the lid
PACKAGING SYSTEMS FOR THE CONTROL OF RELATIVE HUMIDITY OF FRESH FRUITS, VEGETABLES AND FLOWERS WITH SIMULTANEOUS REGULATION OF CARBON DIOXIDE AND OXYGEN

FIELD OF THE INVENTION

This invention relates to a novel process and storage container for the modified atmosphere preservation of fresh fruits, vegetables and/or flowers using preferential relative humidity levels. More particularly, the invention pertains to the preservation of the food integrity and food safety in a sealed container which permits the exchange of oxygen, carbon dioxide and water vapour to maintain high levels of carbon dioxide, low levels of oxygen and intermediate levels of relative humidity for optimum preservation of foods at refrigerated temperatures for extended storage periods.

BACKGROUND OF THE INVENTION

Consumers have come to expect the availability of a wide range for fresh, ripe fruits, vegetables and flowers year round. While most if not all of these commodities are available year round from either the southern or northern hemispheres, they are often not available due to the high cost of air-freight or the produce is picked immature to provide the necessary storage life required for transport and distribution but does not achieve the full ripeness of a premium product. Fruit picked immature will not have the sugar content nor the ability to develop full flavor or ripeness even if exposed to a ripening process. In addition, fruit and vegetables picked immature are often more susceptible to mold, yeast and bacterial diseases that fully ripened fruit and vegetables.

Most modified atmosphere packaging systems use sealed boxes or bags with or without perforations to create high levels of carbon dioxide (5% to 20% CO₂) plus low levels of oxygen (1% to 15% O₂) to suppress product respiration to conserve the products metabolites and maintain quality. Most of these applications provide an elevated relative humidity around the product to prevent desiccation. While this application has a short term benefit, respiration of the product generates moisture which develops a saturated environment leading to the growth of bacteria, yeast and molds which affect product quality and food safety. In addition, excessively high moisture levels lead to softening and necrosis of the product resulting in the rapid deterioration of quality.

Many fresh fruits, vegetables and flowers maintain their respective quality in storage environments that have relative humidity maintained between 84% RH and 94% RH at low temperatures. However, for those products highly susceptible to mold, yeast and/or bacterial growth (i.e. fresh-cut flowers (roses), bell peppers, mushrooms, berries etc.) a relative humidity of 75% to 80% is preferred as the lower relative humidity will suppress microbial growth and provide for optimum quality retention.

Modification of the gas composition in the atmosphere within a package around the food can prolong the storage life of the fruit, vegetable and flowers. Modified Atmosphere Packaging (MAP) is an application which uses the respiring food to reduce the oxygen level and accumulate the carbon dioxide levels within a package. The lower oxygen and higher carbon dioxide atmosphere slows the respiration rate and quality loss of the food and suppresses microbial vegetative growth and spore germination leading to product quality loss (Powrie and Skura, “Modified Atmosphere Packaging of Fruits and Vegetables”, Ellis Horwood, 1991, pages 169-245; “Modified Atmosphere Packaging”, A. Brody, K. Marsh Eds. The Wiley Encyclopaedia of Packaging, 1023 pages, Modified Atmosphere Applications to Food, Agriculture and Agri-Food Canada, 1986, 86 pages).

The use of laminated papers are commonly used for the corrugation of boxes for storage of produce and food that generate high humidity internally or are stored in high relative humidity atmospheres for an extended period of time. These laminates are used to replace paraffin waxed boxes which are non-recyclable. While these laminates are constructed of two layers of kraft paper with an internal layer of low, medium, or high density polyethylene or other plastic material, the laminates do not have a function other than maintaining the strength of the formed box in water saturated environments.

A refinement of the three layer laminate was developed by Wu et al. (U.S. Pat. No. 5,575,418, issued 19 Nov. 1996) and U.S. Pat. No. 5,609,293 (issued 11 Mar. 1997) and Clough et al. U.S. Pat. No. 6,050,412 (issued 18 Apr., 2000) which developed a series of three layer laminates using a range of plastic materials and featured 150 to 200 g Kraft laminated with polymeric film and a third layer consisting of a thin layer of machine finish or machine glaze fine paper. The plastic film characteristics and thicknesses were selected to provide the three layer laminates with selected permeabilities in the range of 6000 to 30,000 ccO₂/m²·24 hr at 1 atm and 5000 to 28,000 ccCO₂/m²·24 hr at 1 atm and 20°C. These laminates when corrugated and formed into a range of box designs were able to create modified atmospheres in the box within the range of 5% to 20% oxygen and 1% to 10% carbon dioxide using the product respiration and selected exchange of oxygen and carbon dioxide with the ambient atmosphere. While the adaptation of the permeable liner was able to create modified atmospheres for oxygen and carbon dioxide, the relative humidity was between 94% and 100% RH due to equilibrium moisture exchange with the produce and the water vapor given off from the produce through respiration. The laminates created in these inventions did not have water vapor exchange capabilities, and the resultant high relative humidity created within the box resulted in condensation and accelerated microbial growth due to yeasts, molds and fungi and product quality loss due to condensation on the produce.

