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(54) **Title:** INFUSED GROUND PLANT HULLS

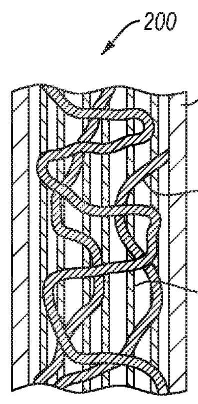

FIG. 2A

(57) **Abstract:** Examples disclose methods, systems, products, devices that are generally related to ground plant hull compositions that include one or more materials infused therein. The example methods include forming a slurry using minimal alkalization. The example methods include minimal alkalization of a ground plant hull slurry to eliminate the need for neutralization and washing of the ground plant hull slurry prior to use.

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INFUSED GROUND PLANT HULLS

BACKGROUND

[001] Psyllium is a fiber of the seeds of the Plantago plant genus, which is used as a supplement to promote digestive health. Psyllium is a prebiotic—a substance for promoting healthy colonies of probiotics in the gut. Psyllium is also used as a food thickener.

[002] Plant hulls such as seeds, hulls, chaff, or husks are often discarded or burned as a byproduct of production processes. Some plant hulls may have a high-fiber content. For example, oat hulls are a high-fiber, low energy, low-protein feed for cattle or horses. Plant hulls may be removed from seeds or fruit prior to human consumption of the seeds or fruit. For example, oat hulls are a source of insoluble dietary fiber, provide little energy, and are therefore not typically present in foods for human consumption.

SUMMARY

[003] Techniques are generally described that include methods, compositions, and systems for making ground plant hull compositions with minimal alkalization. An example method may include a method to form a composition. The example method comprises adding ground plant hulls to water. The example method comprises combining trehalose with the ground plant hulls and water to form a slurry. The example method comprises adjusting a pH of the slurry to a range from about 7.0 to about 7.5. The method comprises heating the slurry to a selected temperature for a first duration under agitation. The slurry of the example method comprises a total solids content of at least about 30 weight % (wt%,) the ground plant hulls is at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

[004] An example slurry may include water, ground plant hulls, and trehalose infused into the ground plant hulls. The example slurry comprises a total solids content of at least about 30 wt%, the ground plant hulls are at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

[005] Another example method includes a method to form a composition. The example method comprises forming a slurry of ground plant hulls. The example method comprises treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5. The example method comprises heating the slurry to a selected temperature for a first duration under agitation. The example method comprises adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry. The example method comprises exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry. The example method comprises cooling the hydrocolloid infused slurry to below the selected temperature.

[006] Another example method includes a method to make a coated plant particle composition. The example method comprises at least partially breaking down ground plant hulls in a slurry using an alkali in an amount effective to cause the slurry to have a pH in a range from about 7 to about 7.5. The example method comprises adding a hydrocolloid material to the slurry while heating the slurry to a selected temperature and agitating the slurry for a selected duration to form a hydrocolloid slurry without neutralizing or washing the slurry, wherein the hydrocolloid slurry comprises the hydrocolloid material and the ground plant hulls. The example method comprises exposing the hydrocolloid slurry to ultrasonic agitation to form hydrocolloid infused ground plant hulls in a hydrocolloid infused slurry. The example method comprises cooling the hydrocolloid infused slurry to below the selected temperature.

[007] Another example method includes a method to make a treated plant product. The example method comprises forming a plurality of trehalose infused ground plant hulls. The example method comprises transporting the trehalose infused ground plant hulls to a blending location. The example method comprises dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture. The example method comprises packaging the dry mixture.

[008] Features from any of the disclosed embodiments may be used in combination with one another, without limitation. In addition, other features and advantages of the present

disclosure will become apparent to those of ordinary skill in the art through consideration of the following detailed description and the accompanying drawings.

[009] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[010] The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several examples in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

FIG. 1 is a flowchart illustrating an example method to form a composition;

FIGS. 2A-2C are schematics of an example ground plant hull at various points during the example method of FIG. 1;

FIG. 2D is an isometric view of an example ground plant hull slurry;

FIG. 3 is a flowchart illustrating an example method to form a composition;

FIGS. 4A-4D are schematics of an example ground plant hull at various points during the example method of FIG. 3;

FIG. 4E is an isometric view of an example ground plant hull slurry;

FIG. 5 is a schematic illustrating an example method to make a treated plant product;

FIG. 6 is a block diagram illustrating an example computing device that is arranged for forming compositions; and

FIG. 7 is a block diagram illustrating an example computer program product that is arranged to store instructions for making compositions,

all arranged in accordance with at least some embodiments of the present disclosure.

DETAILED DESCRIPTION

[011] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative examples described in the detailed description, drawings, and claims are not meant to be limiting. Other examples may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are implicitly contemplated herein.

[012] This disclosure is drawn, inter alia, to methods, systems, products, devices, and/or apparatus generally related to plant hull compositions, such as slurries, powders, and mixtures. The plant hull compositions disclosed herein include oat hull slurries, powders, and mixtures that may further include one or more of trehalose or a hydrocolloid material infused therein. The plant hull compositions are produced using minimal alkalization without one or both of neutralization and washing the slurry after alkalization. For example, the pH of the plant hull slurries may be brought to or maintained at 7.0 to 7.5. The techniques and compositions disclosed herein allow for wet processing and pumpability of plant hull slurries at total solids contents that would preclude pumping without the trehalose contents disclosed herein, such as at least 30 wt% total solids content. Accordingly, the plant hull slurries disclosed herein may be pumpable between production equipment or sites. The slurries disclosed herein may be used to produce powders and mixtures thereof that contain one or more of trehalose infused oat hulls or hydrocolloid materials (e.g., guar infused ground plant hulls).

[013] FIG. 1 is a flowchart illustrating an example method 100 to form a composition. The example method 100 may include one or more operations, functions or actions as illustrated by one or more of blocks 110, 120, 130, or 140. The operations described in the blocks 110-140 may be performed in response to execution (such as by one or more processors described herein) of computer-executable instructions stored in a computer-readable medium, such as

a computer-readable medium of a computing device or some other controller similarly configured.

