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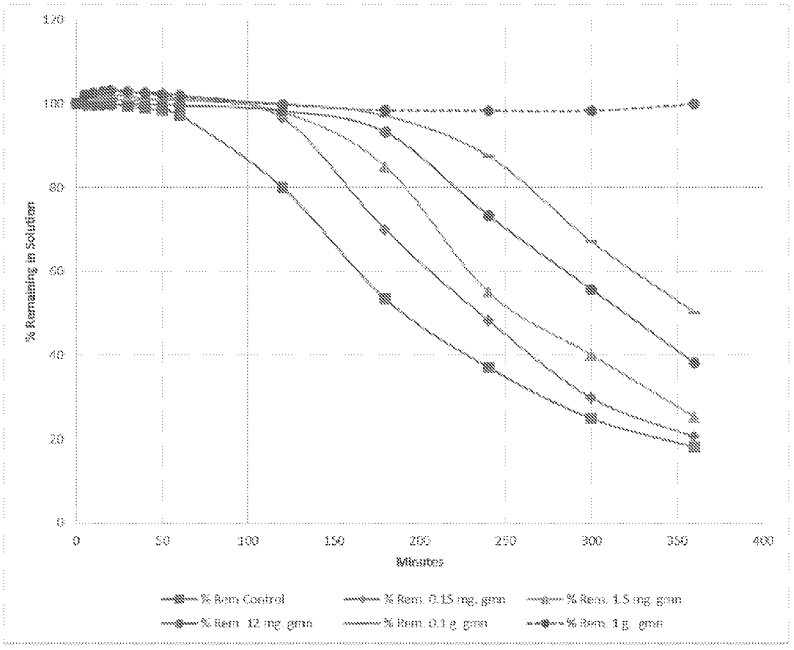


Figure 1

(57) Abstract: Provided are compositions, methods, and solutions for generating aqueous glucomannan solutions with hydrogen compositions greater than 100 parts per billion. Said glucomannan solutions have application in nutritional, therapeutic, and energy fields.

[Continued on next page]

WO 2020/023396 A1

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COMPOSITION AND METHODS FOR GENERATING AND SUSTAINING MOLECULAR HYDROGEN (H_2) IN AQUEOUS SYSTEMS

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Application No. 62/764,222, filed July 23, 2018, which application is incorporated herein by reference.

BACKGROUND

[0002] The health benefits of administering molecular hydrogen to humans and animals by various routes, including IV, oral, transdermal, and inhalation have been. Initially, molecular hydrogen was believed to function as an antioxidant by direct reaction with hydroxyl radicals and peroxynitrite, while leaving the signaling reactive oxygen species - superoxide and hydrogen peroxide, unchanged.

[0003] Molecular hydrogen is used for wellness, anti-aging, as well as prevention and treatment of numerous diseases. Molecular hydrogen is readily absorbed into tissues. The duration of H_2 in the body is short-lived, since it readily diffuses in and out of tissues. Sustaining molecular hydrogen in the tissues of humans and animals is needed for increasing the efficacy of molecular hydrogen for reduction of tissue damage, effects on slowing aging and slowing the progression of chronic degenerative diseases as well as for body weight control. A means of generating and retaining molecular hydrogen in the body, in a safe, economic, and consumer-friendly manner, is needed to advance its use as a therapeutic agent.

SUMMARY

[0004] Provided herein are methods of generating an aqueous glucomannan solution containing molecular hydrogen, the method comprising: providing a volume of an aqueous solvent; and adding from about 0.00001% w/v to about 7.5% w/v glucomannan and about 0.005% to about 2.0% w/v magnesium metal powder to the aqueous solvent, wherein the generated glucomannan solution has an increased volume which is at least 0.01%, at least 0.1%, at least 1%, at least 10%, or at least 20% greater than the volume of a corresponding glucomannan solution which does not comprise H_2; wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion); and wherein, upon exposure of the glucomannan solution to standard temperature and pressure

(STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 50% or at least about 70% of the initial H2 concentration.

[0005] Provided herein are methods of generating a glucomannan solution, the method comprising: providing a volume of an aqueous solvent; generating or sequestering H_2 in the aqueous solvent; and adding glucomannan to the aqueous solvent, wherein the glucomannan solution has an increased volume which is about 0.01%, at least 0.1%, at least 1%, at least 10%, or at least 20% greater than the volume of a corresponding glucomannan solution which does not comprise H_2; wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion); and wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution retains at least 50% of its original concentration of H_2. Further provided are methods, wherein the aqueous solvent comprises water. Further provided are methods, wherein the aqueous solvent is water. Further provided are methods, wherein the generated glucomannan solution has a glucomannan concentration from about 0.00001% w/v to about 7.5% w/v. Further provided are methods, wherein the generated glucomannan solution is a gel. Further provided are methods, wherein the generated glucomannan solution is a flowable liquid. Further provided are methods, wherein the generated glucomannan solution comprises gaseous H_2. Further provided are methods, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration. Further provided are methods, wherein the volume of the generated glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent. In some methods provided herein further comprise a step of treating the aqueous solvent with electrolysis, thereby generating H_2 in the aqueous solvent, prior to, during, or subsequent to adding the glucomannan to the aqueous solvent. Further provided are methods, wherein the glucomannan solution comprises a base metal. Further provided are methods, wherein the aqueous solvent comprises the base metal. Further provided are methods, wherein a base metal is added to the aqueous solvent prior to the addition of the glucomannan to the aqueous solvent. Further provided are methods, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof. Further provided are methods, wherein the base metal is magnesium metal powder.

Further provided are methods, wherein the magnesium metal powder is present in the generated glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v. Further provided are methods, wherein the generated glucomannan solution further comprises an organic acid. Further provided are methods, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof. Further provided are methods, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v. Further provided are methods, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v. Further provided are methods, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided are methods, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v. Further provided are methods, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v. Further provided are methods, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided are methods, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v. Some methods provided herein further comprise a step of diffusing H_2 in to the aqueous solvent or the glucomannan solution from a pressurized environment. Some methods provided herein further comprise a step of exposing the generated glucomannan solution to electrolysis, thereby generating H_2 in the glucomannan solution. Further provided are methods, wherein the initial H_2 concentration is achieved during generation of the glucomannan solution. Further provided are methods, wherein the initial H_2 concentration is achieved prior to generation of the glucomannan solution. Further provided are methods, further comprising an isolating step, wherein bubbles in the glucomannan solution smaller than 37 microns are isolated. Further provided are methods, wherein the isolating is by filtration. Further provided are methods, wherein the isolating is by centrifugation. Further provided are methods, wherein the isolating is by size exclusion chromatography.

[0006] Provided herein are compositions comprising a glucomannan solution and further comprising hydrogen (H_2) at a concentration of greater than about 100 ppb (parts per billion); and wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution declines by less than 50% or less than 30%. Further provided herein are compositions, further comprising an aqueous solvent. Further provided herein are compositions, wherein the aqueous solvent is water. Further provided herein are compositions, wherein the concentration of glucomannan in the glucomannan solution is from about 0.00001% w/v to about 7.5% w/v. Further provided

herein are compositions, wherein the glucomannan solution is a gel. Further provided herein are compositions, wherein the glucomannan solution is a flowable liquid. Further provided herein are compositions, wherein the H_2 is present in the glucomannan solution in a gaseous form. Further provided herein are compositions, wherein the H_2 concentration 240 minutes after generation of the glucomannan solution is at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration. Further provided herein are compositions, wherein the volume of the glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent. Further provided herein are compositions, wherein the glucomannan solution comprises a base metal. Further provided herein are compositions, wherein the composition comprises a base metal. Further provided herein are compositions, wherein the aqueous solvent comprises a base metal. Further provided herein are compositions, wherein the base metal is selected from the group consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof. Further provided herein are compositions, wherein the base metal is magnesium metal powder. Further provided herein are compositions, wherein the magnesium metal powder is present in the glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v. Further provided herein are compositions, wherein the glucomannan solution further comprises an organic acid. Further provided herein are compositions, wherein the organic acid is selected from the group consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid, and any combination thereof. Further provided herein are compositions, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v. Further provided herein are compositions, wherein the malic acid is present in an amount from about 1% w/v to about 50% w/v. Further provided herein are compositions, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are compositions, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v. Further provided herein are compositions, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are compositions, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are compositions, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v. Further provided herein are compositions, wherein the composition is in a capsule or gel.

[0007] Provided herein are glucomannan solutions comprising a concentration of glucomannan and hydrogen (H_2). Further provided herein are solutions, wherein the hydrogen (H_2) is present at a concentration of greater than about 100 ppb (parts per billion) hydrogen (H_2). Further provided herein are solutions, wherein upon exposure to standard temperature and pressure (STP) for 240 minutes, the H_2 concentration is at least about 70% of the initial H_2 concentration as measured in parts per billion (ppb). Further provided herein are solutions, wherein the glucomannan concentration is from about 0.00001% to about 7.5%. Further provided herein are solutions, wherein the solution is a gel. Further provided herein are solutions, wherein the solution is a flowable liquid. Further provided herein are solutions, wherein the H_2 is present in a gaseous form. Further provided herein are solutions, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution declines by less than 1%, less than 5%, less than 10%, less than 15%, less than 20%, less than 25%, or less than 30%. as measured in parts per billion (ppb). Further provided herein are solutions, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution is at least 70% of the H_2 concentration in the solution prior to the exposure as measured in parts per billion (ppb). Further provided herein are solutions, further comprising a base metal. Further provided herein are solutions, wherein the base metal is selected from the group consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof. Further provided herein are solutions, wherein the base metal is magnesium metal powder. Further provided herein are solutions, wherein the magnesium metal powder is present in the glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v. Further provided herein are solutions, further comprising an organic acid. Further provided herein are solutions, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof. Further provided herein are solutions, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v. Further provided herein are solutions, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v. Further provided herein are solutions, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are solutions, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v. Further provided herein are solutions, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v. Further provided

herein are solutions, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are solutions, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v.

[0008] Provided herein are methods, compositions, and solutions as described herein, further formulated for oral administration. Provided herein are methods, compositions, and solutions as described herein, further formulated for rectal administration. Further provided are methods, compositions, or solutions, further formulated for oral delivery. Further provided are methods, compositions, or solutions, further formulated for esophageal delivery. Further provided are methods, compositions, or solutions, further formulated for gastric delivery. Further provided are methods, compositions, or solutions, further formulated for duodenal delivery. Further provided are methods, compositions, or solutions, further formulated for delivery to the small intestine. Further provided are methods, compositions, or solutions, further formulated for delivery to the large intestine. Further provided are methods, compositions, or solutions, further formulated for delivery to the colon.

[0009] Provided herein are methods, compositions, and solutions as described herein, further formulated for parenteral delivery.

[0010] Provided herein are compositions and solutions as described herein, further formulated for a topical dosage form. Further provided herein are compositions and solutions, wherein the topical dosage form is a cream, gel, foam, ointment, lotion, or liquid.

[0011] Provided herein is a bandage comprising compositions or solutions as described herein.

[0012] Provided herein is a kit for treating a skin condition, comprising: a container comprising a composition or solution described herein; instructions for applying the composition or solution topically to the skin.

[0013] Provided herein is a kit for treating a gastrointestinal condition, comprising: a container comprising a composition or solution as described herein; and instructions for oral or rectal administration of the composition or solution.

[0014] Provided herein is a kit for treating an inflammatory disease, comprising: a container comprising a composition or solution as described herein; and instructions for administration of the composition or solution to treat the inflammatory disease.

[0015] Provided herein is a kit for treating obesity, comprising: a container comprising a composition or solution as described herein; and instructions for oral administration of the composition or solution.

[0016] Provided herein are methods for treating a skin condition, comprising administering a composition or solution as described herein to the skin of a subject in need thereof.

[0017] Provided herein are methods for treating a gastrointestinal condition, comprising administering a composition or solution as described herein, to a subject in need thereof.

[0018] Provided herein are methods for treating an inflammatory condition, comprising administering a composition or solution as described herein, to a subject in need thereof.

[0019] Provided herein are methods for treating obesity, comprising administering a composition or solution described herein, to a subject in need thereof.

[0020] Provided herein are methods of providing H_2 as a nutritional supplement to a subject in need thereof, comprising providing a composition or solution as described herein to a subject in need thereof.

[0021] Provided herein are methods of providing H_2 to a body or container of water comprising aquatic or plant life, comprising contacting the water with a composition or the solution as described herein.

[0022] Provided herein are methods of sequestering H_2 from an aqueous solution in need thereof, comprising contacting the aqueous solution with a composition or solution as described herein.

[0023] Provided herein are devices comprising a composition or solution as described herein, flowably connected to a water source, allowing contact between the composition described herein and the water source.

[0024] Provided herein are compositions comprising a base metal and glucomannan. Further provided are compositions, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof. Further provided are compositions, wherein the base metal is magnesium metal powder. Further provided are compositions, further comprising an organic acid. Further provided are compositions, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof. Further provided are compositions, wherein the composition is in a powder form. Further provided are compositions, wherein the composition is substantially free of water. Further provided are compositions, wherein the composition is in a capsule or gel.

[0025] Provided herein are glucomannan solutions produced by a method as described herein. Provided herein are methods of generating a glucomannan solution, comprising

generation of a glucomannan solution that comprises H_2. Provided herein are methods of generating a glucomannan solution, comprising adding a magnesium metal powder and glucomannan to an aqueous solvent. Provided herein are methods of generating a glucomannan solution that retains molecular hydrogen longer than a solution without glucomannan, the method comprising: providing a relatively large volume of an aqueous solvent; adding an amount of glucomannan to the aqueous solvent; and generating and/or infusing an amount of molecular hydrogen into the aqueous solvent, wherein the glucomannan solution has a volume from zero to more than 100% greater than the volume of the aqueous solvent, wherein the increase in volume of the glucomannan solution over the aqueous solvent is dependent on the amount of glucomannan and molecular hydrogen in the glucomannan solution, wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion), and wherein, upon exposure of the glucomannan solution to standard temperature and pressure for at least four hours, the glucomannan solution comprises a level of molecular hydrogen greater than a level of molecular hydrogen in a comparable aqueous solution without glucomannan. Further provided herein are methods, wherein the generated glucomannan solution has a glucomannan concentration from about 0.00001% w/v to about 7.5% w/v. Further provided herein are methods, wherein the generated glucomannan solution is a gel. Further provided herein are methods, wherein the generated glucomannan solution is a flowable liquid. Further provided herein are methods, wherein the generated glucomannan solution comprises gaseous H_2. Further provided herein are methods, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration. Further provided herein are methods, wherein the volume of the generated glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent. Further provided herein are methods, further comprising a step of treating the aqueous solvent with electrolysis, thereby generating H_2 in the aqueous solvent, prior to adding the glucomannan to the aqueous solvent. Further provided herein are methods, wherein the glucomannan solution comprises a base metal. Further provided herein are methods, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof. Further provided herein are methods, wherein the base metal is magnesium metal powder. Further provided herein

are methods, wherein the magnesium metal powder is present in the generated glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v. Further provided herein are methods, wherein the generated glucomannan solution further comprises an organic acid. Further provided herein are methods, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof. Further provided herein are methods, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v. Further provided herein are methods, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v. Further provided herein are methods, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are methods, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v. Further provided herein are methods, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are methods, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v. Further provided herein are methods, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v. Further provided herein are methods, further comprising a step of diffusing H_2 in to the aqueous solvent or the glucomannan solution from a pressurized environment. Further provided herein are methods, further comprising a step of exposing the generated glucomannan solution to electrolysis, thereby generating H_2 in the glucomannan solution. Further provided herein are methods, wherein an initial H_2 concentration is achieved during generation of the glucomannan solution. Further provided herein are methods, wherein the initial H_2 concentration is achieved prior to generation of the glucomannan solution. Further provided herein are methods, further comprising an isolating step, wherein bubbles in the glucomannan solution smaller than 37 microns are isolated. Further provided herein are methods, wherein the isolating is by filtration. Further provided herein are methods, wherein the isolating is by centrifugation. Further provided herein are methods, wherein the isolating is by size exclusion chromatography.

[0026] Provided herein are H_2-generating compositions comprising: lactic acid; glucomannan; magnesium metal powder; glycerin; and an aqueous solvent. Provided herein are H_2-generating compositions comprising: an organic acid; glucomannan; magnesium metal powder; glycerin; and an aqueous solvent. Further provided herein are compositions, wherein the composition is a cream, gel, foam, ointment, lotion, or liquid. Provided herein are, wherein the composition is adapted for application to the skin of a subject. Provided herein are, wherein the composition provides a moisturizing effect to the skin of the subject.

INCORPORATION BY REFERENCE

[0027] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0029] **Figure 1** indicates the time course of molecular hydrogen (H_2) depletion from glucomannan solutions.

[0030] **Figure 2** indicates the time course of hydrogen generation by distilled water electrolysis in the presence and absence of glucomannan.

[0031] **Figure 3** shows microbubbles observed in a solution 4.5 hours after preparation.

[0032] **Figure 4** shows microbubbles observed in a solution 8.5 hours after preparation.

[0033] **Figure 5A** shows an exemplary housing, comprising a glucomannan gel, comprising preformed pores to allow for increased surface area of contact with a solution.

[0034] **Figure 5B** shows an exemplary housing for a glucomannan gel, with inlet and outlet ports to allow flow of liquid through the housing and in contact with the glucomannan gel.

[0035] **Figure 6** shows an exemplary system comprising a device as described in Figure 5A and 5B and a series of pre-filters to remove particles or other compounds.

DETAILED DESCRIPTION

[0036] Provided herein are compositions and methods to generate molecular hydrogen in aqueous compositions. The compositions provided herein maintain levels of molecular hydrogen (H_2) within the composition for longer periods of time and release the molecular hydrogen more slowly than in other compositions previously known in the art.

I. GENERATION OF MOLECULAR HYDROGEN

[0001] The concentration of hydrogen (H_2) is often reported in molarity (moles/liter (M) or millimoles/L (mM)), parts per million (ppm), parts per billion (ppb) or milligrams per liter (mg/L). In dilute concentrations, 1 ppm is about the same as 1 mg/L and they are often used interchangeably. The molar mass of molecular hydrogen is about 2 mg/millimole, 1 mg is approximately equivalent to 0.5 moles, therefore 1 ppm = 1 mg/L = 0.5 mM.

[0002] The solubility of gas dissolved in water is a function of pressure and temperature according to Henry's law:

$$C = P/K_H$$

where C represents the concentration of the dissolved gas (mol/L), K_H is a constant characteristic of the particular gas (Latm/mol), and P represents the partial pressure of the specific gas above the solution (atm). Given hydrogen (H_2) gas constitutes 5.5×10^{-5}% of atmosphere, and Henry's Constant at 25C is 1282.05 l*atm/mol, the concentration of hydrogen in water at 1 atmosphere is 4.29×10^{-7} mM, 8.65×10^{-7}, or 8.65×10^{-4} ppb.

[0003] Generally known methods of generating molecular hydrogen for health care purposes include: electrolysis of water, reaction of base metals and metal hydrides with water, direct water splitting through vibrating piezoelectric zinc oxide microfibers in aqueous solutions, and pressurizing molecular hydrogen into water in containers resistant to permeation.

[0004] In some embodiments described herein, the molecular hydrogen is generated using electrolysis. Several commercial electrolysis devices are available for generating molecular hydrogen from water. These devices are limited in that they require 'purified' water. 'Purified' water is defined here as water that is free of contaminants. Of most concern is the presence of those electrolytes in water that can form deposits on the electrodes of the electrolysis device and render it useless. 'Purified' water can be produced by distillation, reverse osmosis, ion exchange or any method that results in water that is free of, or very low in, ions and organic contaminants. For electrolysis, the pH should be near neutral and free of electrolytes that can degrade the electrodes. Use of electrolytes greatly reduces the lifetime of electrodes. A major disadvantage in using 'purified' water, e.g., distilled water, is the very low output of H_2. To increase molecular hydrogen generation from 'purified' water, high voltage, unsafe for consumers, is generally used.

[0005] In some embodiments described herein, the molecular hydrogen is generated using electrolysis.

II. GLUCOMANNAN

[0006] Konjac glucomannan is derived from the tuber of the *Amorphophallus konjac* plant, which is prevalent in Asian countries including China and Japan. Glucomannan is used in preparing several types of foods. Glucomannan flour contains a variety of insoluble substances as well as water-soluble substances. Glucomannan is a polymer composed of the monosaccharides D-glucose and D-mannose. It forms a highly viscous sol when constituted with water at concentrations of pure glucomannan above 1.0% w/w. It is the only biopolymer currently known to form an aqueous gel at room temperature. The gel forms within a few minutes of mixing with water. U.S. patent 5,486,364 describes processes for preparing konjac glucomannan and is incorporated herein for such disclosure. In some embodiments, compositions described herein comprise clarified glucomannan that forms a clear sol with water. In some embodiments, compositions described herein comprise rapidly hydratable konjac glucomannan that is characterized by at least a 60% viscosity gain after a 10 minute period. In some embodiments, compositions described herein comprise chemically modified glucomannans.

[0007] Glucomannan has been used in Asia, particularly in China, for over 2,000 years in applications for detoxification, tumor suppression, blood stasis alleviation and to treat ailments such as asthma, cough, hernia, breast pain, burns as well as hematological and skin disorders. Glucomannan has additionally been shown to affect body weight reduction in animal and human studies.

[0008] In some embodiments described herein, compositions comprise from about 0.0001% w/v to about 15% w/v glucomannan. In some embodiments, compositions comprise from about 0.0001% to about 0.001% glucomannan. In some embodiments, compositions comprise from about 0.001% to about 0.01% glucomannan. In some embodiments, compositions comprise from about 0.01% to about 0.1% glucomannan. In some embodiments, compositions comprise from about 0.1% to about 1.0% glucomannan. In some embodiments, compositions comprise from about 1.0% to about 15% glucomannan.

III. MAGNESIUM METAL POWDER

[0009] Several base metals, for example, lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese and iron, when reacting with water, generate molecular hydrogen. Conditions such as temperature, or the presence of acids, bases, and other catalysts can affect the rate of the reaction. Magnesium metal powder is

preferred for human consumption due to its wide margin of safety, established health benefits as an essential element and ease of molecular hydrogen generation under room temperature, atmospheric pressure, and mild acidic or basic conditions.

[0010] In some embodiments described herein, compositions comprise lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, or any combination thereof. In some embodiments, compositions comprise lithium. In some embodiments, compositions comprise potassium. In some embodiments, compositions comprise strontium. In some embodiments, compositions comprise calcium. In some embodiments, compositions comprise sodium. In some embodiments, compositions comprise magnesium metal powder. In some embodiments, compositions comprise aluminum. In some embodiments, compositions comprise zinc. In some embodiments, compositions comprise chromium. In some embodiments, compositions comprise iron.

[0011] In embodiments described herein, compositions comprise from about 0.001% w/v to about 2% w/v of the base metal. In some embodiments, compositions comprise from about 0.001% w/v to about 0.01%w/v of the base metal. In some embodiments, compositions comprise from about 0.005% w/v to about 0.05% w/v of the base metal. In some embodiments, compositions comprise from about 0.01% w/v to about 0.1% w/v of the base metal. In some embodiments, compositions comprise from about 0.05% w/v to about 0.5% w/v of the base metal. In some embodiments, compositions comprise from about 0.1% w/v to about 1% w/v of the base metal. In some embodiments, compositions comprise from about 0.5% w/v to about 2% w/v of the base metal.

[0012] In some embodiments, compositions described herein comprise magnesium metal powder (Mg). In some embodiments, compositions comprise from about 0.001% to w/v to about 2% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.001% w/v to about 0.01% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.005% w/v to about 0.05% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.01% w/v to about 0.1% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.05% w/v to about 0.5% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.1% w/v to about 1% w/v magnesium metal powder. In some embodiments, compositions comprise from about 0.5% w/v to about 2% w/v magnesium metal powder.

[0013] Organic acids have been shown to be effective in accelerating the generation of molecular hydrogen in the reaction of magnesium metal powder with water. (*See*, Uan, J-Y. et.

al.(2009) J. of Hydrogen Energy 34 (15), 6137 – 6142, which is incorporated herein for such disclosure). Organic acids can include, without limitation, lactic acid, acetic acid, formic acid, citric acid, oxalic acid, uric acid, malic acid, or any combination thereof. In some embodiments, compositions comprise lactic acid. In some embodiments, compositions comprise acetic acid. In some embodiments, compositions comprise formic acid. In some embodiments, compositions comprise citric acid. In some embodiments, compositions comprise oxalic acid. In some embodiments, compositions comprise uric acid. In some embodiments, compositions comprise malic acid.

IV. COMMERCIAL PRODUCTS CONTAINING MAGNESIUM METAL POWDER

[0014] Products based upon magnesium metal powder, are known in the art for generating molecular hydrogen when reacted with water. Such products require acids or catalysts to rapidly generate molecular hydrogen from water. These products do not have a means of sustaining molecular hydrogen in solution or in the body.

V. RATIONALE FOR USE OF MAGNESIUM METAL POWDER

[0015] In some embodiments described herein, compositions comprise magnesium metal powder. Magnesium metal powder is safe to use for human and animal consumption. It is stable, readily generates molecular hydrogen, is inexpensive, and is commercially available. When reacting with water, it is converted to Generally Recognized as Safe (GRAS) magnesium hydroxide according the reaction

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2.$$

Magnesium hydroxide is an OTC drug approved laxative as well as approved as a GRAS food additive and supplement. Magnesium is an essential nutrient involved in over 400 enzymatic reactions in living systems. Magnesium metal reacts with water to produce molecular hydrogen and form magnesium hydroxide. This reaction is thermodynamically favorable, and its reaction rate is pH–dependent. Ionized magnesium in a salt form, as non-limiting examples, citrate, chloride, sulfate, or chelated magnesium, cannot generate molecular hydrogen in an aqueous environment. Further, covalently bound magnesium compounds such as magnesium oxide, magnesium hydroxide, magnesium carbonate cannot generate molecular hydrogen in an aqueous environment. The rate of reaction of magnesium metal powder with water depends on several factors, some of which are discussed below. The surface area of magnesium metal that will be exposed to water is a factor to consider. Basic physical chemistry would predict that the larger

the surface area, the faster and more efficient the reaction. This otherwise obvious conclusion is modified by two factors: First, the larger the surface area and smaller the particle size, the more likely that magnesium metal can undergo a spontaneous and explosive reaction with oxygen. Thus, safety is an issue. Secondly, left alone or by a process of reducing the risk of spontaneous reaction with oxygen (or water), a magnesium oxide coat is spontaneously formed on the surface of magnesium metal particles through a process called passivation. Although this coat of magnesium oxide does not greatly reduce the amount of magnesium metal in large particles that can react with water, it potentially can reduce the amount of magnesium in small particles that can react with water. For example, the magnesium oxide coat on nanoparticles may constitute a significant percentage of the magnesium present – reducing the amount of magnesium metal available to react with water. All forms of magnesium metal, including but not limited to powders, pellets, and filings, will have some reactivity with water and oxygen. The point to be taken is that there is a particle size distribution of magnesium metal powder that is optimally reactive and safe to handle under Good Manufacturing Practice (GMP) conditions. Magnesium metal powder is generally available at up to 99.999% purity, with aluminum being the main impurity.

[0016] The size distribution of magnesium metal powder used in the studies described herein was determined using Fieldmaster® Sieves of 35, 60, 120, and 230 Mesh, corresponding, respectively to 500, 250, 125 and 63 microns. The size distribution was found to be: 0.7% equal to or greater than 500 microns; 1.2% 250 – 500 microns; 9.3% 125-250 microns; 38.2 % at 63-125 microns, and 50.9% smaller than 63 microns.