A variation of the invention was introduced by Machado et al. (US Patent Publication No. US2004/0188507) which featured a transparent impermeable polyethylene top which was sealed to an open faced tray. This adaptation provided for visibility of the product and improved the heat removal and product temperature maintenance of the product during transport. While the lid was treated with an anti-fog to prevent condensation on the lid, the lid and laminate used in the construction of the tray were impervious to water vapor transmission.

In a separate application Nir et. al (U.S. Pat. No. 6,190,710) used a series of nylon materials to create sealed bags for the creation of modified atmospheres for fruit and vegetables. Although the nylon materials could absorb moisture from the interior of the bag, the films were barriers to the transmission of oxygen and carbon dioxide through the films. To allow oxygen to penetrate into the bag to prevent anaerobiosis and to prevent carbon dioxide created from respiration from exceeding 20% CO₂, a series of microperforations were created in the film to allow gas transmission. The modified
atmospheres created by this method were limited to combinations where the oxygen and carbon dioxide contents totalled 20%.

[0010] A novel functional modified atmosphere package which can provide a range of beneficial relative humidity levels is described. The design and use of moisture absorbing materials can be used to create high carbon dioxide levels within the package through the package design and/or micro-perforations. The package or box can be used in a variety of shapes and configurations for commercial and institutional use and can impart significant benefits in maintaining food quality, extending the usable life of produce and provide greater consumer confidence in food safety.

[0011] The related art cited previously and the limitations referenced are meant to be illustrative and not exclusive. Additional limitations of the related art will become apparent to those of skill in the art upon the description of the specifications and study of the designs noted in the figures.

SUMMARY OF THE INVENTION

[0012] The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools, and methods which are meant to be illustrative and not limiting in scope. In various iterations and embodiments, one or more of the previously described technical shortfalls or problems have been compensated for or eliminated, while other embodiments are directed to other improvements.

[0013] The invention describes a closed gas impermeable paperboard package comprising several iterations which may include a one-piece box design, a three-piece Bliss box design, a box and a lid where the box and lid may consist of a three layer laminate or the lid may be a clear or opaque polymeric lid with gas permeable properties and/or water vapour transmission properties.

[0014] This invention relates to a novel application which provides for simultaneous control and regulation of water vapour transmission through an engineered three layer laminate and oxygen and carbon dioxide transmission through a novel sealing process and/or micro-perforations to maintain the retention of quality of fresh fruit, vegetables and flowers held at refrigerated temperatures for extended storage periods of 10 to 50 days.

[0015] This invention consists of several novel components for both the container body and the lid. The container body consists of a laminate comprised of:

[0016] 1/ A primary structural layer of bleached or unbleached Kraft paper consisting of 150 to 250 g/m² virgin or recycled fibres;
[0017] 2/ An intermediate layer of polymeric coating with water vapour transmission properties with or without oxygen and carbon dioxide transmission properties;
[0018] 3/ A third layer comprising a smooth thin layer of machine finish or machine glaze consisting of 20 to 100 g/m² of natural or bleached virgin or recycled Kraft paper.

[0019] The three layer laminate can be used to create a three or more layer corrugate using standard corrugation practices. The laminate can be used to create a wide range of box types and configurations.

[0020] The objectives of this invention, which are to be achieved from the design, composition and implementation of this system, are:

[0021] 1/ retention of quality of whole or fresh-cut fruit, vegetables and flowers;
[0022] 2/ retention of moisture or a slight reduction of moisture (+ or −2% of total weight of the product)
[0023] 3/ inhibition of mold, yeast and bacterial development on fruit, vegetables and flowers;
[0024] 4/ inhibition of off-flavors that develop from yeast, mould or bacteria growth and/or physiological senescence physiological processes;
[0025] 5/ inhibition of chlorosis and necrosis as a result of loss of energy reserves (i.e. sugars, ATP, ADP and AMP).

[0026] The invention consists of constructing a novel three layer laminate inclusive of the following:

[0027] 1/ utilizing a supportive layer of Kraft for rigidity and strength which may consist of 150 g to 250 g/m² virgin or recycled paper;
[0028] 2/ laminating of a layer of polyamide (nylon 6, 11, 12 and similar water absorbing plastic material or combinations thereof) nylon placing the product in a custom designed container consisting of an open-box structure with a custom designed profile that provides for air movement above and below the container.

[0029] The three layer laminate once constructed should provide a barrier to oxygen and carbon dioxide transmission with oxygen transmission rates of 0 to 200 cm³ per m² per 24 hours at 25°C, at 1 atm, and carbon dioxide transmission rates of 0 to 800 cm³ per m² per 24 hours at 25°C. at 1 atm.