[014] An example method may begin with block 110, which recites "adding ground plant hulls to water." Block 110 may be followed by block 120, which recites "combining trehalose with the ground plant hulls and water to form a trehalose slurry." Block 120 may be followed by block 130, which recites "adjusting a pH of the slurry to a range from about 7.0 to about 7.5." Block 130 may be followed by block 140, which recites "heating the slurry to a selected temperature for a first duration under agitation." The slurry of the example method 100 has a total solids content of at least about 30 wt%, the plurality of ground plant hulls is at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

[015] The blocks included in the described example methods are for illustration purposes. In some embodiments, the blocks may be performed in a different order. In some other embodiments, various blocks may be eliminated. In still other embodiments, various blocks may be divided into additional blocks, supplemented with other blocks, or combined together into fewer blocks. Other variations of these specific blocks are contemplated, including changes in the order of the blocks, changes in the content of the blocks being split or combined into other blocks, etc. In some examples, block 110 and block 120 can be combined into a single block, such as performed substantially simultaneously or contemporaneously. In some examples, the block 110 may be omitted and block 120 may include combining trehalose with ground plant hulls and water to form the slurry.

[016] Block 110 recites, "adding ground plant hulls to water." Adding ground plant hulls to water may be effective to form a pre-slurry. For example, the pre-slurry may be a slurry of ground plant hulls and water. In some examples, adding ground plant hulls to water may include dispersing the ground plant hulls in water that has a temperature of at least about 160 °F, such as at least 175 °F, at least 190 °F, or in a range from about 160 °F to about 200 °F. In some examples, adding ground plant hulls to water may include dispersing ground oat hulls in water. For example, adding ground plant hulls to water may include dispersing ground, trehalose-infused oat hulls in water. In some examples, the ground plant hulls may include one or more of ground oat hulls, ground nut hulls (e.g., coconut hulls), plant seed hulls, etc. The ground plant hulls may include cellulosic fibers, hemicellulose, lignocellulosic fibers, or particles of any of the foregoing. In some examples, any plant matter may be used instead of or addition to the ground plant hulls, such as chaff, bark, husks, leaves, stalks, wood, pulp, fruit, etc.

[017] In some examples, the ground plant hulls may include one or more materials infused therein, such as one or more of trehalose or a hydrocolloid material (e.g., guar). For example, adding ground plant hulls to water may include dispersing ground, trehalose-infused oat hulls in water. In such examples, the pre-slurry may include trehalose-infused oat hulls in water. While the plant hulls herein are described as ground, the ground plant hulls may include chopped, sliced, crushed, or otherwise size-controlled plant hulls.

[018] In some examples, at least some of the ground plant hulls may be substantially fibrous, round (e.g., spherical or elliptical), prismatic, porous, or combinations of any of the foregoing. The ground plant hulls may be ground to an average selected size or sizes. The ground plant hulls may have an average particle size (as defined by the largest dimension of the particle) of at least 1 μm, such as in a range from about 1 μm to about 44 μm, about 5 μm to about 40 μm, about 10 μm to about 35 μm, about 15 μm to about 30 μm, about 1 μm to about 15 μm, about 15 μm to about 30 μm, about 30 μm to about 44 μm, less than about 44 μm, less than about 30 μm, or less than about 20 μm. For example, the ground plant hulls may include substantially round ground oat hulls that have an average particle size of about 44 μm or less. In some examples, the ground plant hulls may have an average particle size of greater than about 44 μm or less than about 1 μm. In some examples, the ground plant hulls may include a mixture of one or more average particle sizes (e.g., a multi-modal particle size distribution). For example, the ground oat hulls may include a first amount of a first average particle size and a second amount of at least a second average particle size, such as any of the average particle sizes disclosed herein.

[019] In some examples, adding ground plant hulls to water may include adding ground plant hulls to water in a ratio of ground plant hulls to water of at least about 1:99 by weight, such as about 1:99 to about 1:2, about 1:9 to about 1:3, about 1:6 to about 1:2, or a ratio of ground plant hulls to water of less than about 1:2 by weight.

[020] In some examples, the pre-slurry formed from the ground plant hulls and water may include at least about 20 weight percent ("wt%") ground plant hulls, such as at least about 25 wt%, at least about 30 wt%, or at least about 35 wt%, or in a range from about 20 wt% to about 35 wt%, about 25 wt% to about 30 wt%, or about 30 wt% to about 35 wt% of the pre-slurry.

[021] Block 120 recites, "combining trehalose with the ground plant hulls and water to form a slurry." In some examples, combining trehalose with the ground plant hulls and water to form a slurry (e.g., trehalose slurry) may include adding trehalose powder to ground plant hulls and water (e.g., the pre-slurry). In some examples, combining trehalose with the ground plant hulls and water to form the slurry may include at least partially dissolving the trehalose powder in water, such as the slurry or water which may then be added to the slurry. In some examples, the trehalose may include trehalose dehydrate or anhydrous trehalose in powder or crystalline form. In some examples, combining trehalose with the ground plant hulls and water to form a slurry (e.g., trehalose slurry) may include adding an amount of trehalose to the slurry effective to cause the slurry to have at least about 5 wt% trehalose therein, such as in a range from about 5 wt% to about 25 wt%, about 7 wt% to about 20 wt%, about 8.5 wt% to about 15 wt%, about 5 wt% to about 10 wt%, about 8.5 wt% to about 10 wt%, about 10 wt% to about 15 wt%, about 10 wt% to about 20 wt%, about 5 wt% to about 15 wt%, about 8.58 wt%, less than about 30 wt%, more than about 8.5 wt%, more than about 10 wt%, or more than about 15 wt% trehalose therein. In some examples, the slurry may have less than about 5 wt% trehalose or more than about 20 wt% trehalose.

[022] In some examples, combining trehalose with the ground plant hulls and water to form a slurry may include adding an amount of trehalose to the slurry effective to cause the slurry (e.g., trehalose slurry) to have at least about 30 wt% solids content, such as in a range from about 30 wt% to about 50 wt%, about 33 wt% to about 45 wt%, about 30 wt% to about 40 wt%, about 30 wt% to about 35 wt%, about 35 wt% to about 40 wt%, about 40 wt% to about 45 wt%, about 45 wt% to about 50 wt%, about 30 wt% to about 33 wt%, about 32 wt% to about 35 wt%, about 35 wt% to about 38 wt%, at least about 33 wt%, at least about 35 wt%, at least about 40 wt%, or at least about 50 wt% total solids content. In some examples, combining trehalose with the ground plant hulls and water to form a slurry may include adding an amount of trehalose to the slurry effective to cause the slurry (e.g., trehalose slurry) to have less than about 30 wt% solids content, such as in a range of about 15 wt% and about 30 wt%, about 15 wt% to about 20 wt%, about 20 wt% to about 25 wt%, about 25 wt% to about 30 wt%, or less than about 25 wt%. In examples, combining trehalose with the ground plant hulls and water to form a slurry may include combining trehalose with the ground plant hulls and water in a ratio of ground plant hulls to trehalose (by weight) of about 5:1 or more (with the remainder including water), such as in a range of about 5:1 to about 5:3, about 5:1 to about 5:1.5, about 5:1.5 to about 5:2, about 5:2 to about 5:2.5, about 5:2.5 to about 5:3, about 5:1 to about 5:2, or about 5:1 to about 5:2.