VI. MAGNESIUM METAL POWDER PLUS GLUCOMANNAN POWDER

[0017] The reaction rate of magnesium metal powder with water in the presence of glucomannan is described herein, and depends on several factors, including pH and the presence of catalysts. For forming gels using magnesium metal powder-glucomannan complexes, a fast rate of molecular hydrogen production is not necessarily desirable. That is, more molecular hydrogen will be sequestered in the gel if the gel is formed before a significant percentage of the available molecular hydrogen is generated.

[0018] As is well known in the art, variation of pH from neutrality can accelerate the reaction of magnesium metal with water. Acidic conditions can include any organic or inorganic acid that lowers the pH below 7.0. Included are gastric fluids, acidic foods, and acidic aquatic environments. Examples of acids and/or their salts that can be used include citric acid, malic

acid, adipic acid, fumaric acid, succinic acid, ascorbic acid, iso-ascorbic acid, salicylic acid, phosphoric acid, potassium sorbate and sodium bisulfite. Examples of antioxidants, that are salts of acids, include sodium ascorbate and potassium ascorbate. On the alkaline side, magnesium oxide, magnesium hydroxide, potassium and sodium hydroxide can be used to increase the pH to alkaline conditions. Combinations of these agents can be used to control the rates of reaction of magnesium metal in aqueous glucomannan at conditions that generate H_2 in solutions and gels.

[0019] In some embodiments described herein, compositions comprise an acid or antioxidant catalyst. In some embodiments, the compositions are formulated for oral administration for gastric delivery. In some embodiments, the oral formulation comprises capsules, powder, tablets or another delivery vehicle. In some embodiments, the composition formulation for gastric delivery utilizes the acidity of stomach fluid to catalyze the reaction of magnesium metal or a magnesium hydride with water to form the molecular hydrogen-rich solution or a viscous solution or a gel. Also, when adding a magnesium metal powder-glucomannan formulation to acidic products, such as tea or acidic beverages, the acidity of the product is more than sufficient to catalyze the reaction of water with magnesium metal powder to generate molecular hydrogen. In some embodiments, the composition comprises a base, for example, sodium bicarbonate, to modulate the reaction.

[0020] It has been found that when combining magnesium metal powder and glucomannan and mixing with water - that a hydrogen-rich solution, viscous solution or expansive gel with unexpected high sustainability of molecular hydrogen is created. Depending on the concentrations of magnesium metal powder and glucomannan, the pH and activity of water - the resulting solutions and gel-like structures display the following novel properties:

1. In a closed plastic container, at ambient temperature, molecular hydrogen remains in glucomannan solutions and gels, at a level of up to 60 % of the original molecular hydrogen content - for over 39 days. (Ref: Table 3).
2. In a closed plastic container, at 1 - 4 degrees centigrade, molecular hydrogen remains in a glucomannan gel, at a level of up to 51 % of the original H_2 content - for over 73 days. (Ref: Table 6)
3. In an open plastic container, at room temperature, molecular hydrogen remains in 0.15 to 1,000 mg/100 mL non – gelling, low viscosity aqueous solutions of glucomannan, at a level of up to 99% of the original H_2 content - for over 15 days. (Ref: Table 14,)

4. In an open plastic container, at room temperature, molecular hydrogen remains in viscous glucomannan solutions, at a level of up to 50% of the original molecular hydrogen content - for over 15 days. (Ref: Figure 1, Table 14).

5. When magnesium metal powder reacts with water in the presence of 1 – 10 % glucomannan, it generates molecular hydrogen which expands the resultant aqueous gel by up to 83% v/v - depending on the pH and concentration of the constituents. (Ref: Table 2).

6. H_2 sequestration by magnesium metal powder - glucomannan gels creates aqueous gels of various density and porosity thereby affecting a desirable 'fluffy' texture – depending of the concentration of the basic constituents. (Ref: Tables 1 and 10).

7. Great tasting, 'fluffy' textured, nutritious aqueous magnesium metal powder – glucomannan gels, with health benefits, can be created by incorporating one or more of the following into the gels: sweeteners, flavoring agents, natural fruit and vegetable powders, tea powders, protein powders, vitamin powders, probiotic powders, prebiotics, drugs and nutritional supplements. (Ref: Tables 8 and 10).

8. Glucomannan, in aqueous solution, increases the yield of molecular hydrogen generation by affecting removal of the passivation coat of magnesium oxide from the surface of magnesium metal. (Ref: Table 14, Fig. 1).

9. Exposing aqueous solutions or gels of glucomannan to molecular hydrogen allows the sequestration of molecular hydrogen by glucomannan. (Ref: Table 15, Fig. 2).

10. Long lasting H_2 microbubble stability in non-viscous magnesium metal powder - glucomannan solutions, in an open system, at room temperature.

11. Creation of H_2 sustained release gels, of various rates of release, for nutrients, drugs and beneficial environmental factors, including H_2.

[0021] Furthermore, it has been conceived that the resulting molecular hydrogen - glucomannan gels and viscous solutions can be utilized to:

1. Provide extended, long lasting delivery of molecular hydrogen to the body of mammals through its persistence in the gastrointestinal tract and other tissues - such as skin;

2. Use of this biotechnology to produce hydrogen-rich magnesium metal powder- glucomannan gels that are low calorie, good tasting, filling, and long lasting due

to floating and expanding in the upper G-I tract – properties that are useful for augmentation of fasting, anti-inflammatory, and weight control programs.

3. Provide molecular hydrogen - generating capsules or tablets, taken orally, that support weight control and fasting regimens by forming an expanded, floating gel in the aqueous acidic environment of the stomach - while reducing the inflammatory complications of obesity.

4. Provide extended, long lasting delivery of molecular hydrogen (H_2) to the oral cavity of humans and animals to treat plaque build-up, gingivitis, periodontal disease, and other inflammatory conditions of the oral cavity, esophagus and stomach.

5. H_2 generating magnesium metal powder - glucomannan gels that act as a sustained drug-delivery system in the upper G-I tract - for drugs that need to be held in the stomach for an extended period or need to be slowly released into the systemic circulation. Molecular hydrogen release will act synergistically with some of these drugs. Drugs that can eradicate Helicobacter pylori from the upper G-I Tract, treat and prevent gastric and duodenal ulcers, treat GERD are of most interest. Gel delivery of bismuth subsalicylate, with and without other drugs to treat G-I afflictions and infections is of interest.

6. Act as an extended release system for topical delivery of molecular hydrogen to dermal tissues for treatment of infections and inflammatory diseases.

7. Drugs delivered topically, for an extended time - or need to be slowly released into the systemic circulation. Hydrogen release will act synergistically with some of these drugs.

8. Enhanced growth and seed germination for aquatic plant, crustacean and fish life by providing a sustained release gel system for both molecular hydrogen and nutrients into aquatic systems.

9. Enhanced growth rates for farming of insects by providing a sustained release gel system for both molecular hydrogen and nutrients needed for accelerated growth.

10. Act both as a generator and storage vehicle for molecular hydrogen that can be used as a fuel, when harvested from the gel.

VII. MAGNESIUM METAL POWDER – GLUCOMANNAN GELS WITH EXCIPIENTS AND FUNCTIONAL AGENTS

[0022] In some embodiments described herein, compositions comprise additional excipients or functional agents. Excipients or functional agent included in some compositions described herein comprise sweeteners, flavoring agents, natural fruit and vegetable powders, tea powders, protein powders, vitamin powders, probiotic powders, anti-caking agents, preservatives, prebiotics, nutritional supplements, drugs, and food colorings.

[0023] In some embodiments, compositions comprise sweeteners, alone or in combination, including, but not limited to, acesulfame, aspartame, saccharin, sucralose, sucrose, monk fruit, glucose, fructose, xylitol, mannitol, glycerin, maltodextrin, inulin, and erythritol. Compositions described herein may contain sweeteners, alone or in combination, in a concentration of from about 0.1 to about 20% w/w of the composition. Compositions described herein may contain sweeteners, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, or from about 0.1% to about 20% w/w of the composition.

[0024] In some embodiments, compositions comprise flavoring agents, alone or in combination, including, but not limited to, natural lemon powder, citric acid, malic acid, hydroxy–citric acid, tartaric acid, adipic acid, vanillin, chocolate, cherry, pomegranate, raspberry, and strawberry flavoring. Compositions described herein may contain flavoring agents, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, or from about 0.1% to about 50% w/w of the composition.

[0025] In some embodiments, compositions comprise water extracts of natural fruit powders, alone or in combination, including, but not limited to, bilberry, lemon, blueberry, cranberry, cinnamon, ginger, lemon balm, vanilla, pumpkin seed and strawberry. Compositions described herein may contain water extracts of natural fruit powders, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, or from about 0.1% to about 50% w/w of the composition.

[0026] In some embodiments, compositions comprise water extracts of natural vegetable powders, alone or in combination, including, but not limited to, carrot juice, spinach, broccoli, sweet potato and white willow bark powder. Compositions described herein may contain water extracts of natural vegetable powders, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, or from about 0.1% to about 50% w/w of the composition.

[0027] In some embodiments, compositions comprise herbal tea water extract powders, alone or in combination, including, but not limited to, white tea, green tea, Red Gush Chai, Matcha, Maca, Kombucha, Turmeric, Dandelion, Ginger, Lemon Ginger, Oolong, Rooibos, Fennell, Nettle Leaf, Peppermint, Echinacea, Valerian, Cinnamon Berry, Chamomile and Lavender tea. Compositions described herein may contain herbal tea water extract powders, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%,

about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, from about 45% to about 55%, from about 50% to about 60%, from about 55% to about 65%, from about 60% to about 70%, or from about 0.1% to about 70% w/w of the composition.

[0028] In some embodiments, compositions comprise protein powders, alone or in combination, including, but are not limited to, non-fat milk, 1% fat milk, 2% fat milk, whole milk, goat milk, rice milk, almond milk, soy milk, coconut, pea protein and brown rice protein. Compositions described herein may contain protein powders, alone or in combination, in a concentration of about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, from about 0.2% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, or from about 0.2% to about 50% w/w of the composition.

[0029] In some embodiments, compositions comprise vitamins or minerals, alone or in combination, including, but are not limited to, vitamin A, vitamin C, calcium, iron, vitamin D3, vitamin E, thiamin, riboflavin, niacin, vitamin B6, Folate, vitamin B12, biotin, pantothenic acid, phosphorous, iodine, magnesium metal powder, zinc, selenium, copper, manganese and chromium. Compositions described herein may contain vitamins or minerals, alone or in combination, in an amount of about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, about 80%, about 85%, about 90%, about 95%, about 100%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, from about 45% to about 55%, from about 50% to about 60%, from about 55% to about 65%, from about 60% to about 70%, from about 65% to about 75%, from about 70% to about 80%, from about 75% to about 85%, from about 80% to about 90%,

from about 85% to about 95%, from about 90% to about 100%, or from about 5% to about 100% of the RDI (Required Daily Intake) for a healthy adult human.

[0030] In some embodiments, compositions comprise probiotics, alone or in combination, including, but not limited to *Bacillus coagulans*, *Bacillus subtilis*, *Bacillus infantis*, *Lactobacillus longum*, *Lactobacillus casei*, *Lactobacillus acidophilus* and *Bifidobacterium*. Compositions described herein may contain probiotics, alone or in combination, in an amount of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, or from about 0.1% to about 10% w/w of the composition.

[0031] In some embodiments, compositions comprise anti-caking agents, alone or in combination, including, but not limited to, calcium phosphate tribasic, calcium silicate, sodium alginate, cellulose, microcrystalline cellulose, xanthan gum, magnesium carbonate, magnesium oxide, magnesium silicate, and magnesium sulfate. Compositions described herein may contain anti-caking agents, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, from about 0.1% to about 2%, from about 0.5% to about 3%, from about 1% to about 4%, from about 2% to about 5%, or from about 0.1% to about 5% w/w of the composition.

[0032] In some embodiments, compositions comprise preservatives, alone or in combination, including, but not limited to, ascorbic acid, calcium ascorbate, erythorbic acid, sodium ascorbate, sodium erythorbate, benzoic acid, calcium sorbate, potassium sorbate, sorbic acid, citric acid, L-cysteine, lecithin, tartaric acid and tocopherols. Compositions described herein may contain preservatives, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, from about 0.1% to about 4%, from about 1% to about 7%, from about 3% to about 10%, or from about 0.1% to about 10% w/w of the composition.

[0033] In some embodiments, compositions comprise prebiotics, alone or in combination, including, but not limited to, psyllium, rice hulks, chicory root, dandelion greens, apples,

bananas, artichokes, leeks, and asparagus. Compositions described herein may contain prebiotics, alone or in combination, in a concentration of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60%, about 65%, about 70%, about 75%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, from about 25% to about 35%, from about 30% to about 40%, from about 35% to about 45%, from about 40% to about 50%, from about 45% to about 55%, from about 50% to about 60%, from about 55% to about 65%, from about 60% to about 70%, from about 65% to about 75%, or from about 0.1% to about 75% w/w of the composition.

[0034] In some embodiments, compositions comprise nutritional supplements, alone or in combination, including, but not limited to, L-arginine, L-ornithine, 5-hydroxytryptophan, acetyl L-tyrosine, acetyl-L carnitine, alpha-lipoic acid, ashwagandha, bacopa, berbine, betaine, biotin, choline, creatine, curcumin, fish oil, flaxseed oil, ginger, ginseng, jiaogulan, kelp, manganese, methyl folate, N-acetyl-cysteine, nattokinase, niacin, quercetin, resveratrol, L-theanine, valerian root, vinpocetine and melatonin. Compositions described herein may contain nutritional supplements, alone or in combination, in a concentration of about 0.01%, about 0.02%, about 0.03%, about 0.04%, about 0.05%, about 0.06%, about 0.07%, about 0.08%, about 0.09%, about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 12%, about 14%, about 16%, about 18%, about 20%, %, about 25%, about 30%, from about 0.01% to about 0.5%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, or from about 10% to about 20%, from about 15% to about 25%, from about 20% to about 30%, or from about 0.01% to about 30% w/w of the composition.

[0035] In some embodiments, compositions comprise over the counter (OTC) and prescription (Rx) drugs, alone or in combination, including, but not limited to salicylic acid, trans-retinoic acid, the alpha-hydroxy acids (e.g., lactic acid), benzoyl peroxide, bismuth subsalicylate, metronidazole, tetracycline, erythromycin, proton pump inhibitors, misoprostol, antibiotics, anti-fungal drugs, anti-inflammatories, or antacids. Compositions described herein may contain over the counter (OTC) and prescription (Rx) drugs, alone or in combination, in an

amount of about 0.1%, about 0.2%, about 0.3%, about 0.4%, about 0.5%, about 0.6%, about 0.7%, about 0.8%, about 0.9%, about 1%, about 2%, about 3%, about 4%, about 5%, about 6%, about 7%, about 8%, about 9%, about 10%, about 15%, about 20%, from about 0.1% to about 5%, from about 1% to about 10%, from about 5% to about 15%, from about 10% to about 20%, or from about 0.1% to about 20% w/w of the composition.

[0036] In some embodiments, compositions comprise food colorings, alone or in combination, including, but not limited to FD&C Blue # 1, FD&C Blue # 2, FD&C Green # 3, FD&C Red #3, FD&C Yellow # 5, FD&C Yellow # 6, riboflavin, annatto, carmine, elderberry juice powder, lycopene, or turmeric. Compositions described herein may contain food colorings, alone or in combination, in an amount of about 0.001ppm, about 0.002ppm, about 0.003ppm, about 0.004ppm, about 0.005ppm, about 0.006ppm, about 0.007ppm, about 0.008ppm, about 0.009ppm, about 0.01ppm, about 0.02ppm, about 0.03ppm, about 0.04ppm, about 0.05ppm, about 0.06ppm, about 0.07ppm, about 0.08ppm, about 0.09ppm, about 0.1ppm, about 0.2ppm, about 0.3ppm, about 0.4ppm, about 0.5ppm, about 0.6ppm, about 0.7ppm, about 0.8ppm, about 0.9ppm, about 1ppm, about 2ppm, about 3ppm, about 4ppm, about 5ppm, about 6ppm, about 7ppm, about 8ppm, about 9ppm, about 10ppm, about 20ppm, about 30ppm, about 40ppm, about 50ppm, about 60ppm, about 70ppm, about 80ppm, about 90ppm, about 100ppm, about 200ppm, about 300ppm, about 400ppm, about 500ppm, from about 0.001ppm to about 0.05ppm, from about 0.05ppm to about 0.1ppm, from about 0.1ppm to about 0.5ppm, from about 0.5ppm to about 1ppm, from about 0.5ppm to about 5ppm, from about 1ppm to about 10ppm, from about 5ppm to about 50ppm, from about 50ppm to about 200ppm, from about 100ppm to about 500ppm, or from about 0.001ppm to about 500ppm w/w of the composition.

VIII. FORMATION AND CHARACTERISTICS OF MOLECULAR HYDROGEN GENERATING AND SUSTAINING GLUCOMANNAN GELS

[0037] It has been unexpectedly found that when magnesium metal powder is combined with glucomannan powder in a powder formulation and then mixed with water, a gel is created that has some novel properties, including generating, holding, and sustaining large volumes of molecular hydrogen for an extended period of time. The resultant gels have low density and high porosity, as noted by observing the molecular hydrogen ‘bubble’ content and measuring the dissolved molecular hydrogen. These characteristics allow for formulating gels that are nutritious and have a desirable texture as a food as well as other applications. There are health benefits such as use as an adjunct to weight control and fasting regimens. The effect of retaining

large quantities of molecular hydrogen in glucomannan gels is non-obvious since it is shown that generation of carbon dioxide in a glucomannan gel does not retain that gas in the gel nor change its density (See Rows 2-5, **Table 1**). Also, preparing control aqueous glucomannan gels in air (i.e., with 20% oxygen), i.e., glucomannan without magnesium metal powder in air does not retain gas bubbles of expand the aqueous glucomannan gel.

Table 1: Effect of CO_2 or H_2 gas generation on glucomannan gel density

	Formulas in 000 Capsules/Aq. Acetic Acid	**Gel**	**Head**	**Total**	H_2	**Final**	**Gel/ g**	**Capsules**
Row	**Potassium Bicarbonate Study**	**mL**	**mL**	**mL**	**ppm**	**pH**	**gmn**	
1	0.1 g Mg	0.0	37.6	37.6	0.7	3.4	0.0	1
2	0.1 g K bicarbonate. + 2.0 g gmn	13.4	0.0	13.4	0.0	3.3	6.7	3
3	0.2 g K bicarbonate. + 2.0 g gmn	21.6	9.3	30.9	0.0	3.2	10.8	3
4	0.4 g K bicarbonate. + 2.0 g gmn	11.0	10.3	21.3	0.0	3.4	5.5	4
5	0.8 g K bicarbonate. + 2.0 g gmn	11.4	14.3	25.7	0.0	3.7	7.2	4
	0.1 g Magnesium Metal Powder Study							
6	1.6 g gmn	18.8	0.0	18.8	0.0	2.9	11.8	3
7	0.1 g Mg + 0.8 g K bicarbonate, 2.0 g gmn	45.5	39.4	84.9	1.3	3.9	22.8	3
9	0.05 g Mg + 1.6 g gmn	49.2	14.2	63.4	0.6	3.4	30.8	2
8	0.1 g Mg + 3.0 g gmn	75.1	22.7	97.8	0.8	3.4	25.0	5
10	0.15 g Mg + 4.0 g gmn	132.7	25.4	158.1	2.2	3.7	33.2	7
	Glucomannan Reduction of Passivation							
11	0.1 g Mg + 0.2 g gmn	17.6	26.9	43.0	1.0	3.4	88.0	1
12	0.1 g Mg + 0.4 g gmn	24.4	25.4	49.8	0.9	3.4	61.0	1
13	0.1 g Mg + 0.8 g gmn	41.6	28.8	70.4	1.2	3.3	52.0	2
14	0.1 g Mg + 1.6 g gmn	73.4	22.5	95.9	1.5	3.5	45.9	3
15	0.1 g Mg + 1.6 g gmn (Repeat)	73.3	25.7	99.0	1.0	3.4	45.8	3

Abbreviations
H_2: Molecular Hydrogen
Mg: Magnesium metal powder
gmn: Konjac glucomannan
K - potassium
Gel Vol. Volume occupied by glucomannan gel
Headspace: Volume (mL) of H_2 gas displacing water in the headspace of the sealed 500 mL bottle.
Total Vol.: Volume occupied by the glucomannan gel and headspace volume.

[0038] As listed in **Table 2** and **Table 3**, formulas were prepared containing 0 to 207 mg of crude magnesium metal powder (Mg), 0 to 8.0 grams of konjac root glucomannan and 0 to 7 grams of citric acid. As listed in **Table 4**, powders containing magnesium metal, glucomannan (gmn), and citric acid were prepared using a gravimetric method.

Table 2 Effect of Varying Components of Magnesium Metal Powder - Glucomannan Formulations

	Formulas/100 mL DW	Gel Dens.	H_2	mL H_2/	Total	Bubble
Row	Vary Magnesium Metal Powder	g/mL	mL	mg Mg	Gel (mL)	Gel Vol.
1	4.0 g gmn + 5.0 g CA(Reference)	0.994	xxxxx	xxxx	112.8	0.0
2	11 mg Mg + 4.0 g gmn + 5.0 g CA	0.825	16.6	1.51	129.4	129.4
3	24 mg Mg + 4.0 g gmn + 5.0 g CA	0.751	29.9	1.25	142.7	142.7
4	42 mg Mg + 4.0 g gmn + 5.0 g CA	0.734	32.8	0.78	146.0	146.0
5	63 mg Mg + 4.0 g gmn + 5.0 g CA	0.704	39.8	0.63	152.6	152.6
6	207 mg Mg + 4.0 g gmn + 5.0 g CA	0.547	83.0	0.40	195.8	195.8
		Gel Dens.	H_2	mL H_2/	Total	Bubble
	Vary Citric Acid (CA)	g/mL	mL	g CA	Gel (mL)	Gel Vol.
7	4.0 g gmn (Ref.)	0.879	xxxxx	xxxxx	112.8	0
8	0.1 g Mg + 4.0 g gmn	0.879	3.3	xxxxx	116.1	116.1
9	4.0 g gmn + 0.5 g CA (Ref.)	0.969	xxxxx	xxxxx	116.1	0
10	0.1 g Mg +4.0 g gmn + 0.5 g CA	0.735	23.3	46.6	139.4	139.4
11	4.0 g gmn + 1.0 g CA (Ref.)	0.861	xxxxx	xxxxx	119.5	0
12	0.1 g Mg + 4.0 g gmn + 1.0 g CA	0.690	29.8	29.8	149.3	149.3
13	4.0 g gmn + 2.0 g CA (Ref.)	0.954	xxxxx	xxxxx	119.5	0
14	0.1 g Mg + 4.0 g gmn + 2.0 g CA	0.682	33.1	16.6	152.6	152.6
15	4.0 g gmn + 4.0 g CA (Ref.)	0.913	xxxxx	xxxxx	116.1	0
16	0.1 g Mg + 4.0 g gmn + 4.0 g CA	0.624	53.1	13.3	169.2	169.2
17	8.0 g gmn + 7.0 g CA (Ref.)	0.986	xxxxx	xxxxx	116.1	0
18	0.1 g Mg + 8.0 g gmn + 7.0 g CA	0.640	59.8	8.5	175.9	175.9
		Gel Dens.	H_2	mL H_2/	Total	Bubble
	Vary Glucomannan (gmn)	g/mL	mL	g gmn	Gel (mL)	Gel Vol.
19	0.5 g gmn + 5.0 g CA/DW (Ref.)	0.916	xxx	xxx	112.8	0
20	0.1 g Mg + 0.5 g gmn + 5.0 g CA/DW	0.677	39.8	79.6	152.6	59.7
21	1.0 g gmn + 5.0 g CA/DW (Ref.)	0.916	xxx	xxx	112.8	0
22	0.1 g Mg + 1.0 g gmn + 5.0 g CA/DW	0.710	33.2	33.2	146.0	146.0
23	2.0 g gmn + 5.0 g CA/DW (Ref.)	0.854	xxx	xxx	122.8	0
24	0.1 g Mg + 2.0 g gmn + 5.0 g CA/DW	0.787	9.9	5.0	132.7	132.7
25	3.0 g gmn + 5.0 g CA/DW (Ref.)	0.842	xxx	xxx	126.0	0
26	0.1 g Mg + 3.0 g gmn + 5.0 g CA/DW	0.778	10.1	3.4	136.1	136.1
27	4.0 g gmn + 5.0 g CA/DW (Ref.)	0.895	xxx	xxx	119.5	0
28	0.1 g Mg + 4.0 g gmn + 5.0 g CA/DW	0.648	36.5	9.1	156.0	156.0

29	6.0 g gmn + 5.0 g CA/DW (Ref.)	0.943	xxx	xxx	114.5	0
30	0.1 g Mg + 6.0 g gmn + 5.0 g CA/DW	0.762	28.2	4.7	142.7	142.7
31	8.0 g gmn + 5.0 g CA/DW (Ref.)	0.985	xxx	xxx	112.8	0
32	0.1 g Mg + 8.0 g gmn + 5.0 g CA/DW	0.668	53.1	6.6	165.9	165.9
33	8.0 g gmn + 7.0 g CA/DW (Ref.)	0.986	xxx	xxx	114.5	0
34	0.1 g Mg + 8.0 g gmn + 7.0 g CA/DW	0.640	61.4	7.7	175.9	175.9

Abbreviations
Mg: magnesium metal powder
gmn: glucomannan
CA: citric acid
DW: distilled water
Dens: Density; Vol.: Volume

Table 3: Room Temperature (23 C) Stability of Molecular Hydrogen (H_2) in Magnesium Metal Powder - Glucomannan Gels

	Study Extended from Table 2	BGV	BGV	BGV	BGV	BGV	BGV
	Formulas/100 mL DW	1-Hr.	53-Hr.	108-Hr.	180-Hr.	204-Hr.	261-Hr.
1	4.0 g gmn + 5.0 g CA(Reference)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
2	24 mg Mg + 4.0 g gmn + 5.0 g CA	142.7	92.9	13.3	xxxx	xxxx	xxxx
3	42 mg Mg + 4.0 g gmn + 5.0 g CA	146.0	106.2	19.9	xxxx	xxxx	xxxx
4	63 mg Mg + 4.0 g gmn + 5.0 g CA	152.6	96.2	29.9	xxxx	xxxx	xxxx
5	207 mg Mg + 4.0 g gmn + 5.0 g CA	195.8	192.4	175.9	179.2	165.9	132.7
6	0.1 g Mg + 4.0 g gmn	116.1	126.1	0.0	xxxx	xxxx	xxxx
7	0.1 g Mg +4.0 g gmn + 0.5 g CA	139.4	142.7	0.0	xxxx	xxxx	xxxx
8	0.1 g Mg + 4.0 g gmn + 1.0 g CA	149.3	149.3	145.6	132.7	89.6	68.00
9	0.1 g Mg + 4.0 g gmn + 2.0 g CA	152.6	152.6	132.7	102.9	86.3	64.7
10	0.1 g Mg + 4.0 g gmn + 4.0 g CA	169.2	149.3	132.7	116.1	109.5	97.9
		BGV	BGV	BGV	BGV	BGV	
	Formulas/100 mL DW	285-Hr.	321-Hr.	492-Hr.	696-Hr.	936-Hr.	
1	4.0 g gmn + 5.0 g CA(Reference)	xxxx	xxxx	xxxx	xxxx	xxxx	
2	24 mg Mg + 4.0 g gmn + 5.0 g CA	xxxx	xxxx	xxxx	xxxx	xxxx	
3	42 mg Mg + 4.0 g gmn + 5.0 g CA	xxxx	xxxx	xxxx	xxxx	xxxx	
4	63 mg Mg + 4.0 g gmn + 5.0 g CA	xxxx	xxxx	xxxx	xxxx	xxxx	
5	207 mg Mg + 4.0 g gmn + 5.0 g CA	43.1	xxxx	xxxx	xxxx	xxxx	
6	0.1 g Mg + 4.0 g gmn	xxxx	xxxx	xxxx	xxxx	xxxx	
7	0.1 g Mg +4.0 g gmn + 0.5 g CA	xxxx	xxxx	xxxx	xxxx	xxxx	
8	0.1 g Mg + 4.0 g gmn + 1.0 g CA	0.0	xxxx	xxxx	xxxx	xxxx	
9	0.1 g Mg + 4.0 g gmn + 2.0 g CA	0.0	xxxx	xxxx	xxxx	xxxx	