[0030] The invention requires the three layer laminate to be corrugated to a flute and a third layer of Kraft paper. The laminate may be positioned on the interior or exterior of the container or alternatively the laminate may comprise both layers on either side of the flute in the final corrugate construction.

[0031] The invention describes the formation of the corrugated laminate into a range of differing container shapes and constructs which are compatible with an airtight sealed lid. The laminate in the formed container should be free of pinholes resulting from creasing, folding and/or sealing the container.

[0032] The described lid can consist of a single piece that may include:

[0033] 1/ a rigidized sheet of plastic material thermoformed and constituted from a range of plastic materials including but not limited to polyamide (nylon 6, 11, 12 or 66 and blends thereof), polycarbonate, polyethylene, polyethyleneterephthalate, polypropylene, polystyrene, polyvinylchloride, and mixtures thereof;
[0034] 2/ a design that provides for a friction fitting lid that is self levelling and which can seal to the laminate of the located at the top profile of the corrugated container;
[0035] 3/ a design that provides for an air tight seal with the bottom of the container which contains the airtight laminate.

[0036] The water vapor absorption and permeability can be determined by regulating the composition of the polymer in the laminate, or by regulating the thickness of the extrusion of the polymer in forming the laminate.

[0037] The oxygen and carbon dioxide gas barrier properties can be modified and customized by regulating the composition of the polymer in the laminate or by regulating the thickness of the extrusion in the laminate. However this invention describes gas barrier applications for oxygen and carbon dioxide gas and does not extend to gas permeabilities.
above 200 cm³ per m² per 24 hours at 25°C at 1 atm for oxygen, and above 800 cm³ per m² per 24 hours at 25°C at 1 atm for carbon dioxide.

[0038] The prescribed lid may be transparent or may be colored in its formation to provide colored coding for operational efficiencies while retaining transparency. The lid may also be opaque.

[0039] The lid may be sealed to the container by adhesives consisting of but limited to silicone, liquid or paste polymeric sealants, hot melt glues and/or gas impermeable or permeable adhesive tapes.

[0040] The sealed container may provide for oxygen diffusion into the construct be a series of regulated openings which may consist of:

[0041] 1/ Microperforations of 50 to 90 micron diameter. The number of microperforations will be determined by the surface area to produce volume, the produce respiration rate and the temperature. However in most cases the number of microperforations will range from 1 to 100 per container;

[0042] 2/ Microperforations may be placed in the lid, the body of the container or both locations;

[0043] 3/ Microperforations may occur at the container body to lid seal depending upon the sealant used;

[0044] 4/ Microperforations may be created at the folds in the formation of the corrugated container;

[0045] 5/ Microperforations should be uniformly distributed across the container and/or lid.

[0046] The container top and bottom materials can to maintain internal humidity in the range of 75% RH to 90% RH by the use of polyamide materials and thickness of construction.

[0047] Prior to sealing the package, air may be removed from the package by vacuum.

[0048] The sealed package of respiring fresh food can contain a ratio mass (grams) to total package volume (cm³) of between 0.3 to 0.6. The headspace gas composition of the sealed package can be between 1 and 50% carbon dioxide and 0.5% to 15% oxygen with internal relative humidity of 75% RH to 100% RH.

BRIEF DESCRIPTION OF THE DRAWINGS

[0049] The disclosed containers are described diagrammatically in the following drawings wherein:

[0050] FIG. 1 provides a plan view of the basic embodiments of the blank construct that, once folded, forms the corrugated container.

[0051] FIG. 2 provides an alternate plan view of the basic embodiments of the blank construct that, once folded, forms the corrugated container.

[0052] FIG. 3 provides top, side and perspective views of the basic embodiments of the lid construct.

[0053] FIG. 4 provides an alternate top, side and perspective views of the basic embodiments of the lid construct.

[0054] The drawings are not necessarily to scale and the embodiments are sometimes illustrated by graphic symbols, phantom lines, diagrammatic representations and fragmentary views. In certain instances, details which are not necessary for an understanding of the disclosed containers or which may render other details difficult to perceive may have been omitted. It should be understood, of course, that the disclosure is not necessarily limited to the particular embodiments illustrated herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0055] Throughout the following description, specific details are set forth in order to provide a more thorough understanding of the invention. However, the invention may be practised without these particulars. In other instances, well known elements have not been shown or described in detail to avoid unnecessarily obscuring the invention. Accordingly, the specification is to be regarded in an illustrative, rather than a restrictive, sense.