[023] Combining trehalose with the ground plant hulls and water (e.g., pre-slurry) to form a slurry may include agitating one or both of the slurry (e.g., trehalose, water, and ground plant hulls) or hydrocolloid slurry, such as via stirring, mixing, tumbling, sonic agitation, ultrasonic agitation, etc. The slurry may include a solution, dispersion, or suspension of trehalose in the slurry. For example, combining trehalose with the ground plant hulls and water to form a slurry may include forming a substantially homogenous dispersion of trehalose in the slurry.

[024] Block 130 recites, "adjusting a pH of the slurry to a range from about 7.0 to about 7.5." Adjusting the pH of the slurry (e.g., trehalose slurry) to a range from about 7.0 to about 7.5 may include adding an alkali or alkali solution to the slurry. The alkali may include sodium hydroxide, potassium hydroxide, calcium hydroxide, or any other alkali salt. Adjusting the pH of the slurry to a range from about 7.0 to about 7.5 provides minimal alkalization of the slurry and ground plant hulls therein. Often, ground plant hull slurries (both with or without trehalose) have a pH of less than 7, such as about 5 to about 7, about 6 to about 7, or about 6.5 to about 7. The minimal alkalization allows for the formation of trehalose infused plant hulls and slurries thereof without neutralization and washing the slurry after alkalization. Such minimal alkalization provides for reduced water consumption

and a reduction in production steps for producing a ground plant hull slurry. In some examples, adjusting a pH of the slurry to a range from about 7.0 to about 7.5 may include adding an alkali to the slurry. For example, adjusting the pH of the slurry to a range from about 7.0 to about 7.5 may include adding the alkali to the slurry effective to cause the pH of the slurry to be in the range from about 7.0 to about 7.5, such as about 7.1 to about 7.5, about 7.0 to about 7.3, about 7.1 to about 7.3, about 7.2 to about 7.4, or about 7.3 to about 7.5.

[025] In some examples, adding the alkali to the slurry may include adding an alkali solid (e.g., salt) or alkali solution to the slurry. For example, adding the alkali to the slurry may include adding sodium hydroxide or a sodium hydroxide solution to the slurry. In some examples, adjusting the pH of the slurry to the range from about 7.0 to about 7.5 may include dissolving the alkali in the slurry in an amount effective to adjust the slurry to have the pH in the range from about 7 to about 7.5. For example, adjusting the pH of the slurry to the range from about 7.0 to about 7.5 may include adding (e.g., dissolving) sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in the range from about 7 to about 7.5 or any of the ranges of pH disclosed herein (e.g., about 7.3 to about 7.5).

[026] The minimal alkalization of the slurry disclosed herein allows for the partial breakdown of the microstructure of the ground plant hulls while providing a pH sufficient enough or similar to allow use of the slurry without neutralization and washing.

[027] Block 140 recites, "heating the slurry to a selected temperature for a first duration under agitation." In some examples, heating the slurry (e.g., trehalose slurry) to a selected temperature for a first duration under agitation may include heating the slurry to the selected temperature over at least a portion of the first duration, such as by ramping up to the selected temperature over a portion of the first duration. In some examples, heating the slurry to a selected temperature for a first duration under agitation may include maintaining the slurry at the selected temperature for at least a portion of the first duration. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry to a temperature of at least about 160 °F, such as in a range from about 160 °F to about 190 °F, about 175 °F to about 200 °F, at least about 175 °F, or at least about 190 °F.

[028] In some examples, the first duration may be at least 10 minutes such as in a range from about 10 minutes to about 10 hours, about 10 minutes to about 30 minutes, about 15 minutes to about 60 minutes, about 30 minutes to about 60 minutes, about 15 minutes to about 30 minutes, about 20 minutes to about 40 minutes, about 40 minutes to about 2 hours, less than about 10 hours, less than about 5 hours, less than about 2 hours, less than about 1 hour, or less than about 30 minutes. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include agitating the slurry by one or more of stirring, mixing, tumbling, sonic agitation, ultrasonic agitation (e.g., ultrasonication), or any other means of agitation. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include applying constant agitation to the slurry or periodic agitation to the slurry.

[029] In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry for at least about 10 minutes under constant agitation. For example, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry to at least about 175 °F for at least about 15 minutes under constant ultrasonic agitation. In some examples, agitating the slurry may alternatively or additionally be performed after block 140. For example, agitating the slurry may be performed after heating the slurry for the first duration, where agitating the slurry may be carried out for a second duration and where the second duration is similar or identical to any of the first durations disclosed herein.

[030] Throughout blocks 130 and 140, the ground plant hulls may at least partially break down and the trehalose may infuse into the at least partially broken down plant hulls. For example, the trehalose may form a gel which at least partially coats the ground and at least partially broken down plant hulls.

[031] FIGS. 2A-2C are schematics of an example ground plant hull at various points during the example method 100. FIG. 2A is a schematic of a ground plant hull 200 prior to blocks 120, 130, and 140. The ground plant hull 200 may be lignocellulose. The ground plant hull

200 may include lignin 202 which retains cellulose 204 and hemicellulose 206 therein. The cellulose 204 may be arranged within the lignin 202 framework in a substantially parallel configuration. The hemicellulose 206 may be arranged in randomly oriented structures which span between and around the cellulose 204 within the lignin 202. Upon exposure to one or more of shear forces (e.g., from agitation) and chemical solvents (e.g., alkali), the ground plant hull 200 may at least partially break down. For example, one or more portions of the ground plant hull 200 may dissociate, decompose, exhibit surface roughness, fracture, etc.

[032] FIG. 2B is a schematic of the ground plant hull of FIG. 2A after the ground plant hull 200 has been at least partially broken down. As shown, one or more of the alkali treatment, heat, or shear forces introduced during blocks 130 and 140 may result in at least partial break down of the ground plant hull. The broken down ground plant hull 200b may include breaks and discontinuities in one or more of the lignin 202, cellulose 204, and hemicellulose 206. For example, the lignin 202 may be at least partially broken down to expose surfaces of one or both of the cellulose 204 and hemicellulose 206. The cellulose 204 may partially break down, thereby creating discontinuities therein. The hemicellulose 206 may at least partially break down to release or expose the cellulose 204. The blocks 130 and 140 may serve to roughen the ground plant hulls and increase the surface area or porosity thereof. One or more of the hemicellulose 206 and lignin 202 may serve to at least partially maintain the bulk structure of the ground plant hull 200b. Accordingly, the ground plant hull 200b will not dissolve or disintegrate, but rather may include pores and roughened surfaces thereon.