10	0.1 g Mg + 4.0 g gmn + 4.0 g CA	96.2	96.2	76.3	56.4	59.7	

Abbreviations: BGV - Bubble Gel Volume; gmn -glucomannan; DW-distilled water; CA- citric acid; mL-milliliters; Tot. - Total; mg-milligrams; Hr. - Hour; Mg- magnesium metal powder

Table 4: Time Course of Molecular Hydrogen (H_2) Generation in Magnesium Metal Powder (Mg) - Glucomannan H_2 Gels with Antioxidants and Acids

				1 hour	1 hour	1 hour	6 hour	6 hour	6 hour
		Gel	Dens.	Gel	Bubble	Gas	Gel	Bubble	Gas
Row	Powder Formulas mixed with 100 mL Distilled Water (DW)	Wt. (g)	g/mL	Vol. (mL)	Vol. (mL)	Vol. (mL)	Vol. (mL)	Vol. (mL)	Vol. (mL)
1	0.5 g ascorbic acid + 4 g gmn.	101.8	0.852	119.5	xxxxxx	xxxxxx	119.5	xxxxxx	xxxxxx
2	0.1 g Mg. + 0.5 g ascorbic acid + 4 g gmn.	102.3	0.752	136.0	136.0	16.5	156.0	156.0	36.5
3	0.5 g Na ascorbate + 0.5 g K citrate + 4 g gmn.	102.5	0.870	119.5	xxxxxx	xxxxxx	116.1	xxxxxx	xxxxxx
4	0.1 g Mg + 0.5 g Na ascorbate + 0.5 g K citrate + 4 g gmn.	102.2	0.751	136.0	136.0	16.5	152.6	152.6	36.5
5	0.5 g isoascorbic acid + 4 g gmn.	102.1	0.867	119.5	xxxxxx	xxxxxx	112.8	xxxxxx	xxxxxx
6	0.1 g Mg + 0.5 g isoascorbic acid + 4 g gmn.	101.8	0.731	139.4	139.4	19.9	142.7	142.7	29.9
7	0.5 g Na ascorbate + 4 g gmn.	101.9	0.853	119.5	xxxxxx	xxxxxx	119.5	xxxxxx	xxxxxx
8	0.1 g Mg + 0.5 g Na ascorbate + 4 g gmn.	102.3	0.856	119.5	119.5	0.0	129.4	129.4	9.9
9	0.5 g salicylic acid + 4 g gmn.	101.6	0.862	119.5	xxxxxx	xxxxxx	117.8	xxxxxx	xxxxxx
10	0.1 g Mg + 0.5 g salicylic acid + 4 g gmn.	101.9	0.660	154.3	154.3	34.8	152.6	152.6	34.8
11	0.5 g Na bisulfite + 4 g gmn.	102.2	0.856	119.5	xxxxxx	xxxxxx	116.1	xxxxxx	xxxxxx
12	0.1 g + 0.5 g Na bisulfite + 4 g gmn.	102.2	0.655	156.00	156.00	36.5	152.6	152.6	36.5

Abbreviations: gmn - glucomannan; DW-distilled water; Mg-magnesium metal powder; Dens. - density; mL-milliliters; H_2- molecular hydrogen; mg-milligrams; K-Potassium; Na-sodium; Vol. - volume

[0039] As listed in **Table 4**, powders were prepared from 0 to 0.1 gram magnesium metal powder, 4 grams of glucomannan and 0.5 grams of ascorbic acid or 0.5 grams of sodium ascorbate plus 0.5 grams of potassium citrate or 0.5 grams of isoascorbic acid or 0.5 grams of salicylic acid or 0.5 grams of sodium bisulfite.

[0040] Gels were prepared, at 22 -25 degrees centigrade, by taring the powders into empty 239 mL Arrowhead® water bottles, then adding 100 mL of distilled water (DW), mixing vigorously by shaking until the gel formed as indicated by perception of increased viscosity.

Gels start to form 15 – 30 seconds after starting to mix the formulas with water. The bottles were then tightly capped.

[0041] After allowing the gels to settle, the total weights of the gel plus the weight of the bottle were gravimetrically determined. Bottles were found to weigh 10.3 grams. Thus, the weight of the gels was determined by subtracting the weight of a bottle from the total weight of the gel plus the bottle. The volume of the gels was calculated based upon the fact that the Arrowhead® bottle volume in contact with the gel is a cylinder. The measurement of the volume of a cylinder is the height of the gel, in centimeters (cm.) times the area of the base of the bottle that was determined to be 33.18 square cm. The height of the gels was measured with a 0.05 cm. graduated ruler. The density of the gels was determined by dividing the weight of the gel by its calculated volume.

[0042] Bubbly gel volumes (BGV) were determined by measuring the length (gel height) of the bubbly gel and multiplying by the 33.18 sq. cm. area.

[0043] The volume occupied by molecular hydrogen is calculated by subtracting the BGV from the control gel volume that does not contain magnesium metal powder, i.e., those control gels that do not generate molecular hydrogen as indicated as "Reference" in Table 2.

IX. DEFINITIONS

[0044] Unless defined otherwise, all terms of art, notations and other technical and scientific terms or terminology used herein are intended to have the same meaning as is commonly understood by one of ordinary skill in the art to which the claimed subject matter pertains. In some cases, terms with commonly understood meanings are defined herein for clarity and/or for ready reference, and the inclusion of such definitions herein should not necessarily be construed to represent a substantial difference over what is generally understood in the art.

[0045] Throughout this application, various embodiments may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosure. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0046] As used in the specification and claims, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a sample" includes a plurality of samples, including mixtures thereof.

[0047] The terms "determining," "measuring," "evaluating," "assessing," "assaying," and "analyzing" are often used interchangeably herein to refer to forms of measurement. The terms include determining if an element is present or not (for example, detection). These terms can include quantitative, qualitative or quantitative and qualitative determinations. Assessing can be relative or absolute. "Detecting the presence of" can include determining the amount of something present in addition to determining whether it is present or absent depending on the context.

[0048] The terms "subject," "individual," or "patient" are often used interchangeably herein. A "subject" can be a biological entity containing expressed genetic materials. The biological entity can be a plant, animal, or microorganism, including, for example, bacteria, viruses, fungi, and protozoa. The subject can be tissues, cells and their progeny of a biological entity obtained in vivo or cultured in vitro. The subject can be a mammal. The mammal can be a human. The subject may be diagnosed or suspected of being at high risk for a disease. In some cases, the subject is not necessarily diagnosed or suspected of being at high risk for the disease.

[0049] The term "*in vivo*" is used to describe an event that takes place in a subject's body.

[0050] The term "*ex vivo*" is used to describe an event that takes place outside of a subject's body. An *ex vivo* assay is not performed on a subject. Rather, it is performed upon a sample separate from a subject. An example of an *ex vivo* assay performed on a sample is an "*in vitro*" assay.

[0051] The term "*in vitro*" is used to describe an event that takes places contained in a container for holding laboratory reagent such that it is separated from the biological source from which the material is obtained. *In vitro* assays can encompass cell-based assays in which living or dead cells are employed. *In vitro* assays can also encompass a cell-free assay in which no intact cells are employed.

[0052] As used herein, the term "about" a number refers to that number plus or minus 10% of that number. The term "about" a range refers to that range minus 10% of its lowest value and plus 10% of its greatest value.

[0053] As used herein, the terms "treatment" or "treating" are used in reference to a pharmaceutical or other intervention regimen for obtaining beneficial or desired results in the recipient. Beneficial or desired results include but are not limited to a therapeutic benefit and/or

a prophylactic benefit. A therapeutic benefit may refer to eradication or amelioration of symptoms or of an underlying disorder being treated. Also, a therapeutic benefit can be achieved with the eradication or amelioration of one or more of the physiological symptoms associated with the underlying disorder such that an improvement is observed in the subject, notwithstanding that the subject may still be afflicted with the underlying disorder. A prophylactic effect includes delaying, preventing, or eliminating the appearance of a disease or condition, delaying or eliminating the onset of symptoms of a disease or condition, slowing, halting, or reversing the progression of a disease or condition, or any combination thereof. For prophylactic benefit, a subject at risk of developing a particular disease, or to a subject reporting one or more of the physiological symptoms of a disease may undergo treatment, even though a diagnosis of this disease may not have been made.

[0054] The term "probiotic" means live microorganisms intended to provide health benefits when consumed, generally by improving or restoring the gut flora.

[0055] The term "prebiotic" means compounds in food that induce the growth or activity of beneficial microorganisms such as bacteria and fungi.

[0056] The term "sustainability" is defined herein as the ability to hold H_2 in gels or solutions over the short–term.

[0057] The term "stability" is defined as the ability to hold H_2 in a gel over the longer – term, i.e., longer than 24 hours.

[0058] The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

X. EXEMPLARY EMBODIMENTS

[0059] Among the exemplary embodiments are:

XI. EXAMPLES

[0060] The following examples are included for illustrative purposes only and are not intended to limit the scope of the invention.

Example 1: Effect on Molecular Hydrogen Content of Varying Gel Components

1. Gel Preparation

[0061] The gel formulations presented in Table 2 were prepared by first placing the glucomannan, magnesium metal and/or citric acid powders in 8 - ounce plastic cups. Then, 100

mL of distilled water was added. Contents mixed by hand with a utensil, until the gel started to form – in less than two minutes.

2. Effects of Varying Magnesium Metal Powder

[0062] The results presented in Table 2 show the effects on gel parameters of varying the components of the gels. The results presented in Rows 1 to 6 show the effect varying the magnesium metal powder concentration (Mg) on Gel Density (Column 3), and molecular hydrogen (H_2) volume in the gel (Column 4). H_2 volume in the gel is calculated by subtracting the volume of the control gel, without Mg (see Row 1) from the gels containing 11 to 207 mg magnesium metal powder (Mg). For example, in Column 6, the gel volume of the control gel in Row 1 is subtracted from the test gel volume seen in Row 2; again, the gel volume of the control gel in Row 1 is subtracted from the test gel volume in Row 3, etc.

[0063] The results indicate that H_2 in the gel increases with the amount of Mg in the formulation (Column 4). Analysis of the results in Column 5 indicates that the H_2 per milligram of Mg in the formulations decreases as the concentration of Mg increases in the gel. Thus, the efficiency of H_2 generation or capture of H_2/mg of Mg in the gel decreases with increasing Mg in the formulation. Observation indicates that for the H_2-generating gels, bubbles were evenly dispersed from bottom to top of the gels affecting a uniform perception of bubble porosity. Bubbles are not seen in the control gel (Row 1).

3. Effects of Varying Citric Acid

[0064] The results presented in Rows 7 - 18 of Table 2 demonstrate the effect of varying the concentration of citric acid (CA) on gel density and molecular hydrogen (H_2) retention in the gel. The odd numbers are the control gels – without magnesium metal powder (Mg). The control gel density is always greater than that of the experimental gels. The H_2 in the gels is calculated by subtracting the odd numbers (i.e., controls) from the even number formulations, as described above. Analysis of the results indicate that H_2 in the gel increases with the amount of citric acid in the formulation. Analysis of the results in Column 5 indicates that the H_2 per milligram of citric acid in the formulation decreases as the concentration of citric acid increases in the gel. Thus, the efficiency of generation of H_2 in the gel decreases with increasing citric acid in the formulation.

4. Effects of Varying Glucomannan

[0065] The results presented in Rows 19 - 34 of **Table 2** show the effect of varying the concentration of glucomannan (gmn) on gel density and H_2 in the gel. The odd numbers are the control gels - without Mg. Density in the control gels is always greater than that of the experimental gels. The H_2 in the gels in calculated by subtracting the odd numbers (controls) from the even number formulations. Analysis of the results indicate that the H_2 calculated to be in the gel does not always increase with an increasing amount of glucomannan in the formulation. At the lowest dose of gmn tested - as indicated in Rows 19 and 20, the Bubble Gel Volume (BGV) shown in Column 7, is markedly less than the Total Gel Volume (Column 6) – indicating a lesser ability of the lowest concentration of gmn to generate H_2 or to hold H_2 within the gel. In contrast, for higher concentrations of gmn (Rows 22, 24, 26, 28, 30, 32, 34) the Bubble Gel Volume (BGV)(Column 7) is equal to the Total Gel Volume (Column 6). The 2 - and 3 – gram/100 mL glucomannan gels appear to hold less H_2 than the 1- gram/100 mL glucomannan gel. This appears to be an artifact due to their control gels having a larger Total Gel Volume. However, as will be shown, below, gels with a higher concentration of glucomannan hold H_2 for a longer period of time.

5. Discussion of the Results in Table 2

[0066] Analysis of the results in Table 2 indicate that increasing the concentration of magnesium metal powder (Mg) and citric acid (CA) in the gel formulations increases the amount of molecular hydrogen (H_2) in the gel while decreasing the efficiency of generation and/or capture of H_2 in the gel. Citric acid is known to have a strong effect on removal of the passivation coat of magnesium oxide from magnesium metal (*See*, Uan, J-Y. et. al.(2009) J. of Hydrogen Energy 34 (15), 6137 – 6142.). Altering the concentration of gmn in the gels presents a more complex H_2 response. The complex interactions between Mg, water, gmn, and citric acid regarding gel density may help to explain this anomalous behavior.

[0067] The information presented in Table 2 may be used in designing gels for different purposes. For example, one application may require fast, large volume release of H_2 from the gel. If so, a low concentration of gmn (e.g., 0.5 -1 g/100 mL) and high concentrations of Mg (60 -200 mg/100 mL) and an acidic pH would be suggested.

[0068] Cost of generating gels, particularly for a specific application, must be taken into consideration. The cost of magnesium metal powder and organic acids are inexpensive, while the cost of glucomannan per kilogram is much more expensive.

[0069] Another important consideration for food applications is taste. Taste can be modified by addition of excipients and functional agents to the magnesium metal powder - glucomannan gels.

Example 2: Effect of Exemplary Antioxidants and Acids on Molecular Hydrogen (H_2) Generation in Aqueous Magnesium Metal Powder (Mg) – Glucomannan (gmn) Gels

[0070] Gel preparation was performed as described in Example 1. The results in **Table 4** show the effect of incorporating exemplary antioxidants, salts of antioxidants or exemplary acids on: aqueous magnesium metal powder – glucomannan gel formation; gel density and the volume of H_2 in the gels. Evaluations at one - hour and at six – hours after gel formation are shown.

[0071] For all but one gel formula, i.e., that containing 0.5 grams of sodium ascorbate, (See **Table 4,** Rows 7 and 8), densities of the control gels at the 1-hour evaluation (**Table 4,** Rows 1, 3, 5, 9, 11) were higher, as found for those gels tested versus the control gels as shown in **Table 2**. Thus, at the 1-hour evaluation, 0.5 g sodium ascorbate/100 mL DW in the 0.1 magnesium metal powder - glucomannan gel does not produce an amount of H_2 that would lower the gel density. In contrast, at the 6-hour evaluation, it was found that 9.9 mL of H_2 was present in this gel. Thus, 0.5 g sodium ascorbate/100 mL DW in a magnesium metal powder - glucomannan gel slowly produces gas that is retained in the gel over the 1 to -hour period. This slower process of H_2 generation may have an advantage in situations where gel formation takes place faster than H_2 generation. That is, a higher percentage of H_2 can be sequestered in the gel.

[0072] Analyzing the 1 to 6–hour time course for H_2 generation in gels containing 0.5 g ascorbic acid (**Table 4,** Rows 1, 2); or 0.5 g sodium ascorbate plus 0.5 g of potassium citrate (Rows 3, 4); or 0.5 g isoascorbic acid (Rows 5, 6), it is observed that H_2 volume sustained in the gel is between 16.5 and 19.9 mL at the one hour evaluation. It rises to between 29.9 and 36.5 mL at the 6-hour evaluation. Knowledge of this slow generation and sequestration of H_2 in the gel is useful for trapping the maximum amount of H_2 in the gel. That is, the gel can be formed before appreciable H_2 is generated and escapes to the environment. Once the gel is formed, the additional H_2 generated will be trapped for an extended period.

[0073] In contrast, magnesium metal powder - glucomannan gel containing either 0.5 g salicylic acid or 0.5 g sodium bisulfite reach their maximum H_2 volume in the gel at 1 hour post gel formation. Like citric and other hydroxy acids, these acids affect fast generation of H_2 in the gels.

Example 3: Effect of Some Acids on the Generation of Molecular Hydrogen in Magnesium Metal Powder (Mg) – Glucomannan (gmn) Gels

[0074] The results shown in **Table 5** demonstrate the effects of some organic acids and one inorganic acid on the generation of molecular hydrogen (H_2) in magnesium metal powder (Mg) – glucomannan (gmn) aqueous gels. For this set of results, dry 296 mL empty water bottles were used. The empty bottles, with caps, weigh 9.6 g. The weight of the gels was determined by subtracting the weight of the empty bottle from the total weight. The area of the circumference of the bottle is 30.19 square cm (i.e., 6.2 cm. diameter). Thus, volumes of the gels were calculated by 30.19 square cm. - multiplied by the height of the gels, in cm.

Table 5: Effect of Acids on Generation of Molecular Hydrogen (H_2) in Magnesium Metal Powder (Mg) - Glucomannan (gmn) Gels

		Dens.	Gas	Bubbly	Tot Gel	pH
Row	Test Formulas/100 mL DW	g/mL	mL	Gel (mL)	mL	unit
1	4.0 g gmn + 4 g lactic acid/DW	0.974	0	0.0	108.7	3.16
2	0.1 g Mg + 4.0 g gmn + 4.0 g lactic acid/DW	0.762	30.2	138.9	138.9	
3	4.0 g gmn + 4.0 g tartaric acid/DW	0.974	0	0.0	108.7	1.62
4	0.1 g Mg + 4.0 g gmn + 4.0 g tartaric acid/DW	0.712	33.2	141.9	141.9	
5	4.0 g gmn + 4 g succinic acid/DW	1.027	0	0.0	102.7	2.14
6	0.1 g Mg + 4.0 g gmn + 4.0 g succinic acid/DW	0.744	39.2	141.9	141.9	
7	4.0 g gmn + 4.8 mL 85% phosphoric acid/DW	1.088	0	0.0	96.6	0.98
8	0.1 g Mg + 4.0 g gmn + 4.8 mL 85% phosphoric acid/DW	0.880	24.2	120.8	120.8	
9	4.0 g gmn + 4.0 g malic acid/DW	0.997	0	0.0	105.7	1.81
10	0.1 g Mg + 4.0 g gmn + 40 g malic acid/DW	0.712	42.2	147.9	147.9	
11	0.1 g Mg + 4.0 g gmn + 4.0 g malic acid/LVVWD	0.730	39.6	144.9	144.9	
12	0.1 g Mg + 4.0 g gmn + 4.0 g malic acid/ROW	0.751	34.7	140.4	140.4	
13	0.1 g Mg + 4.0 g gmn + 4.0 g malic acid/SW	0.752	34.7	140.4	140.4	

Abbreviations: gmn -glucomannan; DW-distilled water; SW-soft water; ROW-Reverse Osmosis Water; LVVWD - Las Vegas City Water; Tot. - Total; H_2- molecular hydrogen; Mg-magnesium metal powder; g - grams; Dens.-density; mL-milliliters.

[0075] The results in Columns 3 and 4, respectively, show the effects on gel density and H_2 gas volume due to incubating the different acids, mixed into magnesium metal powder - glucomannan gel powders, and then mixed with water. The odd numbered formulations 1, 3, 5,

7 and 9 are controls – without Mg. The even numbered gels, as well as 11, 12 and 13 each contain 0.1 g of Mg.

[0076] The results listed in Column 3 of **Table 5** show clearly that the densities of the gels generated with Mg present in the gel, have much lower densities relative to their controls – without Mg present. This lowering of the density is due to the presence of large numbers of H_2 bubbles and dissolved H_2 - in the gel.

[0077] Column 4 of **Table 5** lists the volume of H_2 gas that is present in each gel. The volumes of H_2 are based upon the difference in the volume of the Mg containing gels and their controls without Mg (Rows 1, 3, 5, 7 and 9). The volume of H_2 in the gels range from 24.2 mL for the phosphoric acid containing gel to 42.2 mL for the malic acid containing gel generated with distilled water. Although all types of water used for preparing magnesium metal powder - glucomannan gels readily generates H_2, use of distilled water appears to be the most effective at generating H_2 (See Rows 10 - 13).

[0078] Thus, all the acids tested affect the content of H_2 in the gels and expansion of the volume of gels. The difference in the amount of H_2 in the gels depends on the nature of the acid, the concentration thereof, and the pH of the composition. Comparing the H_2 in the gels shown in **Table 5** with that generated by a comparable amount of citric acid, (See **Table 2**, Row 16) citric acid is a more potent effector of H_2 in the Mg-glucomannan gels.

Example 4: Room Temperature Stability of Molecular Hydrogen (H_2) in Magnesium Metal Powder (Mg) – glucomannan (gmn) Gels

[0079] Longer term studies were carried out to determine the time course of loss of H_2 from magnesium metal powder-glucomannan gels. Here, we define sustainability as the ability to hold H_2 in gels or solutions over the short – term. We define stability as the ability to hold H_2 in the gels over the longer – term, i.e., longer than 24 hours.

[0080] Stability of molecular hydrogen (H_2) in the magnesium metal powder - glucomannan gels is estimated by measuring the extent that a particular gel will maintain its bubble gel volume (BGV) – over time.

[0081] For this Stability Study, some of the test samples shown in **Table 2** were studied for up to 936 hours (39 days). Comparing the results in Rows 1 - 5 of **Table 3**, it is seen that as the concentration of Mg in the gels is increased, the longer the visible bubbles (BGV) last in the gels. Comparing the rate of drop of the BGV, it appears that the highest concentration of Mg (207 mg) is more effective at maintaining H_2 bubbles in the gel. That is, by 108 hours of

stability testing, the gels containing respectively, 24, 42, and 63 mg of Mg have lost, respectively, 91.0, 86.4, and 80.4% of their bubble gel volume. In contrast, the gel containing 207 mg of Mg lost only 10.2% of its bubbly gel volume (BGV). The gel containing 207 mg Mg maintained 68 % of its BGV up to 261 hours (10.9 days) - after gel preparation. Thus, there may be a synergistic effect of Mg in maintaining BGV in glucomannan formulations. It is possible that an interaction of Mg and/or magnesium hydroxide takes place with the H_2 bubble complex in the glucomannan gel. Also, an interaction of Mg particles with H_2 microbubbles in the gel, would tend to keep the H_2 bubbles from escaping from the gel.

[0082] Comparing the results in Rows 6 - 10 of **Table 3**, it is seen that as the concentration of citric acid increases, the stability of H_2 bubbles in the gel (BGV) increases. Thus, it has been unexpectedly found that citric acid increases the stability of H_2 in aqueous Mg – glucomannan formulations.

Example 5: Refrigerated Study of Molecular Hydrogen (H_2) Stability in Aqueous Magnesium Metal Powder - Glucomannan Gels

1. Experimental

[0083] A study was carried out to determine the stability of H_2 in a magnesium metal powder - glucomannan gel under refrigerated conditions (1 – 4 deg. C). A batch consisting of 1.1 g of crude magnesium metal powder (Mg), 44.0 g of Best Naturals® konjac glucomannan powder and 5.5 g of citric acid was prepared and mixed thoroughly. Aliquots of 9.1 g of the batch of powder were added to 5 empty 237 mL plastic bottles. Thereafter, 100 mL of distilled water was added to each bottle. The bottles were tightly capped and shaken vigorously while the gels formed. Bottles labeled # 6 - 10 were designated for the refrigerated stability study. After the gels formed, a line was drawn on the bottle where the gel – air interface formed, thereby delineating the height of the gel. Knowing the area of the base of the bottle as 33.18 square cm, the volume of the gels was calculated, i.e., from the volume of a cylinder. Initially, the entire volume of the gels contained numerous bubbles, of diverse sizes - from top to bottom of the bottle. The volume of gel containing bubbles was designated as the Bubble Gel Volume (BGV). It was observed that the bubbles diffused up from the bottom of the gel with the passage of time. It is observed that the gels become depleted of H_2 bubbles – from bottom – to – top of the gel, as time passes. The change in the BGV, with time, was determined by measuring the length of the gel that still contained bubbles and multiplying times the circumference of the bottle to obtain

the remaining BGV. To gain access to the gel at completion of the time course of the experiment, the top section of the plastic bottle was cut off exposing the gel for measurements of dissolved H_2. Dissolved H_2, in the gels, was measured with the Trustlex® Molecular Hydrogen (H_2) meter, without the guard that protects the electrode. The guard is removed since it would deny access of the Trustlex® electrode to the gel.

2. Results

[0084] The time course of results is shown in **Table 6**. As shown in Column 2, there is a progressive, slow reduction in BGV - with time. At Day 73, the last day of the Study, the gel retained 51.1% of the baseline BGV. H_2 measurements, at that time, indicated that there was 250 ppb dissolved H_2 in the Gel.

Table 6: Refrigerated (1 - 4 C) Study on the Stability of Molecular Hydrogen in a Magnesium Metal Powder - Glucomannan Gel

			Dissolved
		% Change	H_2
Day	BGV	in BGV	ppb
0	169.3	xxxx	NM
2	163.9	-3.2	NM
13	148.7	-9.1	NM
29	148.7	-9.1	432
41	132.7	-21.6	459
50	119.5	-29.4	400
62	124.5	-26.5	379
73	86.6	-48.9	250

Abbreviations
BGV - Bubble Gel Volume
ppb - parts per billion molecular hydrogen (H_2)
NM - Not measured

[0085] This remarkable retention of H_2 in the Mg – gmn gel was unexpected. H_2 is the universe's smallest molecule and it is thought to be able to rapidly diffuse through most materials. A plastic container should not provide a long - term barrier to H_2 diffusion. Rather, there is a stabilization of both H_2 in bubbles and dissolved H_2 in the magnesium metal powder - glucomannan gel.

[0086] There are interesting applications of longer term, low temperature, storage of H_2 gels. For example, there are applications in the refrigerated food category. H_2 – rich, Mg – gmn viscous solutions and gels can be formulated into various food products - including gels. Such

products could be manufactured and stored, for extended periods of time, by manufacturers or consumers.