[0056] This invention provides a novel packaging application involving the preparation of washed, sanitized, fruits and vegetables followed by humidity regulated, modified atmosphere packaging of the product for transport, storage and/or distribution to retail, wholesale and/or institutional markets. The fresh product continues to respire in the sealed container and consumes oxygen and releases carbon dioxide into the chamber environment and is subject to beneficially high carbon dioxide and reduced oxygen concentrations. This state provides for reduction of product respiration, inhibition of microbiological growth and spore germination and inhibition of senescence promoting ethylene action thereby maintaining product ripeness and retarding deterioration of the product.

[0057] The functional, recyclable humidity regulating/modified atmosphere storage container and lid is illustrated in FIGS. 1, 2, 3 and 4. The apparatus provides for the simultaneous and/or independent regulation of water vapor, carbon dioxide and oxygen, transmission between the interior and exterior of the sealed package and the ambient storage atmosphere. Water vapor transmission is regulated by the absorption of water vapor by the polyamide layer contained in the three layer laminate. Oxygen and carbon dioxide transmission is regulated by the use of micro-perforations contained in the lid and/or the container containing and/or the lid to container seal. Generally if micro-perforations are used the total surface area would be in the range of 50 to 200 microns and can be customized for specific product categories. The lid is perforated with micro-perforations with total perforation surface area up to 1% of the total sealed package surface area.

[0058] According to the invention, optimum maturity fruits, vegetables and flowers are placed into the container and sealed in the container constructed with the appropriate linerboard for maintenance of the desired internal relative humidity and the sealed container and lid with the appropriate microperforation surface area for the attainment of high carbon dioxide levels (5% to 20%) and low oxygen levels (15% to 1%) in the headspace of the container after 7 days of storage at 1°C. Sufficient microperforations are provided for specific products and volumes to ensure that oxygen levels do not fall below 1% where anaerobic respiration can affect product quality and food safety may become an issue. Specifically, the film oxygen transmission ranges for ratio mass (grams) to total package volume (cm³) of between 0.3 to 0.6 would be applicable as:

[0059] The invention provides for a range of relative humidity, carbon dioxide and oxygen conditions through creation and application of:

[0060] 1. A novel three layer laminate which is constructed from 50 to 200 g/m² virgin bleached or unbleached kraft paper laminated with plastic material
consisting of a range of plastic materials including but not limited to polyamide (nylon 6, 11, 12 or 66 and blends thereof), polycarbonate, polyethylene, polyethylene-terephthalate, polypropylene, polystyrene, polyvinylchloride, and mixtures thereof and further laminated at a rate of 20 to 100 g/m² to a thin tissue consisting of 10 to 100 g/m² bleached or unbleached paper, to form a construct capable of absorbing and transmitting water vapor and providing a barrier to oxygen and carbon dioxide transmission;  

[0061] 2. Corrugation of the prepared laminate with Kraft paper to form a three to five layer construct and subsequent box formation;  

[0062] 3. A unique plastic lid that may be constituted from a range of plastic materials including but not limited to polyamide (nylon 6, 11, 12 or 66 and blends thereof), polycarbonate, polyethylene, polyethylene-terephthalate, polypolypropylene, polystyrene, polyvinylchloride, and mixtures thereof of a design that provides an airtight seal to the laminate portion of the three to five layer corrugate.  

[0063] The three layer laminate may be constructed from 50 to 200 g/m² virgin bleached or unbleached Kraft paper laminated with plastic material consisting of a range of plastic materials (10 to 100 g/m²) including but not limited to polyamide (nylon 6, 11, 12 or 66 and blends thereof), polycarbonate, polylactide, polyethylene, polyethylene-terephthalate, polylactide, polylactide, polylactide, polylactide, polylactide, and mixtures thereof and further laminated to a thin tissue consisting of 20 to 100 g/m² bleached or unbleached paper, to form a construct capable of absorbing and transmitting water vapor and providing a barrier to oxygen and carbon dioxide transmission.  

[0064] The three layer laminate may be created by  

[0065] The lid may be constructed from a range of plastic materials including but not limited to polyamide (nylon 6, 66, 11, Or 12 and blends thereof) polycarbonate, polylactide, polylactide, polylactide, polylactide, polylactide, and mixtures thereof.  

[0066] The three layer laminate once corrugated into a three or five layer construct may be die cut to a wide range of designs that may be further formed into a range of box designs (FIGS. 1, 2, 3, and 4) that provide for flexible vertical profile that provide ventilation spaces between boxes in a vertical stack and to provide air flow channels within a stack, within an individual pallet and among pallets constituting a container load.  

[0067] The container design may have the functional attributes that provide for interlocking of the boxes within a stack by tabs, adhesion of two adjoining boxes in a vertical stack by adhesives and/or tape and/or by strapping and the use of corner posts to secure a pallet load as a single unit.  