[033] As the ground plant hull breaks down, trehalose may infuse into or onto the ground plant hull. FIG. 2C is a schematic of the ground plant hull of FIG. 2A after the ground plant hull has been at least partially broken down and trehalose infused therein. For example, the trehalose infused ground plant hull 200c may include trehalose 208 infused therein. The trehalose 208 may be infused in one or more of the lignin 202, the cellulose 204, or the hemicellulose 206. In some examples, the trehalose 208 may be present in the slurry (e.g., trehalose slurry) in any of the amounts disclosed herein. One or more of the hemicellulose 206 and lignin 204 may serve to at least partially maintain the bulk structure of the ground

plant hull 200c. According, the trehalose infused ground plant hull 200c may be a single particle. The slurries disclosed herein may include a plurality of ground plant hulls such as any of ground plant hulls 200, 200b, or 200c (or hydrocolloid infused ground plant hulls as shown in FIGS. 4A-4D).

[034] Returning to FIG. 1, the slurry (e.g., trehalose slurry) resulting from blocks 110-140 has a total solids content of at least about 30 wt%, such as any of the total solids content values disclosed herein for the slurry. In some examples, the ground plant hulls may be at least about 20 wt% of the slurry, such as in a range from about 20 wt% to about 40 wt%, about 22 wt% to about 35 wt%, about 20 wt% to about 25 wt%, about 25 wt% to about 30 wt%, about 20 wt% to about 30 wt%, about 25 wt% to about 35 wt%, about 30 wt% to about 40 wt%, more than about 22 wt%, more than about 25 wt%, or more than about 30 wt% of the slurry. In some examples, the trehalose may be at least about 5 wt% of the slurry, such at least about 8.5 wt% of the slurry or any of the trehalose content values disclosed herein for the slurry.

[035] In some examples, the plurality of ground plant hulls is at least about 25 wt% of the slurry and the trehalose is at least about 8.5 wt% of the slurry. In some examples, the plurality of ground plant hulls is at least about 20 wt% of the slurry and the trehalose is at least about 10 wt% of the slurry. In some examples, the plurality of ground plant hulls is at least about 25 wt% of the slurry and the trehalose is at least about 5 wt% of the slurry. In some examples, the plurality of ground plant hulls is at least about 25 wt% of the slurry and the trehalose is at least about 10 wt% of the slurry. In some examples, the plurality of ground plant hulls is at least about 20 wt% of the slurry and the trehalose is at least about 15 wt% of the slurry. In some examples, the ratio of ground plant hulls to trehalose in the slurry may be about 5:1 to about 5:3. In some examples, the total solids content of the slurry may be less than about 25 wt% and the ratio of ground plant hulls to trehalose in the slurry is about 5:1 to about 5:3.

[036] In some examples, the pH of the slurry (e.g., trehalose slurry) may be in a range from about 7.0 to about 7.5, such as any of the ranges of pH disclosed herein. In some examples, the slurry may have a total solids content of at least about 30 wt%, the ground plant hulls may be at least about 20 wt% of the slurry, the trehalose may be at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

[037] In some examples, the slurries (e.g., trehalose slurries) disclosed herein may have a viscosity of at least about 30,000 centipoise, such as in a range from about 30,000 centipoise to about 40,000 centipoise, about 40,000 centipoise to about 50,000 centipoise, about 30,000 centipoise to about 60,000 centipoise, at least about 35,000 centipoise, at least about 40,000 centipoise, at least about 45,000 centipoise, or at least about 50,000 centipoise. Generally, as viscosity increases, the flow rate or pumpability of a material decreases. The trehalose slurries disclosed herein are pumpable at viscosities where conventional plant hulls slurries are not pumpable. The trehalose slurries formed by the example methods disclosed herein may be pumpable where conventional ground plant hull slurries (e.g., oat hull slurries) are not pumpable, such as at a total solids contents of about 30 wt% or higher. The inventors believe that the flowability and pumpability of the ground plant hull compositions disclosed herein may be due to the amount of trehalose in combination with the amount and average particle size (e.g., 44 μm or less) of ground plant hulls (each as a total wt% of the slurry). For example, the inventor currently believes that dissolved trehalose in the range of at least about 8.5 wt% (e.g., 8.58 wt% to about 10 wt%) of the slurry alters a generally viscous and unpumpable ground plant hull slurry to be pumpable. The inventor currently believes this pumpability (e.g., flowability) is due to trehalose entering a liquid gel state at least the wt% of trehalose and total solids content of the slurries disclosed herein. For example, it is currently believed that as the trehalose content of the slurry approaches about 8.5 wt% trehalose (e.g., a 5:1.7 ratio of ground oat hulls to trehalose) enough plant hull particles are coated with a liquid trehalose gel coating (which increases the viscosity of the slurry, but decreases the shear amongst moving plant hull particles in the slurry such as when pumped or flowed) that the slurry can be pumped where the viscosity would normally prevent pumping without the presence of the trehalose. This liquid gel behavior can be observed in desert plants and bacteria; water, bound by trehalose, may form a liquid gel in the protoplasm, coating the nucleus, mitochondria, and other essential cellular organs. Even smoother appearance and higher pumpability (e.g., flowability) is observed at higher

trehalose contents such as 10 wt% or more. Accordingly, the slurries (e.g., trehalose infused slurries) disclosed herein have a smoother appearance and better flowability (e.g., pumpability) than plant hull slurries that do not have the trehalose contents disclosed herein. As demonstrated in the working examples disclosed below, the trehalose infused slurries disclosed herein exhibit Newtonian characteristics in a linear fashion based on the amount of trehalose therein. Typically, ground plant hull slurries are non-Newtonian fluids, which exhibit a constant viscosity at a constant shear rate and decreasing viscosity as a shear rate increases. The trehalose slurries disclosed herein exhibit pseudo-Newtonian characteristics as the trehalose content approaches and exceeds about 8.5 wt% (e.g., 8.58 wt% at a 5:1.7 ratio of ground oat hulls to trehalose) and exhibit Newtonian characteristics as the trehalose content increases. The Newtonian state is especially visible at trehalose contents of about 10 wt% (e.g., a 5:2 ratio of ground oat hulls to trehalose) and greater. For example, as the trehalose content in the slurry approaches 10 wt%, the slurry exhibits an increase in viscosity but no negative change in apparent flow rate. Rather, the flow rate of the slurry increases as demonstrated by the pumpability of the slurries disclosed herein. Accordingly, the slurries (trehalose slurries and hydrocolloid slurries that contain trehalose) disclosed herein are unexpectedly pumpable when conventional ground plant hull slurries that have a similar total solids content are not pumpable. In some examples, the method 100 may include pumping the slurry.