Example 6: Some Special Properties of Magnesium Metal Powder – Glucomannan Complexes

1. Molecular Hydrogen, but not Carbon Dioxide is Retained in Glucomannan Gels

a. Introduction

[0087] A study was carried out to compare the effects of potassium bicarbonate – which generates carbon dioxide gas (CO2) in acidic solutions, and magnesium metal powder – which generates molecular hydrogen (H_2) in acidic solution - on glucomannan gel volume. The '000' capsules containing the ingredients were immersed in aqueous 1.25% acetic derived from vinegar in sealed bottles. This study was done: 1) to determine if the effect of H_2 on increasing gel volume is unique to use of a hydrogen – generating system; 2) to determine the effects on these gas producing agents on both gel volume and headspace volume in a closed system; 3) to have the closed system serve as a model for gel behavior in the upper gastrointestinal tract; 4) to determine the effect of increasing concentrations of glucomannan on gel volume expansion.

b. Experimental

[0088] Formulations, as listed in **Table 1**, were prepared by mixing the powder ingredients and then manually filling vegetarian "000" Vcaps® capsules obtained by Cap-M-Quik.com. Different numbers of capsules were used to accommodate the volume of each powder formulation (See Column 9 of **Table 1**). Diluted vinegar (1.25 % acetic acid), in separate 2500 mL lots, was prepared by mixing 625 mL white vinegar (5 % acetic acid) with 1875 mL of distilled water (DW). Great Value® purified water bottles were emptied and dried before use. When these bottles are filled and topped off, they hold 540 mL of liquid.

[0089] Both magnesium metal powder (Mg) – glucomannan capsules, and potassium bicarbonate – glucomannan capsules were tared before being added to the empty bottles. The weight of the empty capsules was accounted for. Thereafter, the bottles were 'topped off' with the 1.25 % acetic acid solution and tightly capped. The time of starting the experiment was recorded. The contents were periodically mixed by rotating the bottles by hand. Experiments were carried out at 23 C.

[0090] H_2Blue®, a methylene blue - platinum catalyst titration method, used as instructed by the manufacturer (H_2 Sciences.com), was employed to estimate dissolved H_2 in ppm. One drop

of test solution is equivalent to 0.1 ppm H_2. For example, if it takes 5 drops of the test solution to turn six mL of a solution blue, then the solution contains 0.5 ppm H_2. Testing was performed in a 20 mL graduated plastic vial. The pH measurements were taken with an EXTECH® ExStik® PH100 pH meter that was periodically calibrated.

[0091] Generation of H_2 gas from magnesium metal powder reacting with dilute vinegar and generation of carbon dioxide (CO2), from potassium bicarbonate reacting with dilute vinegar, in the sealed bottles creates a headspace. The volume of the 1.25 % acetic acid liquid displaced by the gases generating the headspace in the bottles was measured as follows: At completion of the study, there was a displacement of liquid on the top of the sealed bottles, i.e., the headspace. A marker pen was then used to delineate the length and circumference of the headspace. The marker pen was also used to delineate the length and circumference of the gel in each bottle. After emptying and rinsing the bottles, leaving the caps in place, a scissors was used to 'cut out' and save the plastic section of the bottle representing the headspace plus the plastic section of the bottle previously containing the gel. The bottle cap remained in place as a base to retain liquid in the upper portion of the 'cut out' section of the bottle. A gravimetric procedure was used to determine the amount of solution in the 'cut out' section of the bottle. That is, after weighing the empty plastic piece representing the headspace plus the gel, distilled water was added to the plastic section representing the headspace unit plus the gel - until water totally filled the headspace container. Water contained in the section representing the headspace was weighed and recorded. The upper plastic section representing the headspace was then cut away leaving the section representing the gel. The same gravimetric procedure was used to determine the volume occupied by the gel.

c. Results

[0092] **Table 1**, Rows 1-15, displays the 15 formulations tested. The capsules were placed in the plastic bottles, topped off with 540 mL of the 1.25 % acetic acid solution and capped tightly. Incubation time was 5 hours. It should be noted that the 000 capsules readily dissolve in the aqueous 1.25% acidic acid solution.

[0093] Effect of Potassium Bicarbonate

[0094] The result in Row 1 of Table 1 shows that addition of the capsule containing 0.1 g Mg, without glucomannan, does not result in gel formation – as expected. However, it generates H_2 gas pressure thereby creating a 37.6 mL of headspace. It also produces 0.7 ppm of molecular

hydrogen (H_2) that is dissolved in the 1.25% acetic acid solution. Thus, in this system, H_2 can exist in both the headspace and be dissolved in the aqueous acidic solution.

[0095] The results in Rows 2 – 5 of Table 1 show formulations containing 2 grams of glucomannan (gmn) and different concentrations of potassium bicarbonate – which generates carbon dioxide (CO2) in this acidic solution. Potassium bicarbonate was tested with glucomannan to determine if the resultant generation of CO2 could alter gel formation and affect gel expansion. The results show that incubating the glucomannan - containing formulations with increasing doses of potassium bicarbonate, generates a head space of 0.0 – 14.3 mL in a dose – response manner (See Rows 2 – 5, Column 4). In contrast, a 1.6 g glucomannan formulation, without CO2 - producing potassium bicarbonate, does not produce a head space (See Row 6 of Table 1). The total volume i.e., head space plus gel volume affected by potassium bicarbonate (Rows 2 – 5, Column 5), is 13.4 – 30.9 mL. The gels alone, containing potassium bicarbonate, range from 11.0 to 21.6 mL - where gel volume does not increase with potassium bicarbonate content. Column 8 lists the efficiency of gel formation, i.e., the volume of gel produced per gram of glucomannan. The efficiency of this group ranges from 5.5 to 10.8 mL of gel per gram of glucomannan. There is a lack of a dose – response relationship in affecting gel volume per gram of glucomannan – when tested with potassium bicarbonate. The concentration of potassium bicarbonate in the gel (See Rows 2 – 5, Column 3 and 8) is not related to the volume of gel formation. The formulation containing 1.6 g of glucomannan (Row 6, Column 2), without potassium bicarbonate, is slightly more efficient at gel formation than the glucomannan gels that contain potassium bicarbonate. (Rows 2 – 5, Column 8). Therefore, potassium bicarbonate and, in turn, CO2 does not expand glucomannan gels. These observations on glucomannan – potassium bicarbonate compositions in aqueous acidic environments supports the hypothesis that there is a strong interaction between H_2 generation from magnesium metal powder and glucomannan resulting in the expansion of glucomannan gels that is a unique property of generating H_2 in glucomannan solutions and gels. That is, generation of any gas in aqueous – glucomannan gels will not expand the gel volume – as found for H_2.

d. Effect of Magnesium Metal Powder

[0096] The results in Rows 7 – 15, Column 2 of **Table 1** show magnesium metal powder - glucomannan (Mg - gmn) formulations, in 000 capsules. These capsules were added to 1.25% acetic acid, as a stomach acid model, as discussed above. Magnesium metal powder was combined with glucomannan, in capsules, to determine its effect on gel formation as well as to

determine the generation of molecular hydrogen (H_2) in this aqueous acidic solution. The results in Column 4 show that glucomannan formulations containing magnesium metal powder (Mg) generate a head space of between 14.2 and 39.4 mL. The formulation that generates the 14.2 mL headspace contains the lowest concentration of Mg (0.05 g) while the formulation that generates the largest head space contains both Mg (0.1 g) and potassium bicarbonate (0.8 g). Thus, both Mg and potassium bicarbonate contribute to the head space volume. The gels produced by the Mg containing glucomannan formulations range from 17.6 – 132.7 mL (Column 4). Increasing both magnesium metal powder and glucomannan leads to increased gel volume. The efficiency of gel formation is inversely related to the glucomannan concentration, where the lowest concentration of gmn (0.2 g), in the presence of 0.1 g Mg, generates the most gel/gram of glucomannan. It is of interest that addition of 0.8 g potassium bicarbonate reduces the efficiency of generation of gel volume by magnesium metal powder (Row 7). This shows that the reaction of magnesium metal powder with water in the glucomannan - 1.25% acetic acid solution generates an expanded gel volume larger than would be anticipated from previous results. This generation of expanded gel volume involves the sequestering of bubbly molecular hydrogen in the gel and the presence of dissolved molecular hydrogen in the gel.

e. Removal of the Passivation of Magnesium Metal Powder by Glucomannan

[0097] Comparing the results in Row 6 of **Table 1** with those of Rows 11 -15 of **Table 1**, it is seen that the increasing concentration of glucomannan increases gel volume (Column 3) in a dose - response manner. Since, as shown in Row 6, without magnesium metal powder, the highest concentration of glucomannan studied, i.e., 1.6 g, has a gel volume of 18.8 mL (See Row 6, Column 3). Comparing this volume to the 73.4 mL gel volume generated by the 1.6 g glucomannan plus 0.1 g magnesium metal powder, the effect on generation molecular hydrogen in the gel is obvious. Thus, the generation of H_2 by 0.1 g magnesium metal powder in the glucomannan gel has an effect of increasing gel volume by 390%. Further, comparing the results in Rows 1 - 15 of **Table 1**, it can be seen that there is a dose – response relationship in increasing gel volume by increasing the concentration of glucomannan. This effect must be due to increasing molecular hydrogen in the gel, since all but one of these formulations has much lower concentrations of glucomannan than the control displayed in Row 6 of **Table 1**. These results point to a direct interaction between glucomannan and magnesium metal powder in the aqueous acidic solution - in promoting the generation of molecular hydrogen in the resultant gels. This interaction is best explained by glucomannan having the ability to catalyze the

removal of the magnesium oxide passivation coat from the surface of magnesium metal powder particles.

[0098] Further, results shown here and in Table 14 and Figure 1 demonstrate that glucomannan, without citric acid, can affect the removal of the passivation coat of magnesium oxide from magnesium metal powder.

f. Discussion

[0099] Generation of molecular hydrogen (H_2), in an acidic solution mimicking stomach acid, takes place when glucomannan is combined with magnesium metal powder (Mg). This effect is observed by comparing the generation of 0.7 ppm H_2 by 0.1 g magnesium metal powder - without glucomannan (See Row 1, **Table 1**) - with the formulations containing 0.1 Mg with 0.2 – 4.0 g of glucomannan – which generates 0.8 to 1.5 ppm of dissolved molecular hydrogen (See Rows 7 - 15, **Table 1**).

[0100] There has been a failure of weight loss treatments and programs to stop the progression of the obesity epidemic. Also, there is lack of effective and safe weight loss drugs. Obesity is only the 'tip of the iceberg'. A newly uncovered inflammatory component of obesity is now known to lead to serious diseases, including Type 2 diabetes, cardiovascular disease, cancer, Alzheimer's disease, fatty liver disease and several autoimmune diseases. Thus, there is a need for a safe and effective product that treats both the cause of obesity and the inflammatory component that affects the associated diseases - listed above.

[0101] Molecular hydrogen (H_2)-generating magnesium metal powder (Mg) – glucomannan formulations delivered to the stomach by capsule, tablet or other pharmaceutical dosage forms, can create satiety by generating a feeling of fullness for 4 - 8 hours, while reducing obesity associated inflammation due to the generation and sustained release of anti-inflammatory molecular hydrogen.

Example 7: Effect of Ingestion of Magnesium Metal Powder (Mg) – Glucomannan (gmn) Capsules on Satiety

[0102] A subject experienced hunger sometime between early lunch (around 9:30 AM) and dinner (around 5:30 PM). He would snack on 'junk food' before dinner and found he was gaining unwanted weight.

[0103] It was suggested that when feeling hungry that he consumed a 7% magnesium metal powder–93% glucomannan powder mixture, encased in capsules where each capsule contained 0.4 grams powder per capsule.

[0104] In the first trial, he started feeling hungry at about 2:30 PM. He took one 7% Mg – 93% gmn capsule with an 8 oz. glass of water and was able to avoid snacking until 4:40 PM, upon which he 'broke down' and snacked.

[0105] In the second trial, he again started feeling hungry about 2:00 PM. He took three of the 7% Mg – 93% gmn capsules with a 12 oz. glass of water. He was able to avoid snacking and ate his dinner on time. He did not experience any adverse events from taking the 7% Mg – 93% gmn capsules.

[0106] In the third trial, he again started feeling hungry about 2:00 PM. He took 6 of the 7% Mg-93% gmn capsules with about 15 oz. of water. He experienced a feeling of fullness within five minutes. He was able to avoid snacking. He could finish the main course of his dinner, but refused desert, which he normally ate. The only side effect was a feeling of fullness. It did not alter his sleeping or bowel movement patterns.

Example 8: Development of a Hydrogen – Rich, Low Calorie Lemon Gel

[0107] There is a need for a snack or desert that will substitute for high calorie foods, provide a feeling of fullness – thereby supporting weight control and fasting regimens.

[0108] A delicious tasting, 5 calorie lemon gel, retaining molecular hydrogen (H_2) and expanding in volume, thereby giving a feeling of fullness, was the objective of a product development program. Development took place by a process of variation of the levels of magnesium metal powder (Mg) and glucomannan (gmn), along with testing D-L malic acid, ascorbic acid, iso-ascorbic acid and the natural sweetener - stevia, a natural lemon flavor powder (BioFinest®) and FDC Yellow # 6. Several low-calorie versions of gels were prepared and tested for volume expansion of the gel due to H_2, sweetness, tartness, texture, color and lemon flavor. The initial formulation and taste testing studies which resulted in the elimination of some ingredients are not displayed here.

[0109] **Table 7** displays the results of the last three sequential studies involved in the process of development of the gel.

Table 7: Development of a Low Calorie, Hydrogen - Rich Lemon Gel Based Upon Magnesium Metal Powder and Glucomannan

	Formulas/100 mL Distilled Water (DW)	Sweet-	Tart-	Text-		1-Hr

#	Study 6218	ness	ness	ure	Comments	Vol. Inc. (mL)
1	8 mg Mg + 4.0 gmn + 0.8 g Stevia + 0.5 g LF + 0.3 g Na ascorbate	2	5	10	No LF, not sweet	-5.6
2	16 mg Mg + 4.0 gmn+ 0.8 g Stevia + 0.5 g LF + 0.3 g Na ascorbate	2	5	10	No LF, not sweet	5.6
3	47 mg Mg + 4.0 gmn + 0.9 g Stevia + 0.5 g LF + 0.3 g Na ascorbate	3	5	10	Better than 1 & 2	11.3
4	79 mg Mg + 4.0 gmn + 0.7 g Stevia + 0.5 g LF + 0.3 g Na ascorbate	3	5	10	Same as 3	14.4
5	40 mg Mg + 4.0 gmn + 0.9 g Stevia + 0.7 g LF + 0.3 g Na ascorbate	3	5	10	Little LF, not sweet	11.3
6	39 mg Mg + 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.3 g Na ascorbate	3	4	10	Little LF, starchy	14.4
7	38 mg Mg + 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.2 g isoascorbic acid	2	5	10	Bitter, not sweet	17.0
8	45 mg Mg + 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.4 g isoascorbic acid	1	7	10	Bitter, not sweet	22.6
9	41 mg Mg + 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.2 g malic acid	1	7	10	Bitter, not sweet	11.3
10	43 mg Mg + 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.4 g malic acid	4	7	10	Bitter, not sweet	19.8
11	44 mg Mg + 4.0 gmn + 1.0 g Stevia + 1.0 g LF + 0.2 g ascorbic acid	3	4	10	No LF, not sweet	25.5
12	35 mg Mg+ 4.0 gmn + 0.8 g Stevia + 1.0 g LF + 0.4 g ascorbic acid	2	7	10	No LF, not sweet	19.8
	Study 6318					
1	53 mg Mg + 4.0 g gmn + 1.5 g Stevia + 2.0 g LF + 0.4 g Na ascorbate	7	7	10	slight after-taste	11.3
2	50 mg Mg + 4.0 g gmn + 1.5 g Stevia + 3.0 g LF + 0.4 g Na ascorbate	5	5	10	off -taste	8.5
3	54 mg Mg + 4.0 g gmn + 3.0 g Stevia + 2.0 g LF + 0.4 g Na ascorbate	7	7	10	creamy, off -taste	8.5
4	51 mg Mg + 4.0 g gmn + 3.0 g Stevia + 3.0 g LF + 0.4 g Na ascorbate	8	8	10	Best of Group	5.7
5	51 mg Mg + 4.0 g gmn + 4.0 g Stevia + 4.0 g LF + 0.4 g Na ascorbate	xxxx	xxxx	xxxx	off -taste	14.2
	Study 6418**					
1	31 mg Mg*. + 4.0 g gmn + 0.4 g NaAscorbate + 3.0 g stevia + 3.0 g LF	10	7	10	slght off -taste	19.8
2	32 mg Mg*. + 4.0 g gmn + 0.4 g NaAscorbate + 3.1 g stevia + 3.1 g LF	10	7	10	slight off-flavor	17.0
3	33 mg Mg*. + 4.0 g gmn+ 0.4 g NaAscorbate + 3.2 g stevia + 3.2 g LF	10	9	10	Best Taste	22.6

Abbreviations

gmn-glucomannan

LF- Lemon Flavor

No LF - no lemon flavor perceived by the taste test

Mg* - 63 micron (230 Mesh) Lot of magnesium metal powder

** 0.72 mg FD&C Yellow # 5 is in the 100 mL DW added for color.

1. Study 6218

[0110] Rows 1 – 12 of Study 6218 in **Table 7**, display twelve powder formulations with variation, of Mg, stevia, lemon flavor (LF), Na ascorbate, isoascorbic acid, malic acid and ascorbic acid. After addition of 100 mL distilled water and mixing, the solutions start to gel within 30 - 60 seconds. Within an hour, an experienced dietitian evaluated the resulting gels, on a scale of 1 (bad) to 10 (excellent) for sweetness, tartness and texture.

[0111] All gels had an outstanding texture, being light and uniquely fluffy. However, none of the gels had an acceptable taste (Columns 3 and 4). There was an insufficient amount of sweetness. The gels shown in Rows 2 - 12 expanded in volume by 5.6 – 25.5 mL after standing for at least an hour. The volume of the gel displayed in Row 1, with the lowest concentration of Mg, contracted by 5.6 mL – probably due to an interaction of Mg with glucomannan. Otherwise, there is a dose – response relationship for increase in gel volume with increasing Mg content. (See Rows 1 - 4 of Study 6218). Addition of more Mg generates more H_2 – thereby affecting gel expansion and 'fluffiness'. Although isoascorbic acid, ascorbic acid, and malic acid in the lemon - flavored formulation led to significant volume expansion of the gels (Rows 7 -10), they imparted a bitter, "off" taste at the concentrations tested.

2. Study 6318

[0112] Analysis of the results of Study 6218 led to the design and testing of the formulations listed under Study 6318 of **Table 7**. As a result of Study 6218, it was determined that Na ascorbate did not impart a bitter taste as found with testing the organic acids. An additional amount of stevia was added to enhance sweetness. Also, an additional amount of lemon - flavored powder (LF) was added to enhance the lemon flavor. Magnesium metal powder was tested at 50 - 54 mg/100 mL.

[0113] It was found that none of the 5 gels listed in Rows 1 - 5 of Study 6318 scored above an 8 for sweetness and tartness. The texture was excellent. The gel shown in Row 4 was judged to be best. All 5 gels increased in gel volume upon standing for one hour or more.

3. Study 6418

[0114] It was determined that based upon the results for Gel # 4 of Study 6318 that slightly more sweetness and lemon flavor were needed. A lower dose of Mg was used. This magnesium

metal powder was the 63 - micron (230 Mesh) fraction of the Lot of magnesium metal powder used in previous studies. It is designated in **Table 7** as Mg*. Of the three gel formulas displayed in Rows 1 - 3 of Study 6418, # 3 was judged qualitatively to be best. This gel had the highest level of both stevia and the lemon flavor. All three gels increased in volume upon standing.

[0115] The results demonstrate that it is possible to create a delicious tasting, textured, hydrogen - rich lemon gel based upon glucomannan and magnesium metal powder. This hydrogen rich lemon gel should be helpful to weight management and intermittent fasting regimens.

[0116] Lemon and chocolate hydrogen–rich gels have been prepared and have been used to control food cravings in-between meals.

Example 9: Transforming Marketed Lemon-Flavored Powders, for Drinks, into Delicious Molecular Hydrogen – Generating and Sustaining Gels

1. Introduction

[0117] It has been found that magnesium metal powder (Mg) – glucomannan (gmn) formulations can be used to transform marketed drinks into gels with a desirable taste and texture. Of particular interest here, is turning marketed low-calorie flavored powders designed to make beverages into low calorie hydrogen–rich gels that can be used to augment weight loss and fasting programs. That is, drink making powders formulated with the addition of Mg and gmn - transforms aqueous drinks into hydrogen – rich gels, with an expanded volume, that are perceived as 'filling' and having a desirable and unique 'fluffy' texture.

Table 8: Molecular Hydrogen Gels Containing Marketed Lemon Flavored Drink Powders

	Formula/ 100 mL Distilled Water (DW)			1-Hr Vol.	4-Hr Vol.
#	Study 6518	Taste	Comments	Inc. (mL)	Inc. (mL)
1	24 mg Mg* + 4.0 g gmn + 1.7 g Crystal Light	9	Acceptable, Good	8.5	11.2
2	22 mg Mg* + 4.0 g gmn + 2.5 g Crystal Light	10	Acceptable, better than 1	11.4	5.7
3	41 mg Mg* + 4.0 g gmn + 1.7 g Crystal Light	9	Acceptable	14.2	17.0
4	40 mg Mg* + 4.0 g gmn + 2.5 g Crystal Light	10	Best Gel, best flavor	11.3	14.2
5	20 mg Mg* + 4.0 g gmn + 0.8 g Crystal Light	7	Not acceptable, weak flavor	2.8	16.9
6	42 mg Mg* + 4.0 g gmn + 0.8 g Crystal	8	OK, but weak flavor,	5.7	19.6

	Light		color		
	Study 6618				
1	43 mg Mg*+ 4.0 g gmn + 2.5 g Crystal Light (2012)	10	Excellent Tartness	22.6	31.1
2	44 mg Mg*+ 4.0 g gmn + 2.5 g Crystal Light (2020)	10	Very Good Tartness	22.6	31.1
3	44 mg Mg*+ 4.0 g gmn + 2.5 g Wyler's Light Lemonade	10	Very Good Tartness	22.6	28.3
4	42 mg Mg*+ 4.0 g gmn + 2.5 g Great Value Lemonade	9	Tartness not as good	20.0	31.1
5	4.0 g gmn + 2.5 g Crystal Light (2020)	10	Excellent Tartness	0.0	0.0
	Study 61218				
1	40 mg Mg*+ 4 g gmn + 2.5 g + True Lemon®	8	Needs more lemon taste	11.4	11.4

Abbreviations
Mg* 63 micron(230 Mesh) Lot of magnesium metal powder
gmn glucomannan
Vol Volume
Taste rated 1- awful; 10-Excellent

2. Experimental

[0118] The results presented in **Table 8** outline the development and testing of molecular hydrogen (H_2) - rich lemon gels produced from marketed lemon - flavored drink powders. The gels were developed by addition of glucomannan and Mg to the lemon - flavored powder. 100 mL of water was then added to the 4.8 – 6.6 g of powders and mixed for less than 2 - minutes – until a 'fluffy' gel formed. For these studies, 63 - micron (230 Mesh) magnesium metal powder (Mg*.) was used. Gels were evaluated for organoleptic properties, i.e., sweetness, tartness and texture. These organoleptic properties were grouped under 'Taste' in Column 3 of Table 8. All gels containing Mg - gmn had unique desirable, light, 'fluffy' texture. They were also evaluated for their potential to expand after standing for periods of one - hour and four - hours. Volume increase measurements were made as described previously.

3. Results

[0119] The results presented in Rows 1 - 6 of **Table 8** of Study 6518 show the effect of varying concentrations of Mg* and/or gmn on the taste and volume change of various doses of Crystal Light® Natural Lemonade. The gel formed from the ingredients displayed in Row # 4, i.e., 40 mg Mg* + 4.0 g gmn + 2.5 g Crystal Light® Natural Lemonade was judged to be the best tasting gel. It contained 3.1 times the recommended dose for making Crystal Light®

Natural Lemonade drinks. All formulations containing Mg* - gmn, affected an expansion of gel volume - upon standing. This phenomenon indicated that the gels retained much of the H_2 that was generated. Much of the H_2 was retained as gas bubbles. Mg* continued to react with water, in the gel, and generated H_2 over the 5-hour time frame studied (Compare Columns 5 & 6 of **Table 8**). This extended reactivity of Mg* with water was indicative of glucomannan's ability to affect the removal of the passivation coat of magnesium oxide from Mg*. As noted previously, the expansion of the gels provided for a highly desirable 'fluffy' texture.

[0120] The results in Rows 1 - 5 of Table 8 of Study 6618 showed the effects of addition 42 - 44 mg Mg* and 4.0 g of gmn powders to the various lemon - flavored marketed brands and mixing with 100 mL of distilled water (DW). The organoleptic properties and time course of volume expansion of the lemon gels was determined. Here, volume expansion was measured relative to that of the 4 g gmn + 2.5 g Crystal Light® control gel (See Row # 5, Study 6618). The organoleptic properties of all gels, except # 4, met with approval by the dietitian. All gels containing 42 - 44 mg of Mg* showed marked expansion of the gels - relative to the control gel (in Row # 5). Gels 1 - 4 showed expansion between 1 - and 4 - hours after preparation. The control gel (Row # 5), without Mg*, did not expand after preparation. Thus, this study confirms the need for the generation of H_2 to expand the gels.

Example 10: Time Course of Loss of Dissolved Molecular Hydrogen (H_2) from a Mg* - gmn Gel

[0121] The results presented in **Table 9** show the time course of change in dissolved H_2 when left to stand in an open container at 23 C. Measurements were taken with the H_2 Trustlex® meter. This Gel is generated from 40 mg Mg* + 4.0 g gmn + 2.5 g Crystal Light® powders mixed with 100 mL of distilled water. A 5-hour time delay took place before measurements were taken. The results show that at 5-hours post gel production (zero time of measurement), 709 ppb H_2 remains in the gel. Over the course of the next 535 minutes (about 9 hours), the H_2 drops to 410 ppb, or retains 57.8% its H_2. Thus, in an open container, Mg - gmn gels retain dissolved H_2 for extended periods of time. These results support the presence of a strong interaction of the Mg* - gmn containing gel with H_2.

Table 9: Time Course of Loss of Dissolved Molecular Hydrogen (H_2) from a Magnesium Metal Powder (Mg*) - Glucomannan Gel in an 'Open Cup' Study**

Minutes	ppb H_2	% H_2 Remaining
0	709	xxxx

10	712	100.0
15	690	97.3
25	599	84.5
85	454	64.0
160	455	64.2
195	444	62.6
300	435	61.4
360	436	61.5
420	431	60.7
535	410	57.8

Abbreviations
Mg* 63 micron(230 Mesh) Lot of magnesium metal powder
ppb parts per billion molecular hydrogen
** Started 5-Hours after Gel formation.
gmn glucomannan

Example 11: Production and Analysis of Molecular Hydrogen (H_2) Rich Gels of Different Flavors

1. Introduction

[0122] This Example illustrates the utility and flexibility of the embodiments described herein: The magnesium metal powder (Mg) – glucomannan (gmn) formulations are effective at transforming powders designed to produce beverages into low or no calorie hydrogen – rich, expansive gels that can be used for diet deserts and snacks.