[0068] The container should have rigid walls with high water vapor transmission and oxygen and carbon dioxide barrier properties. The container laminate and lid properties should provide permeability ranges for water vapour of 1 to 10 g H₂O per mm-m² per 24 hr at 25° C. at 80-95% RH; oxygen transmission rates of: 10 to 200 cm³ per m² per 24 hours at 25° C. at 1 atm; and carbon dioxide transmission rates of: 10 to 800 cm³ per m² per 24 hours at 25° C. at 1 atm.  

[0069] The container and lid microperforations provide for oxygen:carbon dioxide diffusion ratio may be in the range of 0.1:0 or 1.5.  

[0070] The microperforations provided in the lid and/or container may be inserted to provide a range of oxygen and carbon dioxide transmissions for the lid/container construct for specific product applications:  

[0071] Category 1:  

[0072] High Barrier:  

[0073] Oxygen transmission rates of: 10 to 1500 cm³ per m² per 24 hours at 25° C. at 1 atm  

[0074] Carbon dioxide transmission rates of: 10 to 2000 cm³ per m² per 24 hours at 25° C. at 1 atm.  

[0075] Sample product applications: Baby carrots, beets, okra and other root crops; fresh cut salads.  

[0076] Category 2:  

[0077] Medium Barrier:  

[0078] Oxygen transmission rates of 1500 to 5000 cm³ per m² per 24 hours at 25° C. at 1 atm  

[0079] Carbon dioxide transmission rates of: 1500 to 7500 cm³ per m² per 24 hours at 25° C. at 1 atm.  

[0080] Sample product applications: Fruits such as cantaloupe, honey dew, tomatoes, apple, pears, cherries, grapes, peaches, nectarines, kiwi, strawberries, tomatoes, cucumbers (in general citrus, pome and drupe fruits, berries and greenhouse crops).  

[0081] Category 3:  

[0082] Low Barrier (High Permeability):  

[0083] Oxygen transmission rates of: 25,000+ cm³ per m² per 24 hours at 25° C. at 1 atm  

[0084] Carbon dioxide transmission rates of: 25,000+ cm³ per m² per 24 hours at 25° C. at 1 atm.  

[0085] Sample product applications: Mushrooms, asparagus.  

[0086] The novel apparatus provides additional maintenance of food product quality with options to regulate the relative humidity within the sealed package through the selection of lid, container and film materials. Fabrication of the film, container and/or lid from a range of polyamide materials provides the ability to absorb moisture and regulate relative humidity levels within the sealed package. Maintenance of internal relative humidity levels at approximately 75% RH to 90% RH maintains product quality by removing residual surface water from the product, providing slight moisture reduction of the product, removal of water vapour generated from product respiration and maintain a relative humidity level that suppresses microbial vegetative growth and spore germination (below 80% RH).  

[0087] Many fresh fruit, vegetable and flowers have demonstrated a 2 times to 4 times increase in the effective storage, distribution and shelf life if the product is stored without residual moisture after washing and dried to original it original weight or within +/-1% (w/w) of its original weight.  

[0088] Fresh produce generates water as a product of respiration. This moisture when added to an enclosed system increases the relative humidity beyond the equilibrium value. In most cases, equilibrium relative humidity between the produce and surrounding atmosphere is an enclosed environment is established at 90% to 94% RH. The present novel application provides for the release of incremental moisture resulting from natural respiration of the produce, eliminates or reduces condensation in the internal atmosphere of the package and provides for the maintenance of optimal internal relative humidities of 75% to 90%.  

[0089] The described invention provides for the maintenance of an optimum range of moisture contents with fresh fruit, vegetables and flowers and in the surrounding enclosed package environment to preserve product quality, freshness and storage, distribution and shelf life. In addition, a second
layer of technology is created through the application of modified atmospheres generated by using a sealed container system with microperforations to create high levels of carbon dioxide (5% to 20% CO₂) plus low levels of oxygen (1% to 15% O₂) to suppress product respiration to conserve the product's metabolites and maintain quality. The present application has long term benefits in suppressing the respiration of the product, maintaining optimal product moisture content and maintaining a favorable internal relative humidity environment that suppresses growth of bacteria, yeast and molds which affect product quality and food safety.

Example 1

[0090] The process for preparation and preservation of fresh peaches (cv. Red Haven) using the invention, involves the following:

[0091] 1. Fresh peaches were harvested at a full ripe maturity indicated by a lack of chlorophyll in the ground cover of the flesh with a firmness of 4 to 6 kgf fruit firmness;

[0092] 2. The fruit were sanitized with a 100 ppm solution of chlorine, dried, cooled to 1°C, and packed in the described container constructed with 30 g per m² nylon 6/12 laminate with oxygen transmission rate 5000 cm³ per m² per 24 hours at 25°C, at 1 atm as created with 10 microperforations in a container containing 9 kg of fresh peaches. Oxygen atmospheres were maintained between 2 and 3% oxygen while carbon dioxide atmospheres were maintained at 5% to 6%;

[0093] 3. A control sample of peaches of the same maturity was placed in a similar modified atmosphere package maintained at 94% RH to 100% RH;

[0094] 3. Peaches in the control and those stored in the invention were held at 1°C for periods of 10, 20 and 30 days;

[0095] Peaches stored in the control packages demonstrated an increase in individual fruit volume after 10 days of storage. The increased fruit volume was associated with a decrease in fruit density and a lack of juiceiness dryness) when evaluated by 5 sensory panelists. The increase in volume was associated with an increase in water uptake resulting from the high relative humidity in the package.