[038] In some examples, the slurry can be further processed to form a different slurry, a powder, or a powder mixture. The example method 100 may include adding a hydrocolloid material to the slurry (e.g., trehalose slurry) to form a hydrocolloid slurry (e.g., hydrocolloid and trehalose-containing slurry). For example, the hydrocolloid material may include guar gum, such as in a powder or partially dissolved form. Adding a hydrocolloid material to the slurry to form a hydrocolloid slurry may include adding the hydrocolloid material in solid form or in a solution (e.g., dissolved guar gum). In some examples, adding the hydrocolloid material to the slurry may include adding guar gum to the slurry while heating and agitating the slurry for at least about 5 minutes. In some examples, adding the hydrocolloid material to the slurry may include dissolving guar gum in the slurry while heating the slurry to or

maintaining the slurry at a temperature of at least about 160 °F, such as at least about 175 °F. For example, adding the hydrocolloid material to the slurry may include dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 175 °F and constantly agitating the slurry for at least about 5 minutes.

[039] In some examples, the method 100 may further include exposing the hydrocolloid slurry to ultrasonic agitation to form a hydrocolloid infused slurry. In some examples, exposing the hydrocolloid slurry to ultrasonic agitation to form a hydrocolloid infused slurry may include exposing the hydrocolloid slurry to ultrasonic agitation for a selected duration. In some examples, the selected duration may be at least 5 minutes, such as in a range from about 5 minutes to about 10 hours, about 10 minutes to about 5 hours, about 15 minutes to about 60 minutes, about 5 minutes to about 20 minutes, about 15 minutes to about 30 minutes, about 20 minutes to about 40 minutes, about 40 minutes to about 60 minutes, at least about 10 minutes, or at least about 15 minutes. For example, exposing the hydrocolloid slurry to ultrasonic agitation may include exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes while maintaining the temperature of the hydrocolloid slurry at least about 175 °F. The hydrocolloid material may be infused in the trehalose infused ground plant hulls after exposing the hydrocolloid slurry to ultrasonic agitation.

[040] In some examples, the method 100 may further include cooling the hydrocolloid infused slurry to below the selected temperature. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to room temperature or below. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to a temperature in a range from above the freezing point of water to about 45 °F. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to a temperature below about 45 °F.

[041] In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include removing the hydrocolloid infused slurry from a heat source. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature

may include one or more of blowing a fluid (e.g., air) across the hydrocolloid infused slurry, placing the hydrocolloid infused slurry in a refrigerated environment, or placing the hydrocolloid infused slurry in an open air environment.

[042] The hydrocolloid infused slurry may include any of the viscosities of the slurries disclosed herein, such as in any of the ranges disclosed herein. However, the hydrocolloid material may increase the viscosity of the slurry and decrease the flowability of the hydrocolloid slurry (as compared to a solely trehalose infused slurry). Accordingly, in some examples, the hydrocolloid infused slurry may have a lower total solids content than the solely trehalose slurries disclosed herein to allow pumpability, such as about a 5 wt% or more lower total solids content or about a 5 wt% to about 10 wt% lower total solids content than the solely trehalose infused slurry. In such examples, the lower total solids content may be solely due to using fewer ground plant hulls (e.g., 5 wt% less to about 10 wt% less) than the trehalose infused ground plant hull compositions disclosed above. In some examples, the method 100 may include pumping the hydrocolloid infused slurry. In some examples, the method 100 may include at least partially filling an aseptic packaging with one or more of the slurry or the hydrocolloid infused slurry.

[043] In some examples, the method 100 may include drying the slurry. In some examples, the method 100 may include drying the slurry (e.g., trehalose slurry or hydrocolloid infused slurry) via one or more of drum drying, flash drying, freeze drying, pulse drying, or spray drying. In some examples, the method 100 may include drying the hydrocolloid infused slurry. In some examples, the method 100 may include drying the hydrocolloid infused slurry via one or more of drum drying, flash drying, freeze drying, pulse drying, or spray drying. Hydrocolloid infused slurries (or trehalose infused slurries) that have at least 20 wt% total solids content, and more particularly a 25 wt% to 35 wt% or 30 wt% to 35 wt% total solids content may be particularly suitable for spray drying or drum drying. In some examples, the method 100 may include drying the hydrocolloid infused slurry to form a hydrocolloid infused (ground plant hull) powder. In some examples, drying the slurry or the hydrocolloid slurry may include drying the slurry effective form one or more of trehalose infused plant hull powder, hydrocolloid infused ground plant hull powder, or trehalose and hydrocolloid infused ground plant hull powder. In some examples, the method 100 may include at least partially filling an aseptic packaging with one or more of trehalose infused plant hull powder, hydrocolloid infused ground plant hull powder, or trehalose and hydrocolloid infused ground plant hull powder.

[044] FIG. 2D is a schematic illustration of a slurry 220 of ground plant hulls 200d, arranged in accordance with at least some embodiments described herein. FIG. 2D shows the slurry 220. The slurry 220 includes water 222, ground plant hulls 200d, and trehalose infused into the ground plant hulls 200d. The slurry 220 may have a total solids content of at least about 30 wt%; ground plant hulls may be at least about 20 wt% of the slurry; trehalose may be at least about 5 wt% of the slurry; and the pH of the slurry is in a range from about 7.0 to about 7.5. The various components described in FIGS. 2A-2D are merely examples, and other variations, including eliminating components, combining components, and substituting components are all contemplated.

[045] The ground plant hulls 200d may be identical to the trehalose infused ground plant hull 200c illustrated in FIG. 2C, in one or more aspects. For example, the ground plant hulls 200d may include trehalose (additive particles 208) infused therein. In some examples, the ground plant hulls 200d can include any of the ground plant hulls disclosed herein. For example, the ground plant hulls 200d may be ground oat hulls. In some examples, the ground plant hulls 200d may have any of the average ground plant hull particle sizes disclosed herein (e.g., about 44 μm or less).