2. Experimental

[0123] Each of 10 different Crystal Light® flavors, 2.5 g/serving, were individually mixed with 40 mg Mg* and 4.0 g of glucomannan to create 10 different powder formulations. To initiate gel formation, 100 mL of distilled water was added to an 8 oz. plastic cup containing each formulation and mixed for 60 - 90 seconds to complete gel formation. After one hour, the gel height was measured and the gel volume calculated, as described above. The gel volume increase, above the control without Mg*, was determined by subtracting the control gel volume from the experimental gel volume. The gels were evaluated for sweetness, texture, tartness, and acceptance by an experienced dietitian.

3. Results

[0124] In Column 3 of **Table 10** are shown the volume increases due to incubation of the test gels for one - hour. Gel expansion was measured - relative to a control gel containing 4.0 g of gmn + 2.5 g of Crystal Light® in 100 mL of distilled water. All test gel volumes increased by

14.2 – 25.5%. i.e., by 14.2 – 25.5 mL. These values reflect molecular hydrogen (H_2) being entrapped in the gel as both dissolved molecular hydrogen and H_2 bubbles. The variability of the increase in volumes for the different gels is due to differences in pH and the concentrations of components of the assorted flavors.

Table 10: Preparation of Hydrogen-Rich Gels using Magnesium Metal Powder (Mg*) Plus Glucomannan (gmn) Plus Crystal Light® Flavors - added to 100 mL Distilled Water (DW)

#	Formulas Containing 40 mg Mg* + 4.0 g gmn	Gel ** Inc. (mL)	Sweet	Texture	Tartness	Accept
	Mixed with 100 mL of Distilled Water					
1	2.5 g CL - Peach Mango Green Tea	17.0	OK	Good	NI	YES
	Comment: Good					
2	2.5 g CL - Lemonade	19.8	OK	NI	0K	YES
	Comment: Good					
3	2.5 g CL - Peach Iced Tea (Black Tea)	17.0	OK	NI	0K	YES
	Comment: Good					
4	2.5 g CL - Grape with Caffeine	25.5	OK	NI	NI	YES
	Comment: Good					
5	2.5 g CL - Wild Strawberry with Caffeine	25.5	OK	NI	0K	YES
	Comment: Good					
6	2.5 g CL - Classic Orange	22.6	NS	NI	0K	YES
	Comment: Good					
7	2.5 g CL - Fruit Punch	14.2	OK	NI	NI	NO
	Comment: Too dense					
8	4 g gmn + 2.5 g CL - Pink Lemonade	19.8	OK	OK	OK	YES
	Comment: Good					
9	2.5 g CL - Lemon Iced Tea	19.8	TS	NI	NI	NO
	Comment: Off Color					
10	2.5 g CL - Raspberry Lemonade	25.5	NS	NI	NI	NO
	Comment: Too dense					

Abbreviations

CL Crystal Light®
Mg* - 230 Mesh Lot of magnesium metal powder.
gmn glucomannan
** Gel volume increase - relative to the control 4.0 g gmn + 2.5 g CL/100 mL DW Gel

Evaluations

TS Too Sweet, reduce the sweetener
NS Needs sweetness - add
OK Excellent sweetness or tartness
NI Needs improvement in sweetness or tartness

[0125] Reviewing the results in Columns 4 - 7, it is observed that eight of ten of the gels were judged to be acceptable – meaning they were delicious and had the desired 'fluffy' texture. Means of improving the organoleptic properties of those gels that were 'not acceptable' was readily identified and delineated in Column 4 - 7 of **Table 10**.

4. Discussion

[0126] These results attest to the flexibility of the embodiments described herein in creating good tasting gel products that are healthful to the consumer for both weight control as well as preventing and treating obesity associated - inflammation.

[0127] Essentially, any food or drink product that contains water, or is intended to contain water, can be formulated with the magnesium metal powder - glucomannan biotechnology - to generate and release molecular hydrogen and expand the gel volume.

[0128] Additional ingredients can be added either before or after forming the magnesium metal powder - glucomannan gels. Health - promoting ingredients are of most - but not exclusive interest.

Example 12: Chocolate Smoothie

[0129] A chocolate smoothie 'control' was prepared with the following ingredients:

300 mL of Great Value® (Walmart) fat-free milk;

5.1 grams of Hershey® Coca Natural Unsweetened;

3.0 grams of Sweet Leaf® stevia with inulin, a prebiotic;

Calorie content - about 100 calories.

[0130] Preparation, at 15 C, took place in a 600 mL Magic Bullet® container by adding the ingredients to the 600 mL container and mixing at high speed for 30 seconds. Then, the mixture was allowed to settle for 5 minutes. It was observed that a non -bubbly liquid – bubbly liquid phase separation takes place at 5 minutes. Therefore, the solution was mixed each time before viscosity measurements took place.

[0131] Viscosity measurements were made using an Elcometer® Shell 6 231005047 viscosity cup. The measurement consists of the time needed for the solution to completely flow through the cup. Increased viscosity results in a slower flow rate. The time needed for the above solution to pass through the viscosity cup was 24.1 seconds (N=5).

[0132] After viscosity measurements were taken, the above formulation was modified by addition of:

3.0 grams of glucomannan;

0.11 grams of crude magnesium metal powder;

1.0 gram of sodium ascorbate; and

1.1 gram of potassium citrate.

[0133] Preparation, at 20 C, took place in a 600 mL Magic Bullet® container by adding the ingredients to the 600 mL container and mixing at high speed for 30 seconds. Then, the mixture was allowed to settle for 5 minutes. It was observed that no phase separation took place. However, the solution was mixed each time before viscosity measurements took place.

[0134] Viscosity measurements took place over a 30 - minute time frame. The average time for the formulation to clear the viscosity cup was 49.2 seconds (N=10). Thus, addition of the Mg-gmn formulation more than doubled the viscosity of the original formulation. During the viscosity measurements, it was observed that the time for the formulation to pass through the cup increased after each viscosity measurement indicating that the viscosity increased with time. Therefore, the modified formulation should be allowed to settle for 30 minutes, or more, before consumption.

[0135] Approximately one hour after preparation, the hydrogen content and pH of the modified formulation was measured. The molecular hydrogen measurement with the Trustlex® H_2 Meter demonstrated that 168 ppb H_2 was still present in the formulation at a pH of 7.10. Expert taste testers agreed that the modified formulation tasted very good and has a nice texture.

[0136] The formulation was frozen in a freezer overnight. After microwaving the formulation for 70 seconds, it was consumed. The taste and texture were considered acceptable.

[0137] For practical purposes, the Mg - gmn hydrogen formulations can be added to the food ingredients and mixed. The mixture can be consumed immediately. Hydrogen will be generated for an extended period in the 'gut' from the Mg in the mixture.

[0138] It should be noted that the Mg – gmn formulations will generate H_2 in several types of drinks. These drinks include soft drinks, fruit juices, milk and milk substitutes, smoothies, alcoholic beverages, soups and several types of water.

Example 13: Blueberry Protein Breakfast Smoothie

[0139] A sweetened blueberry and whey protein breakfast 'control' smoothie was prepared with the following ingredients:

300 mL reverse osmosis water;

3 grams of stevia (PJURE®);

42.5 grams of frozen blueberries (Great Value® Whole Blueberries);

21 grams of EAS® 100% Whey Protein.

About 100 calories.

[0140] Preparation, at 23 C, took place in a 600 mL Magic Bullet® container by adding the ingredients to the 600 mL container and mixing at high speed for 30 seconds. Then, the mixture was allowed to settle for 5 minutes. The volume was transferred to a 600 mL graduated beaker and estimated to be 525 mL. Then, 100 mL of the formulation was removed, and 425 mL of the formulation was returned to the 600 mL Magic Bullet® for additional mixing with Mg-gmn.

[0141] Two grams of a formulation containing 4.65% magnesium metal powder, 2.33% glucomannan, 2.33% maltodextrin, 23.3% isoascorbic acid and 46.5% potassium citrate was added to the 600 mL Magic bullet container holding the 425 mL of formulation. Mixing took place for 30 seconds, followed by a 5- minute period of settling and allowing Mg to react with water in the Magic Bullet® container. The volume was then transferred to a 600 mL graduated beaker and measured to be 525 mL. Thus, there was a 100 mL, or 23.5% gain in volume after addition of 2 grams of the formulation containing Mg, gmn and excipients. A large quantity of gas bubbles was seen to be dispersed throughout the thixotropic formulation. Thus, as much as 98 mL molecular hydrogen (H_2) is present in the bubbly phase of the gel.

[0142] To test for release of H_2 from the bubble phase of the formulation and/or for latent generation of H_2 in the gel, the presence of available H_2 in the formulation was tested using the Trustlex® H_2 Meter. 50 mL of the final formulation was placed in an 80 mL plastic cup. Measurements of H_2 were periodically taken while immersing the H_2 meter in the formulation (23 C) for approximately 5 hours. The results are as follows: from 0 to 10 minutes, there was zero H_2 detected by the Meter; after 20 minutes, H_2 rose to 21 ppb; after one hour, H_2 level increased to 234 ppb; at 2.5 hours H_2 level was 441 ppb; by 3 hours H_2 level was 920 ppb; at about 4.25 hours H_2 level was 1031 ppb; and by 5 hours H_2 level had decreased to 1017 ppb.

[0143] Thus, this breakfast smoothie containing magnesium metal powder, glucomannan, and catalytic excipients provides an extended generation and release of molecular hydrogen. When ingested, the consumer will be provided with a continued release of H_2, in the gastrointestinal tract, for five or more hours.

Example 14: Lemon Flavored Vegetarian Protein Powdered Drink

[0144] A lemon flavored organic vegetarian citrus 'control' drink was prepared with the following ingredients:

300 mL of reverse osmosis water;

10.0 grams Nutra® protein powder blend Greens;

1.5 grams of BioFest® Lemon Powder

Calorie content is about 20 calories.

[0145] Preparation, at 15 C, took place in a 600 mL Magic Bullet® container by adding the ingredients to the 600 mL container and mixing at high speed for 30 seconds. Then, the mixture was allowed to settle for 5 minutes. The formulation was mixed each time before viscosity measurements took place.

[0146] Viscosity measurements were made using an Elcometer® Shell 6 231005047 viscosity cup. The measurement consists of recording the time needed for the solution to completely flow through the cup. The average time needed for the above solution to pass through the viscosity cup was 4.0 seconds (N=5).

[0147] After viscosity measurements were taken, the above formulation was modified by addition of:

2.0 grams of glucomannan;

0.204 grams of magnesium metal powder;

4.1 grams of citric acid; and

4.5 grams of maltodextrin.

[0148] Preparation, at 20 C, took place in a 600 mL Magic Bullet® container by adding the ingredients to the 600 mL container and mixing at high speed for 30 seconds. Then, the mixture was allowed to settle for 5 minutes. It was observed that no phase separation took place. However, the solution was mixed each time before viscosity measurements took place.

[0149] Viscosity measurements took place over a 30 minute period. The average time for the formulation to clear the viscosity cup was 18.3 seconds (N=5). Thus, addition of the Mg-gmn formulation increased the viscosity of the original formulation by more than a factor of four. However, this modification resulted in a flowable liquid and not a gel. Taste testing indicated that this vegetarian formulation had a strong but pleasant texture and citrus taste.

Example 15: H_2 – Rich, Thickened Tomato Soup

[0150] Soup is an appropriate vehicle for delivering H_2 systemically. For soups with a pH below 7, there is no need to add an H_2- generating acid or antioxidant. Otherwise, some combination of isoascorbic acid and sodium or potassium citrate could be added to facilitate the reaction of Mg with water.

[0151] Briefly, 100 mL of commercially available tomato soup was microwaved to provide a temperature of 92 C for the soup. Then, 52 mg of Mg* (63-micron particle size) was added to the soup and stirred for 15 seconds. Next, 1 g of glucomannan was added and stirred for 60 seconds - thickening the soup into a rich texture. The soup mixture was allowed to cool to 55 C. The Trustlex® H_2 Meter indicated that the soup contained 907 ppm H_2. The pH was 4.38. The soup was then consumed and found to be palatably acceptable.

Example 16: Scale-up for Production and Manufacturing

1. Introduction

[0152] All of the above examples have described the preparation and testing of unit doses of powdered formulations containing magnesium metal powder and glucomannan plus other beneficial ingredients that add flavor, sweetness and other desirable attributes. For 'in use' testing by a large number of consumers, as well as for commercial manufacturing, it is necessary to prepare much larger batches that can be packaged in unit dose packets or in large, e.g., 100 – 10,000 g containers - where unit doses can be dispensed, for example, with scoops.

2. Experimental

[0153] An excellent tasting low–calorie lemon flavored powder, proven to gel and sustain molecular hydrogen, when mixed with water, was developed. Thus, it was ready for an 'in use' test. A batch containing 90 - unit doses was determined to be needed. The weight of a unit dose was found to be 5.835 grams. A 3% w/w overage was built into the batch. Konjac glucomannan was from Best Naturals®; malic acid, maltodextrin, aspartame were from Bulk Supplements; anhydrous magnesium sulfate was from Sigma – Aldrich; 230 Mesh magnesium metal powder (Mg*) was prepared from a batch of crude magnesium metal powder (from China); mixed tocopherols, 45%, were from Profood Products Outlet; FD & C Yellow # 5 Dye was from Flavors and Colors.com. A 2L VH-2 dry powder blending, and mixing machine was obtained from RumeiShopping (China). The ingredients of the formulation were placed in the VH -2 mixer and mixed at a setting of 250 (i.e., 15 rotations per minute) for 30 – minutes before being packaged in a sterile plastic container.

3. Results

[0154] The formula, containing the grams of each ingredient that was prepared and each ingredient's functionality are shown in **Table 11**.

Table 11: Scale - up of a Powder Mixture for Making a Molecular Hydrogen Generating and Sustaining Gel

Ingredient		Grams		Function
Konjac glucomannan		278.430		gelling, H_2 sequestration
malic acid		136.103		Flavoring agent, acidifier
maltodextrin		92.716		sweetener, bulking agent
magnesium sulfate - anhydrous		9.234		desiccant, anti-caking
aspartame		7.729		sweetener
230 Mesh Magnesium Metal Powder Powder		5.529		Generate H_2
acesulfame		3.759		sweetener
mixed tocopherols		4.599		anti-oxidant, freshener
FD&C Yellow # 5		0.464		Coloring agent
Total		**538.563**		

[0155] A unit dose, i.e., 5.835 grams, of the batch, was delivered to an empty 8-ounce plastic cup. Thereafter, 100 mL of distilled water was added and mixed with a spoon. Within 120 seconds, a gel formed and expanded by 25% within an hour, demonstrating the generation and sequestration of molecular hydrogen. The gel was judged to have excellent organoleptic properties - including taste, tartness, and texture. Thereafter, it was entered into an 'in use' test.

4. Discussion

[0156] The results demonstrate the feasibility of scaling up formulations containing magnesium metal powder and glucomannan for generating and sustaining molecular hydrogen.

Example 17: Oral Health: Treatment Gingivitis with a H_2 – Chlorhexidine in a Magnesium metal powder – Glucomannan Gel

[0157] It is well known that gingivitis (i.e., gum inflammation) leads to periodontal disease. It is the leading cause of tooth loss in both humans and animals. Older dogs and cats are particularly susceptible to periodontal disease.

[0158] Drugs, such as chlorhexidine, an anti-microbial, and anti-inflammatories (NSAIDS) have been used in the oral cavity to reduce inflammation affecting gingivitis and resultant periodontal disease. These treatments have been only partially effective. There is a need for both better sustained delivery systems of antimicrobials and for more effective, longer lasting anti-

inflammatory therapies. Studies attest to the antibacterial activity of molecular hydrogen water against oral bacteria.

[0159] A gel containing 0.12% chlorhexidine gluconate and 22.1% molecular hydrogen(H_2), a potent anti-inflammatory and antioxidant, was prepared: Three mL of Hibiclens® (4% w/v chlorhexidine) was diluted to 0.12% with 97 mL of distilled water. The solution was then added to an 8 oz. plastic cup containing 99 mg of crude magnesium metal powder and 4.0 g of glucomannan powder. Mixing took place for about 30 seconds, at which time a gel started to form. A line was placed at the top of the gel to delineate its height in the cup at that time. The gel was allowed to expand overnight. Thereafter, a second line was placed on the top of the gel where there was a new gel height. The volume of H_2 in the gel was calculated by multiplying the difference, in centimeters, between the two lines times the area of the base of the cup (i.e., 28.3 square cm.). The volume of hydrogen was calculated to be 28.3 mL. Thus, the total volume of the gel, after expansion is 128.3 mL, resulting in a concentration of H_2 of 22.1% in the gel.

[0160] An N=1, Phase 1 therapeutic trial was carried out. The subject periodically develops gingivitis and has a history of periodontal disease despite good oral hygiene. Thirty-five mL of the gel was placed in the oral cavity with a spoon and then spread over the surface of the gums and teeth with the subject's tongue. The subject found the taste much more acceptable compared to other therapies, for example, a therapeutic oral rinse. The gel was retained in the oral cavity for ten minutes. Symptoms associated with gingivitis, such as sensitive gums, was ameliorated within twelve hours.

[0161] The gel can be applied to the gums by other means such as use of a tongue depressor, a regular toothbrush, an electric toothbrush or any other appropriate means. If the gums are sensitive, application with a 'Q' Tip may be preferred. Regardless, the gel should be retained in the oral cavity for as long as possible. Chlorhexidine and H_2 will diffuse between the teeth. Ten minutes is recommended. Then, it can be washed out with water or mouthwash. Hydrogen peroxide should not be used since it reacts with H_2 and deactivates it.

[0162] It was determined that this product is of utility for veterinary oral care for older animals (e.g., dogs and cats) since it is substantive to the oral cavity. Dogs and cats are subject to tooth loss due gingivitis resulting in periodontal disease. The gel can be administered to animals in an analogous manner as done for humans. An alternative method of delivery consists of incorporating a 'treat' into the gel. For example, a gel was prepared as described above, with the addition of 2% peanut powder. The gel was readily taken into the oral cavity where a

significant amount stuck to the gums and teeth, thereby delivering chlorhexidine and H_2 to the gums for an extended period.

[0163] Compositions as described herein could alternatively be formulated in to a toothpaste for delivery to the oral cavity and gums.

Example 18: Gastrointestinal Diseases: Sustained Release of H_2 and Bismuth Subsalicylate from a Magnesium Metal Powder – Glucomannan Gel

[0164] There are diseases and conditions of the upper gastrointestinal tract where sustained delivery of both effective drugs and H_2 would have an advantage over current treatments. Compositions described herein provide effective treatment of conditions such as gastritis; gastric and duodenal ulcers, gastroesophageal reflux disease (GERD), *Helicobacter pylori* infection, bacterial overgrowth, yeast overgrowth, heartburn, indigestion, upset stomach and nausea. Non-limiting examples of drugs that could be delivered from hydrogen – rich Mg-gmn gels are proton pump inhibitors, misoprostol, H_2 receptor antagonists, antibiotics, antifungals, anti-inflammatories, antacids, bismuth subsalicylate, or any combination thereof. These drugs alone or in some combinations, at therapeutic doses, can be incorporated into aqueous Mg-gmn gels.

[0165] As an example, 50 mg Mg* plus 4 g of glucomannan were mixed and added to a solution containing 30 mL of a solution containing 1.050 g bismuth subsalicylate and 70 mL of distilled water. The mixture was stirred for 60 seconds, at which point the resultant solution gelled. A line was drawn to mark the gel height. The initial height was 5.3 cm indicating a gel volume of 179.4 mL. The weight of the gel was 107.89 g implying a density of 0.602 g/mL. Comparably speaking, this is a low density -relative to previously tested 4% gmn – 20 mg Mg* gels (See Table 2). The gel was allowed set for 3 hours. The height of the gel was determined to be 5.6 cm. with a gel volume of 185.8 mL and a density of 0.581 g/mL. The H_2 content of the gel, as measured with the Trustlex H_2 Meter was 1405 ppb at a pH of 7.25. The low density of this gel, at outset, and its high H_2 content, demonstrates that copious amounts of H_2 was generated at the outset of mixing and gelling of the gel. (NB: Letting the gel set for more than a few minutes is not necessary since the gel will continue to generate H_2 in the stomach for a prolonged period).

[0166] Subsequent oral administration of the mixture described above to a subject experiencing acute heartburn resulted in resolution of symptoms with no discernible side effects.

Example 19: Mg-glucomannan to treat of Helicobacter pylori infection

[0167] Bismuth subsalicylate, in combination with antibiotics (250 mg of metronidazole and 500 mg of tetracycline) has been used to eradicate *Helicobacter pylori* infections. 250 mg metronidazole, 500 mg tetracycline, and 1.055 g bismuth subsalicylate are incorporated into a Mg*-gmn formulation. Such a formulation could be marketed as tablets, capsules or a powder. A gel could be formed in a glass of water – by adding the formulation and mixing and then ingesting the gel. Alternatively, the patient could ingest a capsule (or tablet) containing the formulation followed by an 8 to 16 - ounce glass of water. The gel will spontaneously and rapidly form in the stomach and it will 'float' affecting a long retention time in the stomach. Long lasting, i.e., 5 to 10 - hour delivery of H_2 and the drugs should be achieved.

[0168] An example formula for treatment if *Helicobacter pylori* and bacterial overgrowth provided in a dosage of six '000' capsules is:

1.0 g bismuth subsalicylate

250 mg of metronidazole

500 mg of tetracycline

3.0 g glucomannan

50 mg of 63 - micron magnesium metal powder

[0169] Alternatively, the above formula can be mixed with water in a 12 -ounce glass that will spontaneously form a gel, within 5-minutes - that can be ingested without side effects.

Example 20: Treatment of Skin Disorders with Molecular Hydrogen -Salicylic Acid in a Magnesium Metal Powder – Glucomannan Gel

[0170] Until now, there was no practical manner for sustained topical delivery of H_2 to the integument.

[0171] An anti-acne, keratolytic preparation consisting of 54 mg Mg* (63-micron particle size), 2 g salicylic acid, 2 g konjac root glucomannan in 100 mL distilled water was prepared in a plastic cup by mixing the components for 45 seconds while a gel formed. The gel was allowed to set overnight. The volume expansion of the gel was found to be 34.0 mL or 34%. Therefore, the expanded gel contains 34 mL of H_2. The pH of the gel was found to be 3.34.

[0172] Two 'quarter' – sized areas (4.15 square cm.) were delineated on the hair clipped skin of the right forearm of a male subject. One site served as an untreated control while the other site was treated topically with 0.24 g/square cm. of the gel. The gel was spread over the site with a tongue depressor in a continuous layer. The H_2 in the gel, on the skin surface, was

determined with the Trustlex® H_2 Meter – without the Protective Guard. Removing the Protective Guard allowed for direct contact of the Trustlex® electrode with the skin surface. Thus, the concentration of H_2 being delivered to the skin surface can be determined. The presence of salicylic acid on the skin surface and in the stratum corneum was observed with a Wood's Light (UVA). Salicylic acid fluoresces in the UVA, allowing it to be seen on the skin surface under UV light. Tape stripping (3M Scotch Tape) the skin on the site allows for determining the layers of stratum corneum penetrated by salicylic acid. That is, each tape strip of the salicylic acid-treated site represents a layer of stratum corneum penetrated by salicylic acid.

[0173] It was found that, after washing off the remaining gel from the skin site, it took ten tape strippings of the treated site to remove the visible presence of the UVA fluorescence. Thus, the gel delivered salicylic acid through 9-10 layers of stratum corneum, close to the lowest layers of the stratum corneum of forearm skin.

[0174] The time course of change in H_2 on the skin surface after application of the H_2 – rich gel, was followed. At baseline, it was determined that 432 ppb H_2 was in contact with the skin surface. Within 10 minutes 250 ppb H_2 was detected at the skin surface. At 20 minutes 167 ppb H_2 was detected at the skin surface. At 30 minutes, it had dropped to zero. It is assumed that a substantial portion of the H_2 in contact with the skin surface was absorbed into the skin. Also, once water has evaporated from the skin surface, it is no longer available to react with Mg to generate H_2. The stratum corneum, the top barrier of the skin, is hydrophobic. H_2 is also hydrophobic. Thermodynamically, hydrophobic entities associate with each other, in an aqueous environment. This shows the composition as described above can deliver both H_2 and salicylic acid to the integument. Mg–gmn gels containing numerous drugs, alone or in combination are feasible for treating various skin afflictions.

[0175] Non-limiting examples of skin diseases and conditions that can be treated and drugs that can be incorporated into H_2 Generating Mg–gmn skin care products are:

aging skin: alpha-hydroxy acids, antioxidants, ascorbic acid, trans-retinoic acid;

acne: doxycycline, lymecycline, minocycline, erythromycin, trimethoprim, cotrimoxazole, salicylic acid, trans-retinoic acid;

dry, flaky or thickened skin: alpha – hydroxy acids, salicylic acid, glycerin;

allergic contact dermatitis: corticosteroids, topical antihistamines;

atopic dermatitis: corticosteroids, antihistamines;

psoriasis: salicylic acid, corticosteroids, coal tar, immunosuppressants;

sunburn: topical anesthetics, aloe vera, NSAIDS;

bruising: arnica, vitamin E, vitamin C;

irritated skin: glycerin, cholesterol sulfate;

fungal infections: clotrimazole, econazole, miconazole, terbinafine, fluconazole, ketoconazole, amphotericin;

corns and callouses high dose salicylic acid;

combinations of the drugs listed above for complex diseases; or

dermatology preparations, containing abundant H_2 need special preparation and/or packaging.

[0176] In some embodiments, solids containing Mg and glucomannan must be in a separate compartment from water. They would be mixed 'in situ' in unit-dose packages. The lotion or gel generated would contain abundant H_2 for about a week. A preservative, such as sodium adipate, may be added.

[0177] An alternative means of stabilization for marketing would be to generate H_2 within the formulation, by mixing liquid and solid phases during manufacturing and sterilizing. This product would then be packaged in a sealed aluminum container that can give it a shelf life of over a year. It is best packaged in small doses that would last the consumer about a week.

Example 22: H_2 Moisturizing Gel for Dry, Aging skin

[0178] As skin ages normally or from environmental damage, it is subject to sub-chronic inflammation and hyperproliferation which affects difficulty in holding moisture. A moisturizing product that will reduce sub chronic inflammation without drugs that cause irritating side effects, is needed.

[0179] The following H_2-generating moisturizing skin lotion was prepared:

3.0 g lactic acid;

1.5 g glucomannan;

51 mg Mg* (63 micron);

20 mL glycerin

80 mL distilled water

[0180] For preparation, glycerin and distilled water were mixed and added to the remaining ingredients in an 8 oz. container and mixed for 60 seconds until the contents were dissolved. A lotion resulted. The lotion was allowed to stand at 23 C for one hour. The Trustlex H_2 Meter indicated that the lotion contained 815 ppb H_2 at a pH of 3.86.

[0181] Two quarter – sized areas (4.15 square cm.) were delineated on the hair clipped skin of the right forearm of a subject. One site served as an untreated control site while the other site was treated topically with 0.15 g/square cm. of the lotion. The lotion was spread over the site, with a tongue depressor, as a generous layer of lotion. H_2 on the skin surface, was determined with the Trustlex® H_2 Meter without the Protective Guard. Removing the Protective Guard allowed for direct contact of the Trustlex® electrode with the skin. The electrode was wetted with distilled water before touching the skin surface.

[0182] The time course of change in H_2 on the skin surface is shown in Table 12. At baseline, the H_2 on the skin surface was 804 ppb, close to that in the lotion (i.e., 814 ppb). As time progressed, the H_2 on the surface of the skin fluctuated and did not show a progressive loss, as expected, up to 60 minutes. Thereafter, H_2 measurements on the skin surface showed the presence of significant H_2 up to 210 minutes.