[0096] Peaches stored in the invention at relative humidity maintained at 80% to 85% RH showed no increase in fruit volume or decrease in fruit density after 30 days. Fruit stored in the invention at relative humidity of 80% to 85% RH remained juicy and acceptable to sensory panelist for up to 40 days with an average sensory score of 3.5 rated on a full scale of 5 (5 being excellent and 5 deemed to be marginally acceptable). Browning and wilting of the fruit was not evident after 40 days. No off odors or evidence of mould or decay were identified.

Example 2

[0097] The process for preparation and preservation of perishable kiwi fruit using the invention, involves the following:

[0098] 1. Ready-to-eat firm mature ripe kiwi fruit (cv. Hayward; firmness of 3 to 5 kgf) that are free of obvious decay are selected, washed with or 100 ppm chlorine if available and dried;

[0099] 2. Kiwi fruit are packed in preformed trays composed either of wood fibre or plastic (wood fiber is preferred) and placed in the container;

[0100] 3. The kiwi fruit are cooled to 0°C and the container is sealed by placing the plastic top in place with the desired sealant;

[0101] 4. The kiwi fruit were sealed in the package with microperforations sufficient to provide an oxygen transmission rate of 3000 cm³ per m² per 24 hours at 25°C at 1 atm and stored at 0°C for up to 28 days.

[0102] The quality of the kiwi fruit compared to conventionally packed controls (corrugated boxes) controls demonstrated superior eating quality and freedom from decay after 28 days in the container. Whereas control fruit were noticeably shrivelled, soft and showed an 18% incidence of decay, the fruit packed in the novel box technology showed typical kiwi fruit flavor and sensory characteristics. Incidence of decay of kiwi fruit stored in the novel container was not evident. Kiwi fruit placed in the conventional corrugated containers were rated as unacceptable for consumption after day 8 of storage by a 5 member trained sensory panel.

[0103] Kiwifruit stored in the described novel container were rated by the sensory panel as excellent on day 20 of storage and as acceptable at day 28. Fruit pieces were bright green and opaque with texture equivalent to the texture at day 0. Characteristic kiwi flavour was maintained throughout the 28 days storage period without noticeable off-flavours (ethanol and acetaldehyde), shrivelling of the skin or decay as found in the control fruit.

Example 3

[0104] The process for preparation and preservation of fresh mushrooms using the invention, involves the following:

[0105] 1. Fresh white mushrooms were harvested closed cap maturity;

[0106] 2. The fruit were washed in a fresh water cascade and dried by warm dry air to the original weigh, cooled to 1°C and packed in the described container constructed with 35 g per m² nylon 6/6 laminate with oxygen transmission rate of 30,000 cm³ per m² per 24 hours at 25°C at 1 atm created with 90 microperforations in a container containing 5 kg of fresh mushrooms. Oxygen atmospheres were maintained between 3 and 5% oxygen while carbon dioxide atmospheres were maintained at 7% to 10%;

[0107] 3. A control sample of mushrooms of the same maturity was placed in a similar modified atmosphere package maintained at 94% RH to 100% RH;

[0108] 4. Mushrooms in the control and those stored in the invention were held at 1°C for periods of 5, 10 and 15 days;

[0109] Mushrooms stored in the control packages appeared slimy after ten days at high relative humidity storage. Analysis of the microbial content indicated pseudomonas content of more than 1,000,000 colony forming units (CFU), product was not considered fit for evaluation or consumptions by a trained panel.

[0110] Mushrooms stored in the invention at relative humidity maintained at 75% to 80% RH were evaluated by a 5 member panel as acceptable as acceptable for up to 15 days with an average sensory score of 3.25 rated on a full scale of 5 (5 being excellent and 3 deemed to be marginally accept-
able). Browning and wilting of the fruit was not evident after 15 days. No off odors or evidence of mold or decay were identified.