[046] The slurry 220 may have a total solids content of at least about 30 wt%, such as any of the total solids contents for any of the slurries disclosed herein. In some examples, the ground plant hulls may be at least about 20 wt% of the slurry, such as any of the ground plant hull weight percentages of any of the slurries disclosed herein. In some examples, the trehalose may be at least about 5 wt% of the slurry, such as any of the trehalose weight percentages of any of the slurries disclosed herein. In some examples, the pH of the slurry may be in a range from about 7.0 to about 7.5, such as any of the pH values for any of the slurries disclosed herein. For example, the slurry 220 may have a total solids content of at least about 30 wt%; ground plant hulls may be at least about 20 wt% of the slurry; trehalose

may be at least about 5 wt% of the slurry; and the pH of the slurry is in a range from about 7.0 to about 7.5. In some examples, the ground plant hulls may be at least about 25 wt% of the slurry 220 and the trehalose may be at least about 8 wt% of the slurry 220. In some examples, the ground plant hulls may be at least about 20 wt% of the slurry 220 and the trehalose may be at least about 10 wt% of the slurry 220. In some examples, the ground plant hulls may be at least about 25 wt% of the slurry 220 and the trehalose may be at least about 10 wt% of the slurry 220. In some examples, the ground plant hulls may be at least about 25 wt% of the slurry 220 and the trehalose may be at least about 5 wt% of the slurry 220. For example, the slurry 220 may comprise at least about 25 wt% ground oat hulls and at least about 5 wt% trehalose. The balance of the slurry may include one or more of water, dissolved alkali(s) (e.g., sodium from sodium hydroxide), or a hydrocolloid material.

[047] In some examples, the slurry 220 may exhibit a viscosity of at least 30,000 centipoise, such as any of the viscosities disclosed herein (e.g., at least 40,000 centipoise). The slurry 220 may be pumpable at viscosities of 30,000 centipoise or higher, such as at least 40,000 centipoise or at least 50,000 centipoise.

[048] In some examples, the slurry 220 may include any of the slurries or components thereof disclosed herein, such as a slurry or a hydrocolloid infused slurry (e.g., a trehalose and hydrocolloid infused slurry). In some examples, the slurry 220 may include at least some trehalose at least partially dissolved, suspended, or dispersed in the water 222, but not infused into the ground plant hulls 200d. For example, at least some trehalose may be free in the slurry as a solid that is not infused into the ground plant hulls 200d.

[049] In some examples, the slurry 220 may include a hydrocolloid material such as guar or guar gum may be infused therein. For example, guar or guar gum may be infused into the ground plant hulls 200d. In some examples, guar or guar gum may be at least partially dissolved in, suspended in, or dispersed in the slurry 220, such as in the water 222 of the slurry. In some examples, the hydrocolloid material (e.g., guar gum) may make up at least about 1 wt% slurry, such as in a range from about 1 wt% to about 50 wt%, about 1 wt% to about 25 wt%, about 25 wt% to about 50 wt%, about 1 wt% to about 10 wt%, about 10 wt% to about 20 wt%, about 20 wt% to about 30 wt%, about 30 wt% to about 40 wt%, about 40

wt% to about 50 wt%, about 10 wt% to about 30 wt%, at least about 5 wt%, at least about 10 wt%, at least about 20 wt%, at least about 30 wt%, at least about 35 wt%, about 1 wt% to about 5 wt%, about 5 wt% to about 10 wt%, about 10 wt% to about 15 wt%, about 15 wt% to about 20 wt%, less than about 50 wt%, less than about 30 wt%, less than about 20 wt%, less than about 10 wt%, or less than about 5 wt% of the slurry. In some examples, the slurry 220 may include at least some hydrocolloid material at least partially dissolved, suspended, or dispersed in the water 222, but not infused into the ground plant hulls 200d. For example, at least some hydrocolloid material (e.g., guar gum) may be free in the slurry as a solid that is not infused into the ground plant hulls 200d.

[050] In some examples, the method 100 may include adding or infusing one or more of an anti-fungal material, probiotic(s), stabilizers, flavorants, etc., into the ground plant particles (e.g., trehalose infused ground plant hull particles) or slurry. For example, a probiotic such as *Bifidobacteria* (e.g., *Bifidobacteria animalis, Bifidobacteria breve, Bifidobacteria lactis, Bifidobacteria longum, etc.*) or *Lactobacillus* (e.g., *Lactobacillus acidophilus, Lactobacillus reuteri, etc.*) may be infused or otherwise incorporated on the ground plant hulls or slurry.

[051] FIG. 3 is a flowchart illustrating an example method 300 to form a composition. An example method may include one or more operations, functions or actions as illustrated by one or more of blocks 310, 320, 330, 340, 350, or 360. The operations described in the blocks 310 through 360 may be performed in response to execution (such as by one or more processors described herein) of computer-executable instructions stored in a computer-readable medium, such as a computer-readable medium of a computing device or some other controller similarly configured.

[052] An example method may begin with block 310, which recites "forming a slurry of ground plant hulls." Block 310 may be followed by block 320, which recites "treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5." Block 320 may be followed by block 330, which recites "heating the slurry to a selected temperature for a first duration under agitation." Block 330 may be followed by block 340, which recites "adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry." Block 340 may be followed by block 350, which recites "exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry." Block 350 may be followed by block 360, which recites "cooling the hydrocolloid infused slurry to below the selected temperature."

[053] The blocks included in the described example methods are for illustration purposes. In some embodiments, the blocks may be performed in a different order. In some other embodiments, various blocks may be eliminated. In still other embodiments, various blocks may be divided into additional blocks, supplemented with other blocks, or combined together into fewer blocks. Other variations of these specific blocks are contemplated, including changes in the order of the blocks, changes in the content of the blocks being split or combined into other blocks, etc. In some examples, blocks 320 and 330 may be combined into one block wherein treating the slurry with the alkali to adjust the pH of the slurry to the range from about 7 to about 7.5 and heating the slurry to the selected temperature for the first duration under agitation are performed contemporaneously.

[054] Block 310 recites, "forming a slurry of ground plant hulls." In some examples, forming the slurry of ground plant hulls may include adding ground plant hulls to water to form the slurry. In some examples, adding ground plant hulls to water to form the slurry may be similar or identical to block 110 in one or more aspects. For example, forming a slurry may include adding ground oat hulls to water. In some examples, the ground plant hulls may include one or more of ground oat hulls, ground nut hulls (e.g., coconut hulls), plant seed hulls, etc. The ground plant hulls may include cellulosic fibers, lignocellulosic fibers, or particles of any of the foregoing. In some examples, any plant matter may be used instead of or in addition to the ground plant hulls, such as chaff, bark, husks, leaves, stalks, wood, pulp, fruit, etc. In some examples, forming a slurry of ground plant hulls may include adding (e.g., dispersing, suspending) ground, trehalose-infused oat hulls to water. In some examples, the ground plant hulls may have any of the average particle sizes disclosed herein.