Table 12: Time Course of Change in H_2 on Skin Surface after Application of a H_2-Rich Anti-aging Moisturizing Lotion

	Treated*	**Untreated**
Time	H_2	H_2
(Min.	**ppb**	**ppb**
0	804	0
5	756	0
10	917	0
15	327	0
20	351	0
30	330	0
60	791	0
120	169	0
210	247	0
360	0	0

* Treated with 51 mg Mg*(63 microns), 3.0 g lactic acid, 1.5 g glucomannan, 20 g glycerin and 80 g distilled water, H_2 = 815 ppb, pH = 3.86.
Skin Surface pH = 4.57.

[0183] This level of persistence of H_2 on the skin surface was surprising and unexpected. The lotion rapidly loses most of its water as it dries on the skin surface. Bubbles disappear. Only a thin layer of product remains on the skin surface. However, such persistence may be explained by:

[0184] Mg*, deposited on the skin surface by the lotion, continues to react with water held on the skin surface by the hydroscopic effect of glycerin and lactic acid;

[0185] As noted in previous Examples, H_2 has an affinity for glucomannan. Therefore, glucomannan may contribute to H_2 persistence on skin;

[0186] The stratum corneum has a reservoir effect for hydrophobic molecules. H_2 is hydrophobic. It may contribute to the H_2 detected on the skin surface due to back diffusion of H_2 from the stratum corneum.

Example 23: Sustained Delivery of H_2 to a Model Aquarium or Fish Farm

[0187] It has previously been demonstrated that molecular hydrogen (H_2) can promote the health and growth of both animal and plant life (1, 14). Aquatic life in the form of plants, invertebrates (e.g., shrimp, crabs, etc.) and fish should also benefit from the antioxidant and enhanced bioavailability effects of H_2 in an aqueous environment. Plants, fish, insects and all invertebrates, like higher animals, have mitochondria. H_2 is known to reduce the toxic reactive oxygen species (ROS), i.e., hydroxyl radical and peroxynitrite produced by mitochondria. These promoters of inflammation affect the consumption of energy that could otherwise be used for growth and fighting disease.

[0188] An experiment was designed to determine if a magnesium metal powder (Mg) – glucomannan(gmn) gel that generates H_2 can deliver and sustain H_2 in a model aquarium or aquatic farm. For the model aquarium or fish farm, 9.95 grams of Fisher® phosphate buffered saline (PBS) in 1,000 mL of distilled water was prepared. The pH was 7.6.

[0189] For preparing the gel, 0.1 g of crude magnesium metal powder (Mg), 0.5 g of ascorbic acid and 4 g of glucomannan were mixed into 100 mL of distilled water (DW) - until the gel started to form. The H_2 concentration in the gel was determined to be 1501 ppb – using the Trustlex® H_2 Meter, at a pH of 8.4. The gel expanded in height by 0.9 cm. Thus, the volume of H_2 in the gel is 25.5 mL or 25.5% of the original 100 mL volume.

[0190] After the baseline reading, the 125 mL gel was placed in the 1,000 mL PBS solution representing the aquarium or fish farm. Being less dense than water, the gel floated on top of the 1,000 mL beaker. The PBS was constantly circulated, at 23 C, by stirring with a 1 in. magnetic stirring bar at the lowest power setting on the magnetic stirrer.

[0191] The results are shown in **Table 13**. At baseline, there was found to be 0 ppb H_2 in the PBS solution, at a pH of 7.6. After 15 minutes, the H_2 in the PBS remained at 0 ppb, at a pH of 7.6. By 4.7 hours, there was 562 ppb H_2 in the PBS, at a pH of 7.7. At 13.8 hours, H_2 in the PBS had risen to 691 ppb, at a pH of 7.7. As time progressed, there was an accumulation of small white debris in the PBS. This accumulation appeared to be a product of shedding gmn particles

from the floating gel. Upon cessation of stirring, this material tended to float to the top of the beaker – near the gel supporting the notion that it is gmn particles. At 28.3 hours, the H_2 in the PBS had risen to 1245 ppb at pH 7.6. Thereafter, the H_2 in the PBS was sustained at a level of 1202 ppb, pH 7.3 until 109 hours. At 123 hours there was 1165 ppb H_2, pH 6.8. The pH drop probably indicates bacterial growth in the simulated tank.

Table 13: Test System for Delivery of Molecular Hydrogen (H_2) to Aquatic Life

Time (Hrs.).	ppb H_2 in PBS	pH Units
0	0	7.6
0.25	0	7.6
4.7	562	7.7
13.8	691	7.7
28.3	1245	7.6
86.0	1234	7.3
109.0	1202	7.3
123.0	1165	6.8

[0192] This experiment demonstrates the feasibility of delivering H_2 to an aquarium or aquatic farm. It also points to routine steps that must be taken to insure the maintenance of water quality in an aquarium or fish tank. These maintenance steps include those that would normally be carried out without addition of the gel: filtration of excess particles out of the tank, include antibacterial and anti-algae agents that are compatible with the aquatic life in the tank. If proper maintenance is carried out, the water should be acceptable for 2 – 4 weeks.

[0193] For situations when the body of water contained in the tank is larger than 20:1 tank to gel ratio, fish or invertebrate meal can be incorporated into the gel. This maneuver should attract fish or invertebrates to the gel where they will consume a higher level of H_2.

[0194] The applications foreseen for this method of delivery of H_2 to aqueous systems, of such, include:

home aquariums containing aquatic plants, fish, turtles, invertebrates;

crustacean and mollusk, oyster farms;

fish farms including catfish, tilapia, salmon and carp; or

farming aquatic plants including rice, algaculture seaweed and ornamental plant farming.

[0195] Of importance, is the potential of H_2 delivery to aquatic systems to increase the yield of aquatic food to feed the world's growing population and to protect the environment against over -fishing and destruction of aquatic plant life.

Example 24: Molecular Hydrogen - Rich Magnesium Metal Powder – Glucomannan Gels for Increasing Insect Yields

[0196] As the world's population increases beyond 7,650,000,000, it becomes increasingly difficult to provide complete nutritional food, particularly in the form of complete protein and associated amino acids. There is increasing interest in farming insect populations to feed the growing masses. Insects are an excellent source of complete protein, vitamin B12, vitamin A and riboflavin. They reproduce and grow rapidly and eat almost anything. They are particularly attracted to necrotic life forms, rotting food and feces. Thus, they are 'natural' cleaners of the environment. Crickets, cockroaches, grasshoppers, beetles, moths, etc. are now being farmed for both human and animal consumption.

[0197] Insect food can also serve as food for lower animals, including poultry and fish farming.

[0198] Farming of insects has several advantages over the farming animals, such as cattle and chickens, including reduced feed per yield of protein, greater nutritional efficiency, less concern about epidemics in an insect population compared to an animal population, lower greenhouse gas emissions and lower land usage.

[0199] Although insects breed and grow rapidly, a technology that would increase protein and nutritional yield would be of economic benefit to both insect farmers and nutritionally deficient populations. Since molecular hydrogen has been shown to increase reproduction and growth in many life forms (1, 14), mainly through its antioxidant effects thereby reducing mitochondrial reactive oxygen species, there is no good reason to doubt its growth promoting effects in insect populations. Insect cells are powered by mitochondria.

[0200] A prototype insect farming system was modeled to determine if wildtype insects would be attracted to a molecular hydrogen (H_2) gel that was prepared in an 8 oz. plastic cup. The gel was formulated as follows: 51 mg of Mg plus 4 g of glucomannan and 5 g of fructose were mixed in an 8 oz. plastic cup. Next, 100 mL of white vinegar (5% acetic acid) was added to the cup and the contents mixed with a tongue depressor until the gel formed. The height of the gel was delineated with a blue line drawn with a marking pen. The gel was allowed to stand for one hour for the gel to form and evolve H_2. The new gel height was again delineated with a

marking pen. The H_2 content of the gel was then measured by immersing the unguarded Trustlex® electrode into the gel. The H_2 content of the gel was found to be 800 ppb at a pH of 3.35. The plastic cup containing the gel was placed outside of the laboratory in a garden like atmosphere. The temperature ranged from 90-105 F. Over the course of 24-hours, the gel was observed for the presence of insects. Bees, flies, fruit flies, ants and other un-identified insects appeared to be attracted to the gel.

[0201] The purpose of placing insect food, in this example, fructose and acetic acid, in the H_2-rich gmn gel, is to attract insects to the gel thereby exposing the insects to a high dose level of H_2. As the insects ingest both the insect food and the glucomannan, they will come into close contact with H_2 which will be both ingested and absorbed into their body parts that are in contact with the gel.

[0202] The example gel illustrated here, is not optimized for the most efficient delivery of H_2 for insect farming. Cost of the gel is important, since it must be lower than the value of the increased yield of the nutritional benefit of this biotechnology. To this effect, costs can be minimized by:

use of acidic food waste or acetic acid waste (0.25-7%) rather than high quality acetic acid for acidification;

use a minimum dose of glucomannan (e.g., 1.5 -2.5%) alone or in combination with low dose maltodextrin (e.g., 0.5%);

use 10 – 100 mg of crude magnesium metal powder (Mg); and

water can be any water free of toxic metals, plasticizers, endocrine disrupters and pesticides.

Example 25: Effect of Glucomannan on Generation and Sustaining Molecular Hydrogen (H_2) in Aqueous Solutions -Bellow the Gelling Concentration

5. Introduction

[0203] A study was carried out, in an open 'to the air' container, to determine if low levels of glucomannan (gmn), below the gelation concentration, combined with magnesium metal powder (Mg*) can increase the sustainability of H_2 in Mg* – gmn aqueous solutions - relative to Mg* solutions – without glucomannan.

6. Experimental

[0204] Crystal Light® powder was used since previous experiments (Examples 10 and 11 above) have demonstrated the effectiveness of the aqueous Crystal Light® media in supporting H_2 generation from Mg – gmn formulations.

[0205] Crystal Light® Natural Lemonade powder was mixed with all test powders, including the control without glucomannan. All formulations tested contained 40 mg of 63 – micron (230 Mesh) magnesium metal powder (Mg*) and 1.9 g of Crystal Light® Natural Lemonade (CL). Crystal Light® Lemonade contains citric acid, potassium citrate, sodium citrate, aspartame, magnesium oxide, maltodextrin, acesulfame potassium, soy lecithin, artificial color FD&C Yellow # 5, BHA and less than 2% natural flavor.

[0206] Six different test solutions were prepared containing 0.0, 0.15, 1.5, 12, 100 and 1,000 mg of glucomannan (gmn). The Mg* - gmn plus CL powders were combined and mixed. The formulations were then mixed with 100 mL distilled water (DW) in a 250 mL glass beaker. Close to two - minute mixings took place. Immediately after mixing, measurements of molecular hydrogen (H_2) took place by immersing the Trustlex® H_2 Meter, without its guard cup, in the test solution until a steady reading was reached. Removing the guard cup allows un-impeded contact of the Trustlex® electrode with the gel.

[0207] Viscosity measurements on the control and test solutions took place with a #6 Zahn Viscosity Cup for testing the viscosity of Newtonian liquids. It can be used to measure the time, in seconds, for the test solutions to flow out of the cup that is filled to its capacity.

7. Results

[0208] The results are shown in **Table 14** and **Figure 1**. In Column 2 of **Table 14** are displayed the time points at which H_2 measurements were taken – starting right after two minutes of stirring a mixture.

Table 14: Time Course of Loss of Dissolved Molecular Hydrogen from Solutions Containing Various Non-Gelling Levels of Glucomannan

1	2	3	4	5	6	7	8	9	10	11	12	13	14
		gmn		**gmn**		**gmn**		**gmn**		**gmn**		**gmn**	
		0		**0.15 mg**		**1.5 mg**		**12 mg**		**0.1 g**		**1 g**	
	Time	H_2	**%**	H_2	**%**	H_2	**%**	H_2	**%**	H_2	**%**	H_2	**%**
Row	**Min.**	**ppb**	**Rem**	**ppb**	**Rem.**	**ppb**	**Rem.**	**ppb**	**Rem.**	**ppb**	**Rem**	**ppb**	**Rem.**
1	**0**	807	100	785	100	800	100	808	100	784	100	803	100
2	**5**	806	99.9	798	101.7	808	101.0	804	99.5	789	101	820	102

3	**10**	812	100.6	804	102.4	809	101.0	804	99.5	790	101	824	103
4	**15**	814	100.9	805	102.6	812	102.0	806	99.8	790	101	826	103
5	**20**	808	100.1	809	103.1	814	102.0	806	99.8	793	101	828	103
6	**30**	802	99.4	808	1029	812	102.0	806	99.8	789	101	825	103
7	**40**	798	98.9	806	102.7	810	101.0	807	99.9	792	101	823	103
8	**50**	794	98.4	804	102.4	xxx	xxx	806	99.7	791	101	819	102.0
9	**60**	786	97.4	802	102.1	808	1.01	805	99.6	791	101	816	102
10	**120**	646	80.0	758	96.6	784	98.0	790	98.3	783	99.9	802	99.8
11	**180**	431	53.4	549	69.9	680	85.0	753	93.2	761	97.1	790	98.4
12	**240**	299	37.1	379	48.3	440	55.0	592	73.3	686	87.5	789	98.3
13	**300**	201	24.9	234	29.8	321	40.1	450	55.7	526	67.1	789	98.3
14	**360**	146	18.1	161	20.5	202	25.3	309	38.2	394	50.3	802	99.9
Visc.	**(sec.)**	1.2		xxx		xxx		1.1		1.7		23.0	

Abbreviations

% Rem.	% dissolved H_2 remaining in solution - as measured with the Trustlex H_2 Meter.
Visc.	Viscosity
Min.	Minutes
ppb	parts per billion
H_2	molecular hydrogen
gmn	glucomannan
g	gram
mg	milligram
sec.	seconds

8. Control Formulation

[0209] Columns 3 and 4 of **Table 14** show respectively, the parts per billion (ppb) and percent of dissolved H_2 remaining in solution due to generation in the control formulation (i.e., 40 mg Mg* + 1.9 g CL – without glucomannan). It is observed that there is an almost steady state level of H_2 in solution up to one - hour after starting measurements. This phenomenon is clearly depicted in Figure 1. This result, at first glance, is surprising, since experience in generating H_2 by electrolysis of water has shown a much more rapid rate of loss of H_2 from aqueous solution. This persistence of H_2 in Mg* - generated H_2 solutions is attributed to continued generation of H_2, for a period of time after Mg* is mixed with water.

[0210] After one hour, there is a faster rate of loss of dissolved H_2 from the control solution so that at 6 – hours post preparation, only 18% of the original amount of dissolved H_2 remains. Thus, it appears that there are two phases as is observed by analyzing **Figure 1**: A 'Steady State Phase' where dissolved H_2 is generated at approximately the same rate that it is lost to the

environment, and a 'Depletion Phase', when dissolved H_2 is lost to the environment at a faster rate than can be replaced by a reaction of the unreacted Mg* with water.

9. Test Formulations

[0211] Formulations all containing 40 mg Mg* + 1.9 g CL and also containing respectively, 0.15, 1.5, 12, 100 mg and 1.0 g glucomannan mixed with 100 mL of distilled water - were tested. At these low concentrations of gmn, viscous gels are not formed. The results presented in Columns 5, 7, 9, 11 and 13 show the ppb of dissolved molecular hydrogen (H_2) remaining in solution - as a function of time. It is observed that there is a dose-response relationship where glucomannan extends the 'Steady State' Phase, beyond the 60 - minute cut-off time found for the control solution – without glucomannan in the formulation. This phenomenon is seen by observing the results presented in Figure 1. Even at the lowest concentration of glucomannan tested (1.5 ppm), the 'Steady State' Phase is shifted from lasting 1 – hour to close to 2 – hours. Formulations containing higher concentrations of gmn progressively increase the length of the 'Steady State' Phase as can be seen by analyzing the results in Columns 3 – 14 of **Table 14** and Figure 1. The results presented in Columns 13 and 14 of **Table 14** and **Figure 1** - show that the 40 mg Mg* + 1.9 g CL formulation containing 1.0 g of gmn/100 mL DW extends the 'Steady State' Phase to 360 minutes (6-hours) - and perhaps well beyond the 6-hour time course of this Study. In fact, previously described studies (See Examples 4 and 5, above) attest to the long - term stability of H_2 in Mg – gmn gels. However, as tested here, 40 mg of Mg* + 1.9 g CL formulations containing, respectively, 0.15, 1.5, 12 and 100 mg of gmn/100 mL DW extend the 'Steady State' Phase without appreciably increasing the viscosity or forming a gel. The 40 mg Mg* + 1.9 g CL formulation containing 1.0 g of gmn/100 mL DW modestly increases the viscosity, forming a viscous solution but does not form a viscous gel.

10. Discussion

[0212] Reviewing the results of the 1 to 6 - hour time frame as depicted in **Table 14** and **Figure 1**, it is observed that the 'Steady State' Phase progressively increases while the 'Depletion Phase' progressively decreases as the concentration of glucomannan is increased in the 40 mg Mg* + 1.9 g CL formulations. For the formulations containing 0.15 mg to up to 1.0 g of gmn, this remarkable stabilization of H_2 in the solutions cannot be due to a gelation effect. In an attempt to understand the mechanism by which 'below gelling concentrations' of

glucomannan sustain H_2 in 40 mg Mg* + 1.9 g CL aqueous solutions, the following possibilities are considered:

gmn slows down the reaction of Mg* with water which generates H_2;

gmn has an affinity for H_2 which slows down its loss to the environment from solution;

gmn stabilizes H_2 bubbles, in solution, thereby slowing down the rate of loss from solution; or

gmn sustains the generation of H_2 in solution by removing the passivation coat of magnesium oxide that is naturally found on magnesium metal powder particles that have been exposed to oxygen.

[0213] Analysis of the data can eliminate possibility '1' above. By observing the results for the control solution in Columns 3 - 4, relative to the results for the test solutions in Columns 5 - 14, it is seen that the initial rate of reaction for producing H_2 is approximately equal to that of the test solutions (See Row 1). Therefore, glucomannan does not slow down the depletion of Mg and resultant H_2 production.

[0214] The idea that H_2 has an affinity for gmn is more than worthy of consideration. Copious visible bubbles are initially present in solution due to the generation of H_2 by magnesium metal powder. Stabilization of these bubbles in solution should create a reservoir of H_2 for dynamic exchange with dissolved H_2. This phenomenon should lead to increased stabilization of H_2 in solution - compared to solutions containing dissolved H_2 – without microbubbles. Accepting that H_2 has an affinity for gmn, it is reasonable to assume that non – gelling gmn molecules and complexes would be attracted to the H_2 bubble – water interface forming more stable bubbles.

[0215] As discussed in Example 7, glucomannan can possibly catalyze the removal of the passivation coat of magnesium oxide from magnesium metal powder particles, thereby increasing the efficiency of molecular hydrogen production. This mechanism can also play a role in sustaining molecular hydrogen in solutions containing glucomannan.

[0216] In summary, there are three mechanisms by which glucomannan can increase the sustainability of molecular hydrogen in aqueous magnesium metal powder solutions.

Example 26: Electrolysis Study: Sequestration of Molecular Hydrogen (H_2) by Glucomannan

11. Introduction

[0217] To test if there is an attractive interaction between H_2 and glucomannan, in aqueous solution - in the absence of magnesium metal powder, an independent method of generating H_2 in glucomannan solution was sought. Electrolysis of water is a well - known means of generating H_2 in solution. The reaction, at the electrodes, breaks down water into H_2 and O2. As discussed in the Background Section, above, water free of electrolytes, is needed to prevent chemical reactions that shorten the 'life' of the electrodes. Use of water free of electrolytes, such as distilled water, will generate H_2, but at a much slower rate than in the presence of electrolytes.

[0218] It was decided to use electrolysis for generating H_2 in the presence and absence of gmn. For this purpose, the loss of H_2 from solutions after electrolysis of neat distilled water as compared to the electrolysis of distilled water containing 120 ppm glucomannan - was performed.

12. Experimental

[0219] Five hundred ml of distilled water containing 62 mg of gmn was prepared in a 500 mL glass beaker by mixing and then heating to 65C to insure gmn solubility. The mixture was then allowed to cool to room temperature (23 C). Electrolysis of water took place in a 460 mL GX-H11 electrolysis bottle from Yongkang Gomax Ind. & Trade Co., Yogkang City, China. The bottle has a working current of 1 Amp. with a DC12V/5V power supply. Electrolysis studies of both distilled water and 120 ppm gmn, in distilled water, were repeated.

13. Results

[0220] The time course of the electrolysis results is shown in **Table 15**. Column 1 shows the time points of measurements after the start of the study. The results in Column 2 show the ppb of H_2 generated at each time point after completion of 6 minutes of electrolysis of distilled water (DW). Only 27 ppb of H_2 is present at the outset. As shown in Column 3 and depicted in Figure 2, at one - hour after completion of electrolysis, no detectable H_2 remained in the electrolyzed solution. This is in accord with previous observations that electrolysis of DW has a low yield of H_2 which depends on the time course of the applied voltage - which is constant for the studies described here.

Table 15: Effect of Glucomannan (gmn) on Molecular Hydrogen (H_2) Generation by Electrolysis in Distilled Water (DW)

Time	DW (N=3)	%	gmn (N=2)	%
min.	ppb H_2	Change	ppb H_2	Change
0	27	0	197	0
5	20	-26	235	19
10	18	-33	241	22
20	17	-37	243	23
40	4	-85	223	13
60	0	-100	207	8
120	xxx	xxx	155	-21
180	xxx	xxx	103	-48
240	xxx	xxx	45	-77

Abbreviations
gmn - 120 ppm glucomannan (0.012%)
ppb - parts per billion H_2
min. - minutes after starting H_2 measurements with the Trustlex Meter.
H_2- Molecular hydrogen
DW - Distilled water
N - Number of repeats

[0221] The results presented in Column 4 and **Figure 2** show the ppb of H_2 generated at each time point after completion of 6 minutes of electrolysis of distilled water containing 120 ppm glucomannan. Immediately after completion of electrolysis, 197 ppb of H_2 is detected in the electrolyzed solution. H_2 then rises to 243 ppb at 20 minutes after completion of electrolysis. This increase – relative to electrolysis, without gmn, is attributed to an interaction of H_2 with gmn that helps retain H_2 in solution. Glucomannan, a polymer of glucose and mannose, is not charged and should not directly affect electrolysis. At one - hour after completion of electrolysis, 207 ppb (85%) H_2 remains in the electrolyzed solution. H_2 persists at 45 ppb at 4-hours after completion of electrolysis.

14. Discussion

[0222] **Figure 2** contains a plot of the results that clearly shows the effect that a low dose (120 ppm) of glucomannan has on retaining H_2 in solution – without the presence of magnesium metal powder. Thus, glucomannan:

[0223] enhances the retention of H_2 in water that has been electrolyzed;

[0224] affects a rise in H_2 for at least 20 minutes after generation of H_2 in solution;

[0225] stabilizes H_2 in the solution – relative to generation of H_2 in DW.

[0226] Any method of making H_2 available to gmn should stabilize H_2 in aqueous solution.

[0227] These results point to a strong interaction of H_2 with gmn, without the presence of magnesium metal powder. Generation and subsequent infusion of molecular hydrogen from a canister or electrolysis of water device into an aqueous solution containing glucomannan is another means by which glucomannan can interact with H_2 and stabilize H_2 in solution.

[0228] Electrolysis devices have been discussed previously. From the results presented here, these devices could be used to deliver H_2 to solutions containing gmn. Longer times of electrolysis and higher concentrations of gmn would increase the stability of H_2 in aqueous solutions.

[0229] Using a commercial source of H_2 to deliver H_2 to glucomannan solutions is another method to consider. Canisters containing pressurized H_2 are commercially available from Restek (34453-PI – Hydrogen; $724.94). H_2 generators such as Zen Earth (HX300 Hydrogen Machine – around $2,500) and Parker Hydrogen Generator ($ 10,000 – 17,000) are also commercially available. These devices can readily be located on the internet. These canisters and devices can be used to diffuse or pressurize H_2 into glucomannan solutions. They provide another reliable source of H_2. The disadvantages are cost and a safety issue – if the level of H_2 in the surrounding atmosphere reaches 4% v/v or higher.

[0230] Another application of the Invention is the sequestration and storage of H_2 from environmental sources. This application would be particularly important in third world countries in need of an inexpensive source of energy. H_2 is a well - known source of energy as well as administered for improving health. H_2 is produced, in quantity, mostly by microbial anaerobic metabolism: in wastewater; wastewater plants; parts of the ocean - by sea life including cyanobacteria; swamps; the gastrointestinal tracts of animals and humans. Passing hydrogen or solutions containing H_2 through gmn solutions or filters containing gmn – will result in sequestration of H_2 that can be recovered for energy use.

Example 27: Electrolysis of Water in the Presence of 0.05% K Bicarbonate and Glucomannan

[0231] It is well known that addition of sodium or potassium bicarbonate to 'pure' water such as distilled water, will increase the output of H_2 due to electrolysis. However, keeping the concentration of bicarbonate low is desirable due to its 'off taste', as well as keeping sodium or

potassium from reaching a level that is detrimental to health of individuals as well as the electrodes.

[0232] Since it has been shown that 120 ppm glucomannan (gmn) enhances H_2 generation and sustainability in electrolyzed distilled water (See **Table 15**), an electrolysis experiment was designed to determine if there is such an effect on generation of H_2 when 120 ppm gmn is added to 0.05% potassium bicarbonate.

[0233] The results are shown in **Table 16**. The first column lists the time course of the Study. Column 2 shows the change in H_2 generated by electrolysis of the K bicarbonate solution as time progresses. In the first 10 minutes, H_2 rises by 4% and then progressively falls to losing 52% of H_2 at 3 hours and 95% of H_2 at 7-hours.

Table 16: Effect of Glucomannan (gmn) on Molecular Hydrogen (H_2) Generation by Electrolysis of K bicarbonate in Distilled Water (DW)

	0.05% K bicarbonate		**0.05% K bicarbonate,**	
Time	**in DW**	**%**	**120 ppm gmn in DW***	**%**
min.	**ppb**	**Chg**	**ppb**	**Chg**
0	575	-4	541	-7
5	591	-1	580	xxx
10	596	xxx	565	-3
20	575	-4	566	-3
40	554	-7	546	-6
60	518	-13	528	-9
120	395	-34	461	-21
180	289	-52	406	-30
240	214	-64	347	-40
420	32	-95	133	-77
pH	8.78		7.90	

Abbreviations:

gmn - 120 ppm glucomannan (0.012%)
Ch - Change in H_2 in solution
ppb - parts per billion H_2
min. minutes after starting H_2 measurements with the Trustlex Meter.
H_2- Molecular hydrogen
DW - Distilled water

[0234] Column 4 shows the time course of H_2 changes after 6 minutes (3 minutes x 2) of electrolysis of 120 ppm gmn + 0.05% K bicarbonate in DW. The results were normalized for

differences in pH - to those of Column 2 - using the Nernst equation. Comparing the results in Column 4 with those in Column 2, it is observed that a similar pattern of H_2 increasing from 0 to 5-minutes, followed by a progressive decrease of H_2 in solution. However, there is a marked stabilization of H_2, in the electrolyzed solution containing gmn with 0.05% K bicarbonate – relative to the electrolysis of 0.05% K bicarbonate solution. After 60 minutes, this effect becomes more obvious. For example, at 2-hours after the start of the study, there is a 16.1% increase in H_2 in the electrolytic solution containing 120 ppm gmn while at 7 hours after the start of the study, there is a 416% increase. These results point to microbubbles being present in the electrolysis solution containing 120 ppm glucomannan.