Example 4

[0111] The process for preparation and preservation of fresh grapes (cv. Thompson Seedless, Perlette) on the stem using the invention, involves the following:

[0112] 1. Fresh grapes were harvested at a full ripe maturity indicated by sugar/acid ratio (soluble solids content);

[0113] 2. The fruit were sanitized with a 100 ppm solution of chlorine, dried, cooled to 1°C and packed in the described container constructed with 35 g per m² nylon 6/12 laminate with oxygen transmission rate 4000 cm³ per m² per 24 hours at 25°C at 1 atm as created with 15 microperforations in a container containing 9 kg of fresh grapes. Oxygen atmospheres were maintained between 2 and 3% oxygen while carbon dioxide atmospheres were maintained at 5% to 6%;

[0114] 3. A control sample of grapes of the same maturity was placed in a similar modified atmosphere package maintained at 94% RH to 100% RH;

[0115] 4. Grapes in the control and those stored in the invention were held at 1°C for periods of 10, 20 and 30 days;

[0116] Grapes stored in the control packages at elevated relative humidity of 94% RH to 100% RH demonstrated an increase in individual fruit weight after 5 days of storage and continued to increase with extended storage time. The increased fruit weight was associated with an increase in the proportion of the number of fruit detached from the vine. The increase in individual fruit absorption of water vapor increased the turgidity of the fruit and resulted in the fruit separation from the vine.

[0117] Grapes on the vine stored in the invention at relative humidity maintained at 75% to 85% RH showed no increase in individual fruit weight fruit density after 30 days of storage. Individual fruit weight remained +/- within 1% of the initial weight. Fruit stored in the invention at relative humidity of 75% to 85% RH remained juicy and acceptable to sensory panelist for up to 35 days with an average sensory score of 3.8 rated on a full scale of 5 (5 being excellent and 3 deemed to be marginally acceptable). Browning and wilting of the fruit was not evident after 40 days. No off odors or evidence of mould or decay were identified.

Example 5

[0118] The process for preservation and preservation of fresh bell peppers using the invention, involves the following:

[0119] 1. Fresh greenhouse grown bell peppers were harvested at a full ripe maturity indicated by color, heat units and productions days;

[0120] 2. The fruits were sanitized with a 200 ppm solution of chlorine, dried, cooled to 1°C and packed in the described container constructed with 35 g per m² nylon 6/12 laminate with oxygen transmission rate 4000 cm³ per m² per 24 hours at 25°C at 1 atm as created with 15 microperforations in a container containing 7 kg of fresh peppers. Oxygen atmospheres were maintained at 2 and 3% oxygen while carbon dioxide atmospheres were maintained at 5% to 6%;

[0121] 3. A control sample of peppers of the same maturity was placed in a similar modified atmosphere package maintained at 94% RH to 100% RH;

[0122] 4. Bell peppers in the control and those stored in the invention were held at 1°C for periods of 10, 20 and 30 days;

[0123] Bell peppers stored in the control packages at elevated relative humidity of 94% RH to 100% RH demonstrated an increase in individual fruit weight after 7 days of storage and continued to increase with extended storage time. The increased fruit weight was associated with an increase in the incidence of mold in the stem cavity of the fruit.

[0124] Bell peppers stored in the invention at relative humidity maintained at 75% to 85% RH showed no increase in individual fruit weight after 25 days of storage. Individual fruit weight remained +/- within 1.5% of the initial weight. Fruit stored in the invention at relative humidity of 75% to 85% RH remained free of overt mold symptoms and acceptable to sensory panelists for up to 35 days with an average sensory score of 4.0 rated on a full 5 point scale.

[0125] As will be apparent to those skilled in the art with respect to the foregoing disclosures, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined in the following claims.

[0126] Most modified atmosphere packaging systems use sealed boxes or bags with or without perforations to create high levels of carbon dioxide (5% to 20% CO₂) plus low levels of oxygen (1% to 15% O₂) to suppress product respiration to conserve the products metabolites and maintain quality. Most of these applications provide an elevated relative humidity around the product to prevent desiccation. In addition the water vapor produced from the respiration of the produce contributes to excessively high level of relative humidity that exceeds the equilibrium humidity established under passive conditions. While the passive application has a short term benefit, respiration of the product generates moisture which develops a saturated environment leading to the growth of bacteria, yeast and molds which affect product quality and food safety. In addition, excessively high moisture levels lead to softening and necrosis of the product resulting in the rapid deterioration of quality.

[0127] As will be apparent to those skilled in the art with respect to the foregoing disclosures, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined in the following claims.

What is claimed is:

1. A water permeable sealed container for the preservation of fresh fruits, vegetables and flowers that consists of:
   a) A three layer water permeable laminate corrugated to form a further three to five layer construct consisting of one or two layers of kraft paper fluting and a further one or two layers of kraft paper;
   b) A water permeable lid that is sealed by a range of adhesives and/or tape to the laminate.

2. A sealed container system and lid (FIG. 1, FIG. 2, FIG. 3 and FIG. 4) that be designed in various shapes, sizes and container designs.