[055] In some examples, forming a slurry of ground plant hulls may include forming the slurry with a total solids content of at least about 20 wt% (e.g., 20 wt% of the slurry is ground

plant hulls), such as at least about 25 wt%, at least about 30 wt%, or at least about 35 wt%, or in a range from about 20 wt% to about 35 wt% of the slurry. In some examples, the total solids content of the slurry may be less than about 20 wt%, such as about 10 wt% to about 20 wt% or about 15 wt% to about 20 wt%. In some examples, forming a slurry of ground plant hulls may include adding ground plant hulls to water in a ratio of ground plant hulls to water of at least about 1:99 by weight, such as about 1:99 to about 1:2, about 1:9 to about 1:3, about 1:6 to about 1:2, or a ratio of ground plant hulls to water of less than about 1:2 by weight.

[056] In some examples, forming the slurry of ground plant hulls may include dispersing the ground plant hulls in water that has a temperature of at least about 33 °F, such as at least about 50 °F, at least about 72 °F, at least about 100 °F, at least about 150 °F, at least about 160 °F, at least about 175 °F, at least about 190 °F, less than about 250 °F, less than about 200 °F, less than about 160 °F, in a range from about 33 °F to about 210 °F, about 50 °F to about 190 °F, about 100 °F to about 200 °F, or about 150 °F to about 190 °F.

[057] Block 320 recites, "treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5." Treating the slurry with an alkali may include adding an alkali or an alkali solution to the slurry. The alkali may include sodium hydroxide, potassium hydroxide, calcium hydroxide, or any other alkali salt. In some examples, treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5 may be similar or identical to block 130 "adjusting the pH of the slurry to a range from about 7.0 to about 7.5" disclosed herein, in one or more aspects.

[058] In some examples, treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5 provides minimal alkalization of the slurry and ground plant hulls therein. The minimal alkalization allows for formation of additive infused ground plant hulls (e.g., trehalose and/or guar gum infused ground plant hulls) and slurries thereof without neutralization and washing the slurry after alkalization. In some examples, treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5 may include adding the alkali to the slurry (e.g., trehalose infused oat hull slurry) effective to cause the pH of the slurry to be in the range from about 7.0 to about 7.5, such as about 7.1

to about 7.5, about 7.0 to about 7.3, about 7.1 to about 7.3, about 7.2 to about 7.4, or about 7.3 to about 7.5. In some examples, treating the slurry with the alkali may include adding sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in the range from about 7 to about 7.5 such as about 7.3 to about 7.5. In some examples, treating the slurry with the alkali may include adding an alkali solution to the slurry or dissolving the alkali in the slurry in an amount effective to adjust the slurry to have the pH in a range from about 7 to about 7.5.

[059] The minimal alkalization of the slurry disclosed herein allows for the partial breakdown of the microstructure of the ground plant hulls while providing a pH sufficient enough (e.g., neutral enough) or similar to allow use of the slurry, such as in ingestible applications (e.g., nutraceutical, food, or beverages) without neutralization and washing.

[060] Block 330 recites, "heating the slurry to a selected temperature for a first duration under agitation." In some examples, heating the slurry to a selected temperature for a first duration under agitation may include heating the slurry to a temperature of at least about 160 °F. In some examples, heating the slurry (e.g., trehalose slurry of ground plant hulls and trehalose) to the selected temperature for the first duration under agitation may include heating the slurry to a temperature of at least about 160 °F, such as in a range from about 160 °F to about 190 °F, about 175 °F to about 200 °F, about 175 °F to about 190 °F, at least about 175 °F, or at least about 190 °F.

[061] In some examples, heating the slurry to a selected temperature for a first duration under agitation may include heating the slurry to the selected temperature over at least a portion of the first duration, such as by ramping up to the selected temperature over at least a portion of the first duration. In some examples, heating the slurry to a selected temperature for a first duration under agitation may include maintaining the slurry at the selected temperature for at least a portion of the first duration.

[062] In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry for at least about 10 minutes under constant agitation. In some examples, the first duration may be at least 10 minutes such as in a range from about 10 minutes to about 10 hours, about 10 minutes to about 30 minutes, about 15 minutes to about 60 minutes, about 30 minutes to about 60 minutes, about 15 minutes to about 30 minutes, about 20 minutes to about 40 minutes, about 40 minutes to about 2 hours, less than about 10 hours, less than about 5 hours, less than about 2 hours, less than about 1 hour, or less than about 30 minutes. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include agitating the slurry by one or more of stirring, mixing, tumbling, sonic agitation, ultrasonic agitation (e.g., ultrasonication), or any other means of agitation. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include applying constant agitation to the slurry or periodic agitation to the slurry.

[063] In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry under constant agitation for at least about 10 minutes. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating the slurry to at least about 175 °F for at least about 15 minutes under constant agitation. In some examples, heating the slurry to the selected temperature for the first duration under agitation may include heating a ground oat hull slurry (e.g., ground trehalose infused oat hull slurry) to at least about 175 °F for at least about 15 minutes under constant agitation.

[064] In some examples, heating the slurry to the selected temperature for the first duration under agitation may include evaporating at least some water from the slurry, such as to cause the slurry to have any of the total solids contents disclosed herein.

[065] FIGS. 4A-4C are schematics of an example ground plant hull at various points during the example method 300. FIG. 4A is a schematic of a ground plant hull 400 prior to blocks 320, 330, 340, 350, and 360. The ground plant hull 400 may be lignocellulose. The ground plant hull 400 may include lignin 202 that retains cellulose 204 and hemicellulose 206 therein. The cellulose 204 may be arranged within the lignin 202 framework in a substantially parallel configuration. The hemicellulose 206 may be arranged in randomly oriented structures which span between and around the cellulose 204 within the lignin 202. Upon exposure to one or more of shear forces (e.g., from agitation), heat, and chemical solvents (e.g., alkali), the ground plant hull 400 may at least partially break down. For example, one or more portions of the ground plant hull 400 may dissociate, decompose, exhibit surface roughness, fracture, etc.

[066] FIG. 4B is a schematic of the ground plant hull of FIG. 4A after the ground plant hull 400 has been at least partially broken down. As shown, one or more of the alkali treatment, heat, or shear forces introduced during blocks 320 and 330 may result in at least partial break down of the ground plant hull. The broken down ground plant hull 400b may include breaks and discontinuities in one or more of the lignin 202, cellulose 204, and hemicellulose 206 as disclosed above with respect to FIGS. 2A-2C. For example, the lignin 202 may be at least partially broken down to expose surfaces of one or both of the cellulose 204 and hemicellulose 206. One or more of the hemicellulose 206 and lignin 202 may serve to at least partially maintain the bulk structure of the ground plant hull 400b. As the ground plant hull breaks down 400, hydrocolloid material may infuse into or onto the ground plant hull 400b.