Example 28: Optical Microscopy Detection of H_2 Microbubbles

[0235] Due to the unexpected enhanced sustainability of H_2 in both aqueous magnesium metal powder and electrolysis systems containing glucomannan (gmn), a study was carried out to determine if significant amounts of microbubbles are present in a solution showing enhanced H_2 stability. The formulation investigated contained 44 mg Mg*, 120 ppm gmn, 1.9 g Crystal Light® Natural Lemonade powder mixed into 100 mL distilled water. After mixing for 60 seconds in an 8 oz. cup, the formulation was allowed to stand at 23 C for 4.5-hours before filtration and testing. The formulation was filtered through a 400 - mesh filter (ATPWONZ Food Strainer) which provides for a larger than 37 - micron particle size retention in the filter. Therefore, all microbubbles passing through the 400 Mesh filter were 37 microns or smaller. Thereafter, 20 uL of the filtered solution was injected onto the sintered glass space adjacent to the glass coverslip covering the grid on a hemocytometer. The grid was observed under the 40/0.065 magnification on the OMAX® Binocular Compound Microscope Model: M83EZ.

[0236] At the 4.5 - hour observation, numerous microbubbles were observed, as shown in **Figure 3**. Here a wide range of sizes (diameters) are observed. Since the largest size is 37 microns, then the smaller size ranges observed must range between 2-10 microns.

[0237] At 8.5-hours, the filtered formulation was refreshed by cleaning and drying the hemocytometer and injecting 20 uL of the solution onto the sintered glass space adjacent to the glass coverslip - covering the grid on the hemocytometer. A wide range of microbubbles of assorted sizes is observed. Thus, the microbubbles observed, have a sustainability of at least 8.5 hours in the 44 mg Mg*, 120 ppm glucomannan, Crystal Light ® formula. These results are in accord with the results shown in Columns 9 and 10 of **Table 15** - where it is seen that 309 ppm

H_2 (38.2%) is present 6-hours after preparation of a 40 mg Mg*, 120 ppm glucomannan, Crystal Light® solution.

[0238] From the results presented in Figures 3 - 4 and **Tables 15-17**, there is convincing evidence that the persistence of H_2 in non-viscous solutions containing glucomannan is due to the stabilization of microbubbles by aqueous glucomannan.

[0239] Variable quantities of H_2 bubbles in non-viscous glucomannan (gmn) solutions can be generated and controlled by:

Electrolysis of aqueous 0.5 ppm – 1,000 ppm gmn solutions: Extending the electrolysis time and/or voltage, and the presence of bicarbonate electrolytes will increase bubble formation, including microbubbles. Other electrolytes are not recommended due to their adverse effects on the lifetime of the electrodes.

Reaction of magnesium metal powder (Mg) with water in acidic 0.5 ppm – 1,000 ppm gmn solutions. Increasing the concentration of Mg, e.g., 1 mg - 1000 mg per 100 mL , will increase the generation of H_2 bubbles stabilized by glucomannan.

Using a hydrogen canister for diffusing or pressurizing H_2 into aqueous 0.5 ppm – 1,000 ppm gmn solutions. This method requires a source of H_2, such as a canister, to be available for use.

Using a hydrogen generator (e.g., Parker Hannifin 20h hydrogen generator capable of 160 mL H_2/min.

Direct water splitting through vibrating piezoelectric zinc oxide microfibers in aqueous 0.5 ppm – 1,000 ppm gmn solutions.

[0240] The size of the H_2 microbubbles in H_2 - generating systems can be selected by:

Molecular sieving, e.g., passing a solution through a 1250 Mesh filter will allow 10 micron or smaller microbubbles to pass.

Centrifugation where larger bubbles are removed before the microbubbles. The time and speed of centrifugation is contingent on the bubble size cut-off desired.

Size exclusion chromatography where the microbubbles readily pass through the column while the larger bubbles are held back.

[0241] The ability to generate sufficient quantities of stable H_2 microbubbles in aqueous solution has important health benefits regarding enhancing ultrasonic biotechnology:

ultrasonic imaging of organs and the circulatory system of humans and lower life forms;

ultrasonic drug delivery, including chemotherapy, to specific organs, including crossing the blood – brain barrier;

treatment of prostate cancer, histotripsy (mechanical tissue fractionation using high frequency ultrasound) and sonothrombolysis (removal of blood clots using sound waves);

ultrasonic delivery of macromolecules including DNA, RNA and proteins to specific tissues, including enhancement of CRSPR biotechnology.

vascular permeability enhancement;

lithotripsy, the disintegration of kidney and bladder stones; or

the benefits listed above, plus the delivery of antioxidant and anti-inflammatory efficacy due to H_2.

Example 29: Sequestration of Molecular Hydrogen (H_2) from Water Flowing through a Filter Containing a Glucomannan Gel

15. Introduction

[0242] There is a need for an inexpensive source of clean energy in poor, third world environments. These environments usually have an abundance of wastewater. Anaerobic fermentation of wastewater generates copious amounts of both H_2 and CO2 as well as methane. A method has been devised by which an aqueous glucomannan gel can be used to sequester H_2 from flowing waste - water and simultaneously - separate it from carbon dioxide. It is noted the konjac plant that contains glucomannan is often farmed in some third – world countries. In such places, it would be cost effective to use glucomannan for sequestering H_2 from wastewater.

16. Results

[0243] The drawing in **Figure 5A** depicts a preformed aqueous 3 – 10% glucomannan gel (520) placed in a filter casing (530) that allows 20 -50% expansion of the gel in the casing. The gel is preformed around 20 – 100 plastic or metal rods, 2 -4- cm in diameter, so that pores (510) extend from one end of the gel to the other after the gel forms and the rods are withdrawn. Filter casings can be 'off the shelf' products. Gels can be sized according to the needs for sequestering of H_2.

[0244] **Figure 5B** depicts the filter casing (550) comprising the aqueous glucomannan gel for sequestering H_2 from a stream of water flowing into the canister through an intake port (560). Water is exposed to the glucomannan gel and within the canister and flows out through the output port (540). The diagram in **Figure 6** is descriptive: 1)waste water is pressurized into the system by gravity or a pump; 2) large particles and/or sludge is removed from the water stream by Prefilter #1 (670) which can comprise inexpensive and reversibly cleaned sand; 3) small particles, metals and organic compounds are removed from the stream by Prefilter # 2 (680) which can comprise zeolites as well as other such sequestering materials; and 4) water flows into Filter # 3 (650), comprising the aqueous glucomannan gel, water flows into the gel through the pores and around the gel until the gel expands due to its sequestration of H_2, hereafter, the water flows through the gel, H_2 is removed, sequestered and stored in the expanded aqueous glucomannan gel; 5) the H_2-glucomannan gel can be degassed by heating, or otherwise to produce H_2 gas for energy or health use; and 6) the aqueous glucomannan gel can be recycled to the filter casing, to collect additional cycles of H_2. Filters are connected in series, by non-limiting example, with connectors (690).

17. Discussion.

[0245] As shown in Example 6 (above), aqueous glucomannan gels sequester H_2 but not carbon dioxide. Therefore, the H_2 sequestered by the aqueous glucomannan gel will not be 'poisoned' by carbon dioxide. That is, carbon dioxide will not be present to extinguish the flammability of the sequestered H_2. On the other hand, if the aqueous glucomannan gel sequesters some methane, it will not present a problem since methane, like H_2, can be burned for energy.

Example 30: Effect of Varying Magnesium Metal Powder on the Physical -Chemical Properties of a Weight Loss Product

18. Introduction

[0246] Volume and viscosity are two properties of a gel formulation that can impart a feeling of fullness when residing in the stomach. Increases in both volume and viscosity will enhance the experience of satiety.

[0247] A study was carried out to determine the effect of increasing the concentration of magnesium metal powder (Mg*) on the viscosity, volume, molecular hydrogen content and related physical-chemical properties of a lemon-flavored weight loss formulation.

19. Experimental

[0248] **Table 17** contains a list of ingredients in the formulations. As shown, the Mg* concentration was varied from 0, 0.12, 0.24 to 0.48 g in the respective formulations. Gels were prepared by adding 4.0 grams of each formulation to 400 mL of distilled water and mixing with a utensil for 120 seconds. The resultant gels were allowed to stand at 70 deg. F for 1-hour.

Table 17: Effect of Varying Magnesium Metal Powder on the Physical - Chemical Properties of a Weight Loss Product

	Formula Ingredients/ 400 mL Distilled Water					
Grams	**Ingredient**					**Purpose**
8.00	Erythritol					Sweetener/Filler
7.00	L-citric acid - anhydrous					Lemon Flavor
5.20	Konjac glucomannan					Viscosity Builder
2.00	Xanthan gum					Thickener
1.20	sodium ascorbate					antioxidant/preserve
0.92	Magnesium sulfate					Anti-caking
0.72	sucralose					sweetener
Variable	230 Mesh Magnesium metal powder (MMP)					Generate H_2
0.16	Vitamin E Powder					antioxidant/preserve
0.02	Riboflavin					Color
MMP	**Dens.(g/mL)**	**Vol (mL)**	**Viscosity**	H_2	**pH**	
0	1.050	405	17,400	0	2.62	
0.12	0.859	495	34,200	629	2.93	
0.24	0.810	525	90,500	715	3.00	
0.48	0.709	600	78,500	585	3.14	

Abbreviations
MMP Magnesium metal powder passing through a 230 Mesh sieve.
Dens. Density
g grams
mL milliliters
Vol. Volume
H_2 molecular hydrogen measured with the Trustlex Meter.

[0249] Volumes were determined by the height of gel attained in the 600 mL beaker. Viscosities were measured with an NDJ-1 rotary type viscometer. For the control gel, not containing Mg*, which had the lowest viscosity, Rotor #3 at a rotation rate of 6 rpm was used. For the three formulations containing Mg*, Rotor #4 and at a rotation rate of 12 rpm was used. The dissolved molecular hydrogen persisting in the gels, after standing for 1-hour, was measured with the Trustlex® H_2 Meter. pH was measured with a calibrated ExStick II pH meter. Gel

density was calculated by dividing the total weight of each gel by its volume - as listed in Column 14.

20. Results and Discussion

[0250] Increasing the concentration of Mg* in the weight loss formulation, depicted in Column 1 of Table 17, results in a concomitant increase in gel volume (see Column 3 of Table 17). This increase in gel volume is due to the generation of molecular hydrogen (H_2). This increase in volume results in a decrease in gel density as shown in Column 2 of **Table 17**.

[0251] Viscosity measurements indicate a more complex picture, where the presence of Mg* markedly increases the viscosity – relative to the Control – without Mg* (Column 4 of Table 17). However, a maximum viscosity is reached at an intermediate concentration, i.e., at a concentration of 0. 24 g Mg*. Also, this is the gel that retains the highest concentration of dissolved H_2. In contrast, the pH of the gels increases as the concentration of Mg* in the gels increases – due to the formation of magnesium hydroxide due to the reaction of Mg* with water.

[0252] The results are best explained by: As H_2 is generated in the gels containing Mg*, the gels retain H_2 bubbles by a strong interaction with glucomannan in the gels. As the density is decreased to 0.810 g/mL, there is a parallel increase in viscosity due to the interaction of H_2 bubbles with the gel matrix. This effect is conducive to retaining dissolved H_2, as well. As the volume increases beyond 525 mL, the gel becomes more porous, allowing a greater escape of dissolved H_2 as well as a relative decrease in gel viscosity.

[0253] In summary, the optimal gel for affecting satiety - is the gel containing 0.24 g of Mg*/400 mL distilled water.

While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

CLAIMS

WHAT IS CLAIMED IS:

1. A method of generating an aqueous glucomannan solution containing molecular hydrogen, the method comprising:
providing a volume of an aqueous solvent; and
adding from about 0.00001% w/v to about 7.5% w/v glucomannan and about 0.005% to about 2.0% w/v magnesium metal powder to the aqueous solvent,
wherein the generated glucomannan solution has an increased volume which is at least 0.01%, at least 0.1%, at least 1%, at least 10%, or at least 20% greater than the volume of a corresponding glucomannan solution which does not comprise H_2;
wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion); and
wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 50% or at least about 70% of the initial H2 concentration.

2. A method of generating a glucomannan solution, the method comprising:
providing a volume of an aqueous solvent;
generating or sequestering H_2 in the aqueous solvent; and
adding glucomannan to the aqueous solvent,
wherein the glucomannan solution has an increased volume which is about 0.01%, at least 0.1%, at least 1%, at least 10%, or at least 20% greater than the volume of a corresponding glucomannan solution which does not comprise H_2;
wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion); and
wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution retains at least 50% of its original concentration of H_2.

3. The method of claim 2, wherein the aqueous solvent comprises water.

4. The method of claim 2, wherein the aqueous solvent is water.

5. The method of claim 2, wherein the generated glucomannan solution has a glucomannan concentration from about 0.00001% w/v to about 7.5% w/v.

6. The method of claim 2, wherein the generated glucomannan solution is a gel.

7. The method of claim 2, wherein the generated glucomannan solution is a flowable liquid.

8. The method of claim 2, wherein the generated glucomannan solution comprises gaseous H_2.

9. The method of claim 2, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration.

10. The composition of claim 2, wherein the volume of the generated glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent.

11. The method of claim 2, further comprising a step of treating the aqueous solvent with electrolysis, thereby generating H_2 in the aqueous solvent, prior to, during, or subsequent to adding the glucomannan to the aqueous solvent.

12. The method of claim 2, wherein the glucomannan solution comprises a base metal.

13. The method of claim 12, wherein the aqueous solvent comprises the base metal.

14. The method of claim 2 or claim 12, wherein a base metal is added to the aqueous solvent prior to the addition of the glucomannan to the aqueous solvent.

15. The method of any one of claims 12 to 14, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof.

16. The method of claim 15, wherein the base metal is magnesium metal powder.

17. The method of claim 16, wherein the magnesium metal powder is present in the generated glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v.

18. The method of claim 2, wherein the generated glucomannan solution further comprises an organic acid.

19. The method of claim 18, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof.

20. The method of claim 19, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v.

21. The method of claim 19, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v.

22. The method of claim 19, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v.

23. The method of claim 19, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v.

24. The method of claim 19, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v.

25. The method of claim 19, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v.

26. The method of claim 19, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v.

27. The method of claim 2, further comprising a step of diffusing H_2 in to the aqueous solvent or the glucomannan solution from a pressurized environment.

28. The method of claim 2, further comprising a step of exposing the generated glucomannan solution to electrolysis, thereby generating H_2 in the glucomannan solution.

29. The method of claim 2, wherein the initial H_2 concentration is achieved during generation of the glucomannan solution.

30. The method of claim 29, wherein the initial H_2 concentration is achieved prior to generation of the glucomannan solution.

31. The method of claim 2, further comprising an isolating step, wherein bubbles in the glucomannan solution smaller than 37 microns are isolated.

32. The method of claim 31, wherein the isolating is by filtration.

33. The method of claim 31, wherein the isolating is by centrifugation.

34. The method of claim 31, wherein the isolating is by size exclusion chromatography.

35. A composition comprising a glucomannan solution and further comprising hydrogen (H_2) at a concentration of greater than about 100 ppb (parts per billion); and wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution declines by less than 50% or less than 30%.

36. The composition of claim 35, further comprising an aqueous solvent.

37. The composition of claim 35, wherein the aqueous solvent is water.

38. The composition of claim 35, wherein the concentration of glucomannan in the glucomannan solution is from about 0.00001% w/v to about 7.5% w/v.

39. The composition of claim 35, wherein the glucomannan solution is a gel.

40. The composition of claim 35, wherein the glucomannan solution is a flowable liquid.

41. The composition of claim 35, wherein the H_2 is present in the glucomannan solution in a gaseous form.

42. The composition of claim 35, wherein the H_2 concentration 240 minutes after generation of the glucomannan solution is at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration.

43. The composition of claim 35, wherein the volume of the glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent.

44. The composition of claim 35, wherein the glucomannan solution comprises a base metal.

45. The composition of claim 44, wherein the composition comprises a base metal.

46. The composition of claim 36, wherein the aqueous solvent comprises a base metal.

47. The composition of any one of claims 44 - 46, wherein the base metal is selected from the group consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof.

48. The composition of claim 47, wherein the base metal is magnesium metal powder.

49. The composition of claim 48, wherein the magnesium metal powder is present in the glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v.

50. The composition of claim 35, wherein the glucomannan solution further comprises an organic acid.

51. The composition of claim 50, wherein the organic acid is selected from the group consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid, and any combination thereof.

52. The composition of claim 51, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v.

53. The composition of claim 51, wherein the malic acid is present in an amount from about 1% w/v to about 50% w/v.

54. The composition of claim 51, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v.

55. The composition of claim 51, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v.

56. The composition of claim 51, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v.

57. The composition of claim 51, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v.

58. The composition of claim 51, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v.

59. The composition of any one of claims 35 to 58, wherein the composition is in a capsule or gel.

60. A glucomannan solution comprising a concentration of glucomannan and hydrogen (H_2).

61. The solution of claim 60, wherein the hydrogen (H_2) is present at a concentration of greater than about 100 ppb (parts per billion) hydrogen (H_2).

62. The solution of claim 60, wherein upon exposure to standard temperature and pressure (STP) for 240 minutes, the H_2 concentration is at least about 70% of the initial H_2 concentration as measured in parts per billion (ppb).

63. The solution of claim 60, wherein the glucomannan concentration is from about 0.00001% to about 7.5%.

64. The solution of claim 60, wherein the solution is a gel.

65. The solution of claim 60, wherein the solution is a flowable liquid.

66. The solution of claim 60, wherein the H_2 is present in a gaseous form.

67. The solution of claim 60, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution declines by less than 1%, less than 5%, less than 10%, less than 15%, less than 20%, less than 25%, or less than 30%. as measured in parts per billion (ppb).

68. The solution of claim 67, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes, the concentration of hydrogen in the glucomannan solution is at least 70% of the H_2 concentration in the solution prior to the exposure as measured in parts per billion (ppb).

69. The solution of claim 60, further comprising a base metal.

70. The solution of claim 69, wherein the base metal is selected from the group consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof.

71. The solution of claim 70, wherein the base metal is magnesium metal powder.

72. The solution of claim 71, wherein the magnesium metal powder is present in the glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v.

73. The solution of claim 60, further comprising an organic acid.

74. The solution of claim 73, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof.

75. The solution of claim 74, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v.

76. The solution of claim 74, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v.

77. The solution of claim 74, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v.

78. The solution of claim 74, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v.

79. The solution of claim 74, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v.

80. The solution of claim 74, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v.

81. The solution of claim 74, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v.

82. The method of any one of claims 1 to 34, the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81, further formulated for oral administration.

83. The method of any one of claims 1 to 34, the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81, further formulated for rectal administration.

84. The method, composition, or solution of claim 82, further formulated for oral delivery.

85. The method, composition, or solution of claim 82, further formulated for esophageal delivery.

86. The method, composition, or solution of claim 82, further formulated for gastric delivery.

87. The method, composition, or solution of claim 82, further formulated for duodenal delivery.

88. The method, composition, or solution of claim 82, further formulated for delivery to the small intestine.

89. The method, composition, or solution of claim 82 or 83, further formulated for delivery to the large intestine.

90. The method, composition, or solution of claim 82 or 83, further formulated for delivery to the colon.

91. The method of any one of claims 1 to 34, the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81, further formulated for parenteral delivery.

92. The composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81, further formulated for a topical dosage form.

93. The composition or solution of claim 92, wherein the topical dosage form is a cream, gel, foam, ointment, lotion, or liquid.

94. A bandage comprising the composition or solution of claim 92 or claim 93.

95. A kit for treating a skin condition, comprising:

a) a container comprising the composition or solution of any one of claims 92 or 93;

b) instructions for applying the composition or solution topically to the skin.

96. A kit for treating a gastrointestinal condition, comprising:

a) a container comprising the composition or solution of any one of claims 82 to 90; and

b) instructions for oral or rectal administration of the composition or solution.

97. A kit for treating an inflammatory disease, comprising:

a) a container comprising the composition or solution of any one of claims 82 to 93; and

b) instructions for administration of the composition or solution to treat the inflammatory disease.

98. A kit for treating obesity, comprising:

a) a container comprising the composition or solution of any one of claims 82 to 90; and

b) instructions for oral administration of the composition or solution.

99. A method for treating a skin condition, comprising administering the composition or solution of any one of claims 92 or 93 to the skin of a subject in need thereof.

100. A method for treating a gastrointestinal condition, comprising administering the composition or solution of any one of claims 82 to 90 to a subject in need thereof.

101. A method for treating an inflammatory condition, comprising administering the composition or solution of any one of claims 82 to 93 to a subject in need thereof.

102. A method for treating obesity, comprising administering the composition or solution of any one of claims 82 to 90 to a subject in need thereof.

103. A method of providing H_2 as a nutritional supplement to a subject in need thereof, comprising providing the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81 to a subject in need thereof.

104. A method of providing H_2 to a body or container of water comprising aquatic or plant life, comprising contacting the water with the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81.

105. A method of sequestering H_2 from an aqueous solution in need thereof, comprising contacting the aqueous solution with the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81.

106. A device comprising the composition of any one of claims 35 to 59, or the solution of any one of claims 60 to 81 flowably connected to a water source, allowing contact between the composition described herein and the water source.

107. A composition comprising a base metal and glucomannan.

108. The composition of claim 107, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof.

109. The composition of claim 108, wherein the base metal is magnesium metal powder.

110. The composition of any one of claims 107 to 109, further comprising an organic acid.

111. The composition of claim 110, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof.

112. The composition of any one of claims 107 to 111, wherein the composition is in a powder form.

113. The composition of any one of claims 107 to 112, wherein the composition is substantially free of water.

114. The composition of any one of claims 107 to 113, wherein the composition is in a capsule or gel.

115. A glucomannan solution produced by the method of any one of claims 1-34.

116. A method of generating a glucomannan solution, comprising generation of a glucomannan solution that comprises H_2.

117. A method of generating a glucomannan solution, comprising adding a magnesium metal powder and glucomannan to an aqueous solvent.

118. A method of generating a glucomannan solution that retains molecular hydrogen longer than a solution without glucomannan, the method comprising:
a) providing a relatively large volume of an aqueous solvent;
b) adding an amount of glucomannan to the aqueous solvent; and
c) generating and/or infusing an amount of molecular hydrogen into the aqueous solvent,
wherein the glucomannan solution has a volume from zero to more than 100% greater than the volume of the aqueous solvent,
wherein the increase in volume of the glucomannan solution over the aqueous solvent is dependent on the amount of glucomannan and molecular hydrogen in the glucomannan solution,
wherein the generated glucomannan solution comprises an initial H_2 concentration of greater than about 100 ppb (parts per billion), and
wherein, upon exposure of the glucomannan solution to standard temperature and pressure for at least four hours, the glucomannan solution comprises a level of molecular hydrogen greater than a level of molecular hydrogen in a comparable aqueous solution without glucomannan.

119. The method of any one of claims 116 to 118, wherein the generated glucomannan solution has a glucomannan concentration from about 0.00001% w/v to about 7.5% w/v.

120. The method of any one of claims 116 to 118, wherein the generated glucomannan solution is a gel.

121. The method of any one of claims 116 to 118, wherein the generated glucomannan solution is a flowable liquid.

122. The method of any one of claims 116 to 118, wherein the generated glucomannan solution comprises gaseous H_2.

123. The method of any one of claims 116 to 118, wherein, upon exposure of the glucomannan solution to standard temperature and pressure (STP) for 240 minutes after its generation, the glucomannan solution comprises an H_2 concentration at least about 75%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or at least about 99% of the initial H_2 concentration.

124. The method of any one of claims 116 to 118, wherein the volume of the generated glucomannan solution comprising H_2 is at least 1% , at least 10%, at least 20%, at least 30%, or at least 50% greater than the volume of the aqueous solvent.

125. The method of any one of claims 116 to 118, further comprising a step of treating the aqueous solvent with electrolysis, thereby generating H_2 in the aqueous solvent, prior to adding the glucomannan to the aqueous solvent.

126. The method of any one of claims 116 to 118, wherein the glucomannan solution comprises a base metal.

127. The method of any claim 126, wherein the base metal is selected from the list consisting of lithium, potassium, strontium, calcium, sodium, magnesium metal powder, aluminum, zinc, chromium, manganese, iron, and any combination thereof.

128. The method of claim 127, wherein the base metal is magnesium metal powder.

129. The method of claim 128, wherein the magnesium metal powder is present in the generated glucomannan solution in an amount from about 0.00001% w/v to about 2% w/v.

130. The method of claim 129, wherein the generated glucomannan solution further comprises an organic acid.

131. The method of claim 130, wherein the organic acid is selected from the list consisting of citric acid, malic acid, lactic acid, acetic acid, tartaric acid, succinic acid, phosphoric acid or any combination thereof.

132. The method of claim 131, wherein the citric acid is present in an amount from about 0.1% w/v to about 15% w/v.

133. The method of claim 131, wherein the malic acid is present in an amount from about 1% (w/v) to about 50% w/v.

134. The method of claim 131, wherein the lactic acid is present in an amount from about 1% w/v to about 10% w/v.

135. The method of claim 131, wherein the acetic acid is present in an amount from about 0.5% v/v to about 3% v/v.

136. The method of claim 131, wherein the tartaric acid is present in an amount from about 1% w/v to about 10% w/v.

137. The method of claim 131, wherein the succinic acid is present in an amount from about 1% w/v to about 10% w/v.

138. The method of claim 131, wherein the phosphoric acid is present in an amount from about 1% v/v to about 10% v/v.

139. The method of any one of claims 116 to 118, further comprising a step of diffusing H_2 in to the aqueous solvent or the glucomannan solution from a pressurized environment.

140. The method of any one of claims 116 to 118, further comprising a step of exposing the generated glucomannan solution to electrolysis, thereby generating H_2 in the glucomannan solution.

141. The method of any one of claims 116 to 118, wherein an initial H_2 concentration is achieved during generation of the glucomannan solution.

142. The method of claim 141, wherein the initial H_2 concentration is achieved prior to generation of the glucomannan solution.

143. The method of any one of claims 116 to 118, further comprising an isolating step, wherein bubbles in the glucomannan solution smaller than 37 microns are isolated.

144. The method of claim 143, wherein the isolating is by filtration.

145. The method of claim 143, wherein the isolating is by centrifugation.

146. The method of claim 143, wherein the isolating is by size exclusion chromatography.

147. An H_2-generating composition comprising:
lactic acid;
glucomannan;
magnesium metal powder;
glycerin; and
an aqueous solvent.

148. An H_2-generating composition comprising:
an organic acid;
glucomannan;
magnesium metal powder;
glycerin; and
an aqueous solvent.

149. The composition of claim 147 or 148, wherein the composition is a cream, gel, foam, ointment, lotion, or liquid.

150. The composition of any one of claims 147 to 149, wherein the composition is adapted for application to the skin of a subject.

151. The composition of any one of claims 147 to 150, wherein the composition provides a moisturizing effect to the skin of the subject.