3. A sealed container system and lid for the preservation of fresh fruits, vegetables and/or flowers modified atmosphere
package between 1% and 15% oxygen and 1% and 20% carbon dioxide at relative humidity between 75% RH and 100% RH.

4. A sealed container that includes a three layer laminate that consists of:
   a) A first layer of 150 to 250 g per m² kraft paper;
   b) A layer 10 to 100 g per m² of water permeable polymer that may be constituted from a range of plastic materials including but not limited to polyamide (nylon 6, 11, 12 or 66 and blends thereof), polycarbonate, polyethylene, polyethylene terephthalate, polypropylene, polystyrene, polyvinylchloride, and mixtures thereof;
   c) A second layer of 20 to 100 g per m² kraft paper which effectively encloses the polymeric film between the two layers of kraft paper.

5. A sealed container that is constituted from a three to five layer corrugate formed by the corrugation and adhesion of the laminate to a kraft paper flute and a further layer of kraft paper.

6. A sealed container that is formed by die cutting the corrugate sheet into a range of container shapes that may include constructs shown in FIG. 1 and FIG. 2.

7. A sealed container that is formed from kraft paper that is either bleached or unbleached.

8. A sealed container that is formed from kraft paper that consists of either virgin or recycled wood fiber.

9. A sealed container that consists of a thermoformed polymeric lid that may be constituted from a range of plastic materials including but not limited to polyamide (nylon 6, 66, 11, Or 12 and blends thereof), polycarbonate, polyethylene, polyethylene terephthalate, polypropylene, polystyrene, polyvinylchloride, and mixtures thereof.

10. A sealed container that deploys several methods to provide an airtight seal between the laminate and the lid including but not limited to:
    a) A lid with friction fit compressed physical attachment to the laminate;
    b) A lid with adhesive applied to the lid edges at the point of contact with the laminate of the container;
    c) A lid design that is sealed to the laminate of the container with gas barrier adhesive tape.

11. A sealed container that uses a laminate and lid that absorbs water vapour and transmits water vapour from the interior of the container (80% to 100% RH) to the exterior of the container (10% RH to 50% RH).

12. A sealed container that contains a laminate and lid that have low permeabilities to the transfer of oxygen and carbon dioxide gas.

13. A sealed container that uses a range of microperforations (60 to 90 microns in diameter) in either the container laminate and/or the lid.

14. A sealed container that provides a range of microperforations designed for specific package volumes, product type and respiration to provide for the following conditions:

   Category 1:
   High Barrier Film:
   Oxygen transmission rates of: 100 to 1500 cm³ per m² per 24 hours at 25°C. at 1 atm Carbon dioxide transmission rates of: 100 to 2000 cm³ per m² per 24 hours at 25°C. at 1 atm.
   Sample product applications: Baby carrots, beets and other root crops; fresh cut salads.
   Category 2:
   Medium Barrier Film:
   Oxygen transmission rates of: 1500 to 5000 cm³ per m² per 24 hours at 25°C. at 1 atm Carbon dioxide transmission rates of: 1500 to 7500 cm³ per m² per 24 hours at 25°C. at 1 atm.
   Sample product applications: Fruits such as cantaloupe, honey dew, tomatoes, apple, pears, cherries, grapes, peaches, nectarines, kiwi, strawberries, tomatoes, cucumbers (in general citrus, pome and drupe fruits, berries and greenhouse crops).
   Category 3:
   Low Barrier (High Permeability) Film:
   Oxygen transmission rates of: 25,000+ cm³ per m² per 24 hours at 25°C. at 1 atm Carbon dioxide transmission rates of 25,000+ cm³ per m² per 24 hours at 25°C. at 1 atm.
   Sample product applications: Mushrooms, asparagus.

15. A system that can regulate relative humidity within the container within a range of 75 to 94%, preferably between 75% and 85% for some foods by removing moisture from the food and the moisture generated from respiration. The resulting relative humidity suppresses product decay due to microorganisms.

16. A system for the maintenance of fruit, vegetable and flower quality using modified atmospheres consisting of 1% to 50% carbon dioxide and 1% to 15% oxygen.

17. A system that independently controls modified atmospheres and relative humidity within the container at temperatures of 0°C to 25°C.

18. A system where the sealed package of respiration produce can contain a mass ratio (grams) to total package volume (cm³) of between 0.3 to 0.6. The headspace gas composition of the sealed package can be between 1% and 50% carbon dioxide and 1% to 15% oxygen with an internal relative humidity of 75% RH to 100% RH.

19. A system which independently controls modified atmospheres and humidity within the container.

20. A system where the three layer laminate once corrugated into a three or five layer construct may be die cut to a wide range of designs that may be further formed into a range of box designs that provide for flexible vertical profiles that provide ventilation spaces between containers in a vertical stack and to provide air flow channels within a stack, within an individual pallet and among pallets of containers constituting a trailer or storage room load.

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