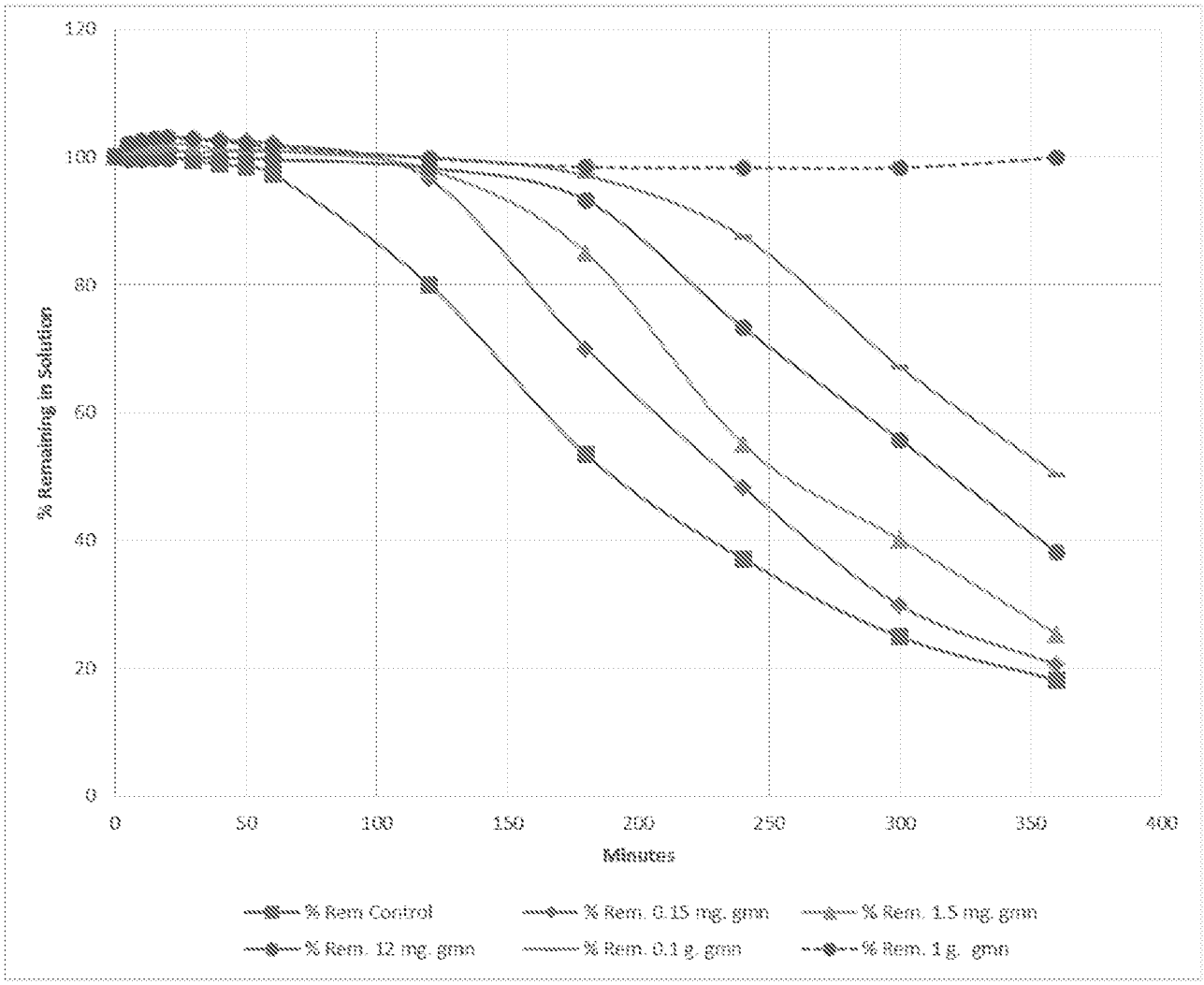

120
100
80
60
40
20
0
% Remaining in Solution
0
50
100
150
200
250
300
350
400
Minutes
% Rem Control
% Rem. 0.15 mg. gmn
% Rem. 1.5 mg. gmn
% Rem. 12 mg. gmn
% Rem. 0.1 g. gmn
% Rem. 1 g. gmn

Figure 1

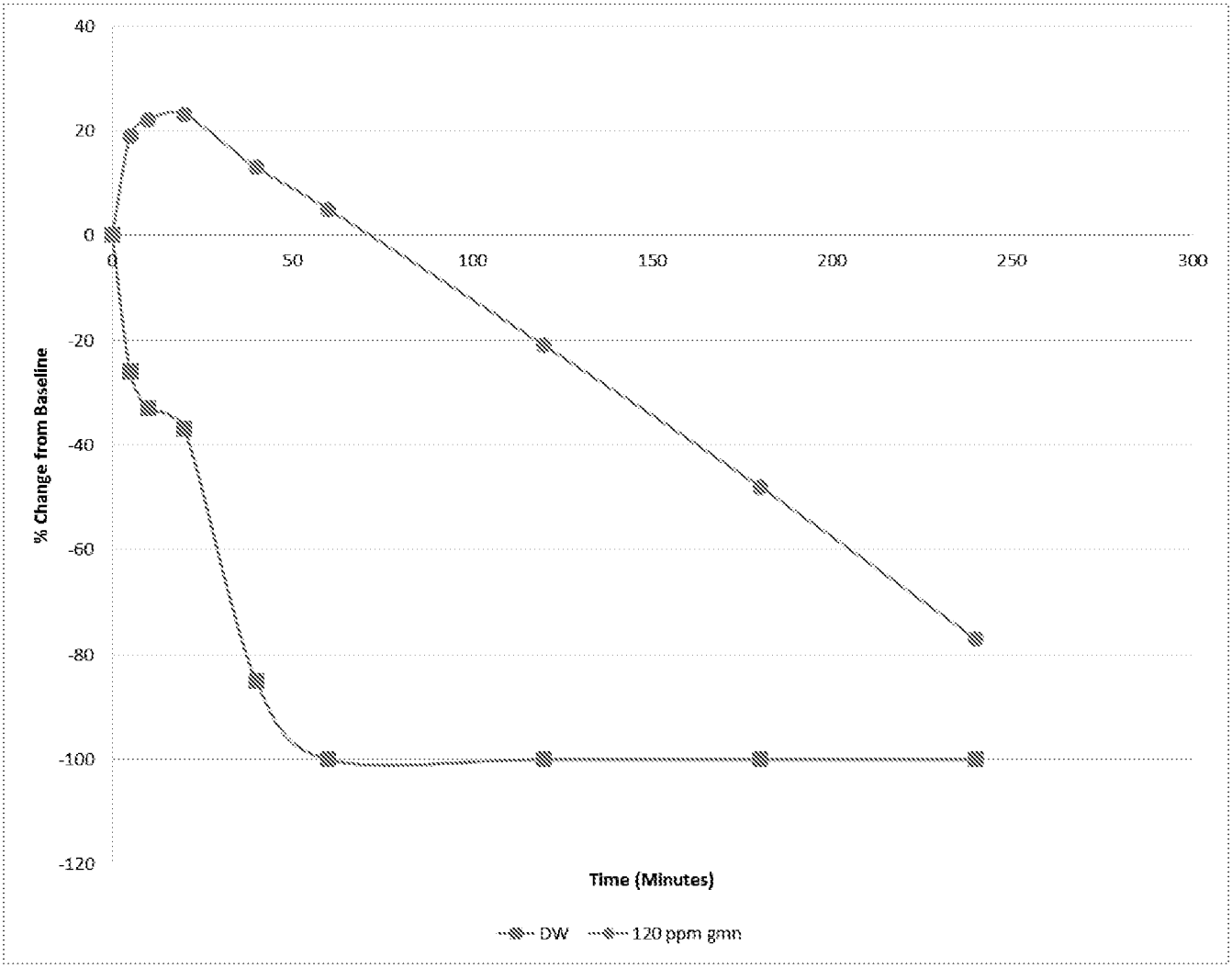

40
20
0
-20
-40
-60
-80
-100
-120
0
50
100
150
200
250
300
% Change from Baseline
Time (Minutes)
DW
120 ppm gmn

Figure 2

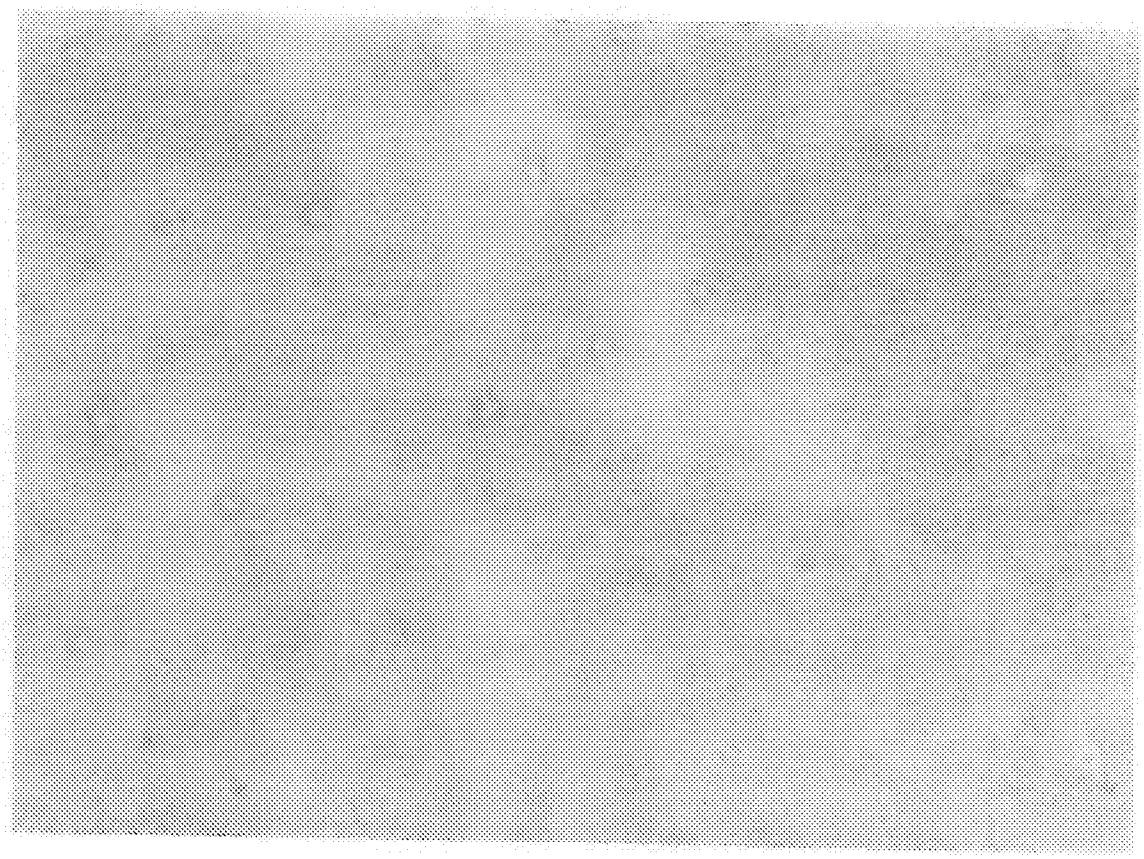


Figure 3

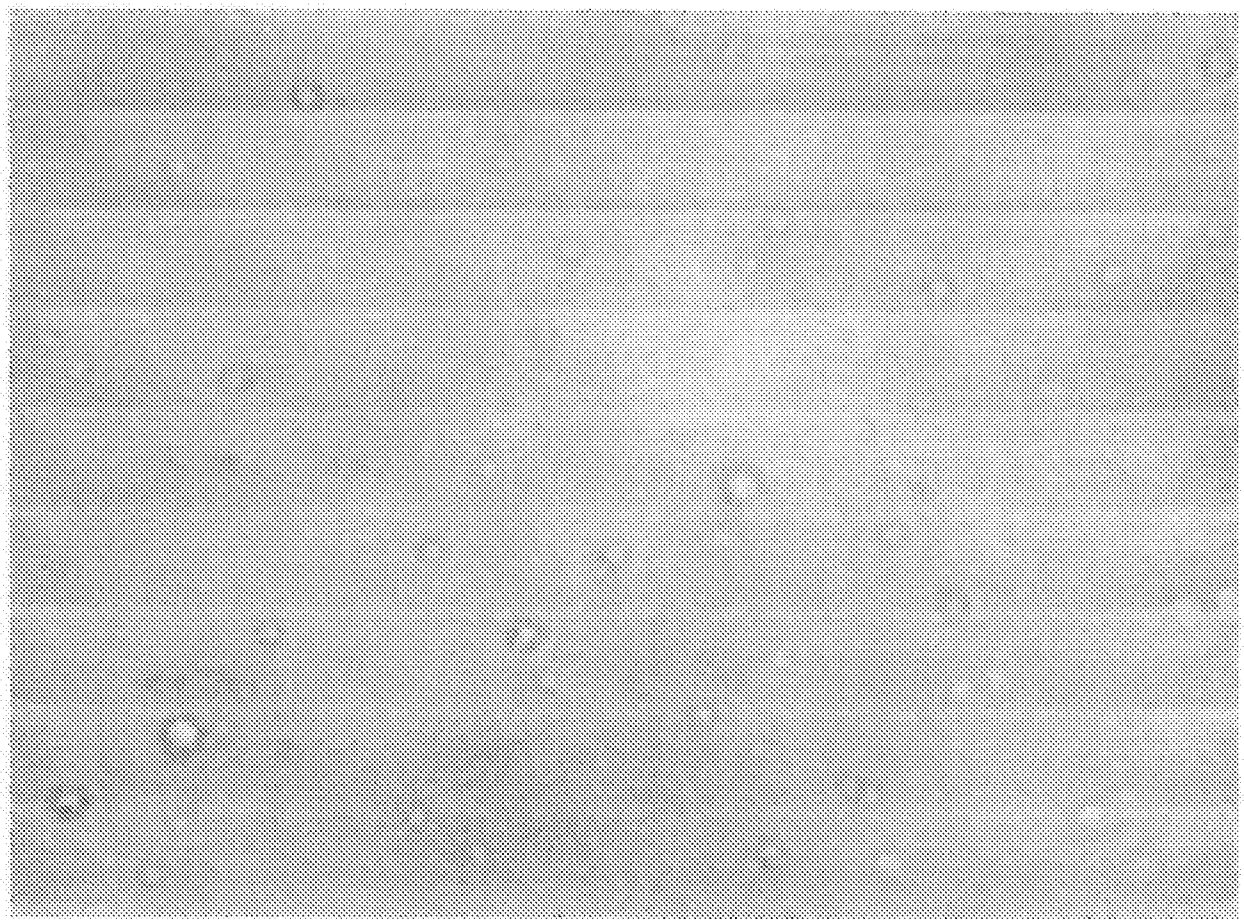


Figure 4

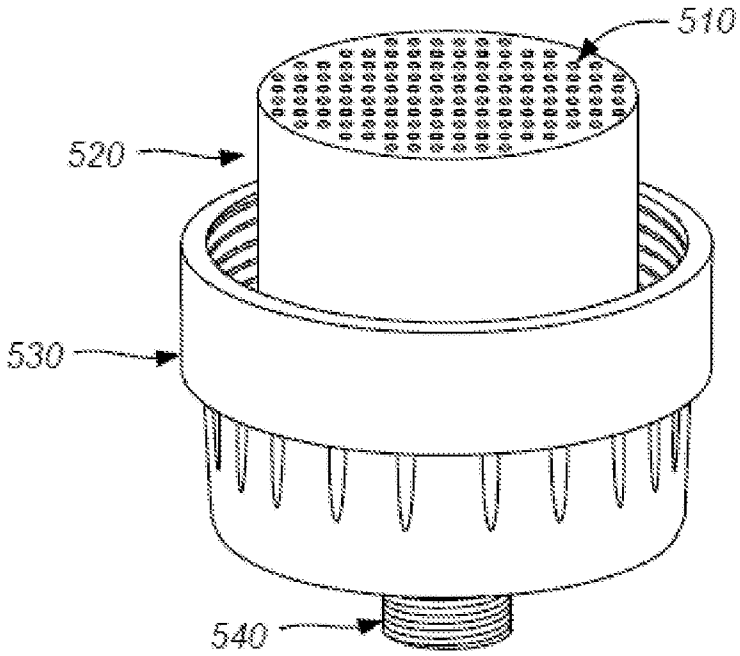


Figure 5A

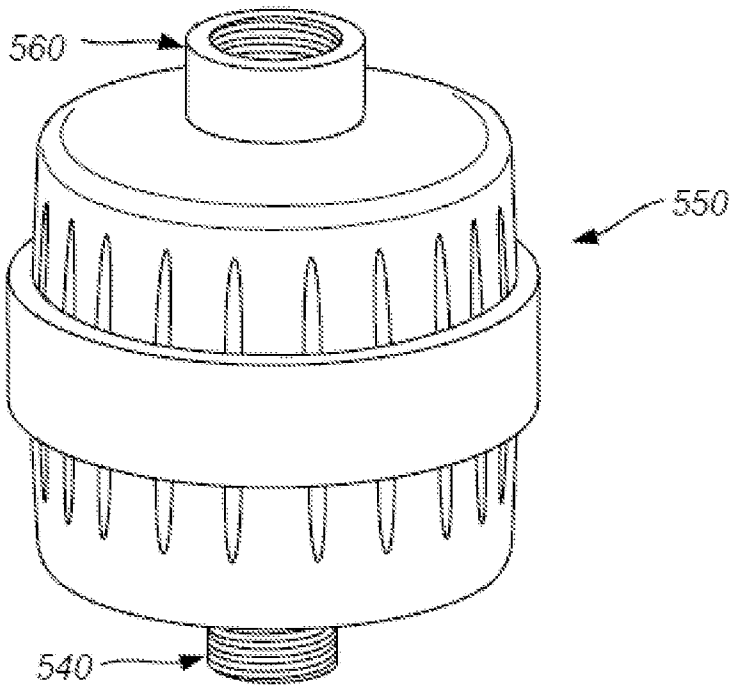


Figure 5B

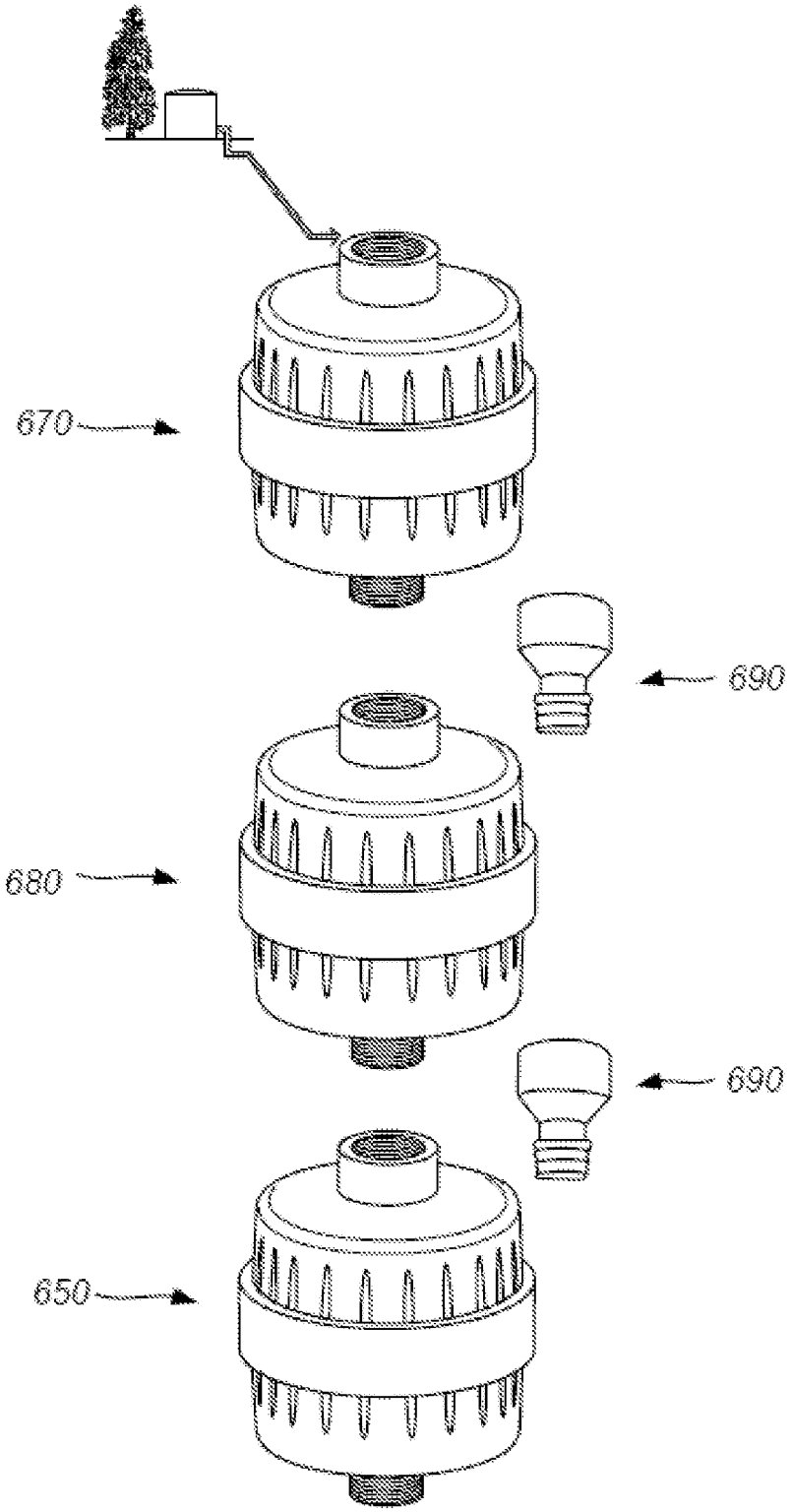


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/42833

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C08B 16/00; D21C 9/00 (2019.01)
CPC - C08B 16/00; C08B 37/0003; C08B 37/0057

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)
See Search History Document

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 2013/0011756 A1 (Weaver et al.) 10 January 2013 (10.01.2013) Entire document, especially Abstract, para [0005]-[0006], [0058], [0084]	2-5, 7-10, 29-30, 35-38, 40-43, 60-63, 65-68, 118, 119/(116,118), 121/116, 121/(118), 122/116, 122/(118), 123/(116,118), 124/(116,118), 141/(116,118), 142/141/(116,118) ---------- 1, 6, 11-13,14/12/2,18-28, 31-34, 39, 44-47, 50, 64, 69-73, 107-110, 117, 119/117,120/(116-118), (121-124)/117,125/(116-118),126/(116-118),127/126/(116-118), 128/127/126/(116-118), 139/117,129/128/127/126/(116-118),130/129/128/127/126/(116, 118), 140/(116-118), 141/117, 142/141/117,143/(116-118),(144-146)/143/(116-118), 148, 149/148 ----------

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* 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
4 November 2019	20 NOV 2019

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. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/42833

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 15-17, 48-49, 59, 82-106, 111-115, 150-151
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-- See Extra Sheets --

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/42833

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
		19-26, 51-58, 74-81, 111, 131/130/129/128/127/126/(116, 118), 131/130/129/128/127/126/117,(132-138)/131/130/129/128/127/126/(16-18), 147, and 149/147
Y --- A	US 2010/0008849 A1 (Martin) 14 January 2010 (14.01.2014) Entire document, especially Abstract, para [0043], [0047], [0057]	1, 27, 71-72, 107-110,117,(119-126)/117,127/126/117,128/127/126/(116-118), 129/128/127/126/(116-118),130/129/128/127/126/(116-118),139/117,140/117, 141/117, 142/141/117, 143/117,145/143/147148, 149/148 ---------- 111,131/130/129/128/127/126/(116-118), 132-138)/131/130/129/128/127/126/(116-118), 147,149/147
Y --- A	US 6,558,652 B2 (Takata) 6 May 2003 (05.06.2003) Entire document, especially Abstract, col 2 ln 46-48	6, 18-26, 39, 50-58, 64, 73-81, 107-110, 120/(116-118), 130/129/128/127/126/(116-118), 148-149/148 ---------- 19-26, 51-58, 74-81, 111, 131/130/129/128/127/126/(116-118),(132-138)/131/130/129/128/127/126/(116-118), 147,149/147
Y	US 2011/0127167 A1 (Misra et al.) 2 June 2011 (02.06.2011) Entire document, especially para [0001], [0012]	11, 28, 125/(116-118), 140/(116-118)
Y	US 8,252,141 B2 (Stigsson et al.) 28 August 2012 (28.08.2012) Entire document, especially col 1 ln 61-65; col 2 ln 61-64; col 4 ln 60-62	12-13, 14/12/2, 44-47, 69-72, 126/(116-118), 127/126/(116-118), 128/127/126/(116-118), 129/128/127/126/(116-118),130/129/128/127/126/(116, 118)
Y	Wang et al. "Interactions between Carboxymethyl Konjac Glucomannan and Soy Protein Isolate in Blended Films." Carbohydrate Polymers, vol. 101, 2014, pp. 136-145., doi:10.1016/j.carbpol.2013.09.028.	31-34, 143/(116-118), 144/143/(116-118), 145/143/(116-118), 146/143/(116-118)
Y	General Electric. Size Exclusion Chromatography Principles and Methods. GE Healthcare Life Sciences, 2000.	32, 34, 144/143/(116-118), 146/143/(116-118)
	-- Further documents on next page --	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 19/42833

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	-- C (Continuation) --	
A	Tang et al. "Construction and Evaluation of Fibrillar Composite Hydrogel of Collagen/Konjac Glucomannan for Potential Biomedical Applications." Regenerative Biomaterials, Oxford University Press, 20 July 2018, www.ncbi.nlm.nih.gov/pmc/articles/PMC6077832/.	6, 39, 4 118, 120/(116,-118)
A	Goodall, Chris. "Hydrogen Made by the Electrolysis of Water Is Now Cost-Competitive and Gives Us Another Building Block for the Low-Carbon Economy." Carbon Commentary, Carbon Commentary, 5 July 2017, www.carboncommentary.com/blog/2017/7/5/hydrogen-made-by-the-electrolysis-of-water-is-now-cost-competitive-and-gives-us-another-building-block-for-the-low-carbon-economy.	11, 125/(116-118), 140/(116-118)
A	Nakao et al. "Effectiveness of Hydrogen Rich Water on Antioxidant Status of Subjects with Potential Metabolic Syndrome-An Open Label Pilot Study." Journal of Clinical Biochemistry and Nutrition, vol. 46, no. 2, 2010, pp. 140-149., doi:10.3164/jcbn.09-100.	12, 44, 69, 126/(116-118)
A	"Ingredients." ALOECREAM.BIZ, ALOECREAM.BIZ, 2013, www.aloecream.biz/ingredients/.	18, 50, 73, 110, 130/129/128/127/126/(116-118)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/42833

Continutation of Box No. III - Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-14, 18-34 and 116-146 directed to a method of generating a glucomannan solution.

Group II: Claims 35-47, 50-58, 60-81, and 107-111, directed to a composition comprising a glucomannan solution.

Group III: Claims 147-149, directed to H2 generating compositions further comprising an organic acid, glucomannan, magnesium metal powder, glycerin, and an aqueous solvent.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

Group I requires a method for making a glucomannan solution, not required by Groups II or III.

Group III requires an H2-generating composition, further comprising an organic acid, magnesium metal powder, and glycerin, not required by Groups I and II.

Common Technical Features:

Groups I-III share the technical feature of a composition or solution comprising glucomannan.

However, these shared technical features do not represent a contribution over prior art, because the shared technical feature is being anticipated by as being anticipated by US 6,733,769 B1 to Ryan et al. (hereinafter 'Ryan'). Ryan discloses a composition or solution comprising glucomannan (Abstract - '...Methods of producing low viscosity glucomannan compositions by mixing a viscosity lowering compounds with glucomannan...').

As the shared technical features were known in the art at the time of the invention, they cannot be considered common technical features that would otherwise unify the groups. Therefore, Groups I and II lack unity under PCT Rule 13.