[067] Returning to FIG. 3, block 340 recites "adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry." In some examples, adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry may include adding a selected amount of hydrocolloid material to the slurry. The hydrocolloid material may include a hydrocolloid gum, such a guar gum may be added to the slurry to form the hydrocolloid slurry. The hydrocolloid material may include one or more of guar gum, locust bean gum, gum Arabic, gum karaya, gum tragacanth, acacia gum, starch, xanthan gum, or any other hydrocolloid. In some examples, the hydrocolloid material may be in solution, dispersion, suspension, or a powder. In some examples, adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry may include adding the hydrocolloid material in one or more of solution, dispersion, suspension, or a powder to the slurry. In some examples, the hydrocolloid material may include at least one or more of hydrocolloid material powder or prehydrated hydrocolloid material. For example, adding the hydrocolloid material to the slurry comprises adding guar gum to the slurry, such as in one or more of a guar gum powder or a prehydrated guar gum.

For example, the hydrocolloid material may include a guar gum composition of about 25% of a hydrated guar gum and about 75% guar gum powder. In some examples, the hydrocolloid material may include at least 10 wt% (e.g., at least 10 wt%, 20 wt%, 25 wt%, 30 wt%, or 50 wt%), of a hydrocolloid gum powder and at least 10 wt% (e.g., at least 10 wt%, 20 wt%, 25 wt%, 30 wt%, or 50 wt%) of a prehydrated hydrocolloid gum.

[068] In some examples, adding the hydrocolloid material to the slurry comprises adding the hydrocolloid material to the slurry in an amount effective to cause the hydrocolloid slurry to have a ratio of hydrocolloid material to slurry of at least about 1:99 (e.g., by weight), such as about 1:99 to about 1:2, about 1:9 to about 1:3, about 1:6 to about 1:2, 1:99 to about 1:9, or a ratio of hydrocolloid material to slurry of less than about 1:2. For example, adding the hydrocolloid material to the slurry comprises adding the hydrocolloid material (e.g., guar gum) to the slurry in an amount effective to cause the hydrocolloid slurry to have a ratio of hydrocolloid material to slurry in a range from about 1:99 to about 1:9.

[069] In some examples, adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry may include heating the slurry (e.g., trehalose slurry) to at least one intermediate temperature. The at least one intermediate temperature may be at least about 160 °F, such as in a range from about 160 °F to about 190 °F, about 175 °F to about 200 °F, about 175 °F to about 190 °F, at least about 175 °F, or at least about 190 °F. In some examples, the at least one intermediate temperature may include 2 or more intermediate temperatures, such as 3, 4, 5, 6 or more intermediate temperatures.

[070] In some examples, adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry may include one or both of heating or agitating the slurry or hydrocolloid slurry for the second duration. In some examples, the second duration may be at least 5 minutes such as in a range from about 10 minutes to about 10 hours, about 10 minutes to about 30 minutes, about 15 minutes to about 60 minutes, about 30 minutes to about 60 minutes, about 15 minutes to about 30 minutes, about 20 minutes to about 40 minutes, about 40 minutes to about 2 hours, less than about 10 hours, less than about 5 hours, less than about 2 hours, less than about 1 hour, or less than about 30 minutes. For example, adding the hydrocolloid material to the slurry may include adding guar gum to the slurry while heating and constantly agitating the slurry for at least about 5 minutes.

[071] In some examples, adding the hydrocolloid material to the slurry may include one or more of dissolving, suspending, or dispersing guar gum in the slurry while maintaining the slurry at a temperature of at least about 160 °F. For example, adding the hydrocolloid material to the slurry may include dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 175 °F and constantly agitating the slurry for at least about 5 minutes.

[072] The hydrocolloid slurry may include ground plant hulls and the hydrocolloid material both in water. In some examples, the hydrocolloid slurry may include an alkali dissolved, suspended, or dispersed therein. In some examples, the hydrocolloid slurry may include hydrocolloid material on ground plant hulls, such as any of the ground plant hulls disclosed herein (e.g., trehalose infused ground plant hulls). For example, the hydrocolloid slurry may include guar gum and trehalose infused oat hulls in water.

[073] Block 350 recites "exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry." In some examples, exposing the hydrocolloid slurry to an ultrasonic agitation may include applying sonic agitation or ultrasonic agitation to the hydrocolloid slurry (ground plant hulls) such as in a container (e.g., tank, drum, beaker, etc.). In some examples, exposing the hydrocolloid slurry to ultrasonic agitation comprises exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes, such as at least 30 minutes. In some examples, exposing the hydrocolloid slurry to ultrasonic agitation comprises exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes while maintaining the temperature of the hydrocolloid slurry at a temperature of at least about 160 °F such as at least about 175 °F or at least about 185 °F.

[074] In some examples, the hydrocolloid infused slurry may have a total solids content of at least about 1 wt%, such as about 1 wt% to about 50 wt%, about 5 wt% to about 40 wt%, about 10 wt% to about 30 wt%, about 15 wt% to about 25 wt%, about 20 wt% to about 30

wt%, about 30 wt% to about 50 wt%, about 30 wt% to about 40 wt%, about 30 wt% to about 35 wt%, more than about 25 wt%, more than about 30 wt%, more than about 35 wt%, less than about 30 wt%, or less than about 25 wt%.

[075] In some examples, the hydrocolloid infused slurry may be at least 20 wt% ground plant hulls, such as in a range from about 20 wt% to about 40 wt%, about 22 wt% to about 35 wt%, about 20 wt% to about 25 wt%, about 25 wt% to about 30 wt%, about 20 wt% to about 30 wt%, about 25 wt% to about 35 wt%, about 30 wt% to about 40 wt%, more than about 22 wt%, more than about 25 wt%, or more than about 30 wt% ground plant hulls. The hydrocolloid infused slurry may include any of the viscosities of the slurries disclosed herein, such as in any of the ranges disclosed herein. However, the hydrocolloid material may increase the viscosity of the hydrocolloid infused slurry and decrease the flowability of the hydrocolloid slurry (as compared to a solely trehalose infused slurry). Accordingly, in some examples, the hydrocolloid infused slurry may have a lower total solids content than the solely trehalose slurries disclosed herein to allow pumpability, such as about a 5 wt% or more lower total solids content or about a 5 wt% to about 10 wt% lower total solids content than the solely trehalose infused slurry. In such examples, the lower total solids content may be solely due to using fewer ground plant hulls (e.g., 5 wt% less to about 10 wt% less) than the trehalose infused ground plant hull compositions disclosed above. For example, the hydrocolloid infused slurry may include less than about 20 wt% ground plant hulls.

[076] In some examples, the hydrocolloid infused slurry may include at least 1 wt% hydrocolloid material, such as in a range from about 1 wt% to about 50 wt%, about 1 wt% to about 25 wt%, about 25 wt% to about 50 wt%, about 1 wt% to about 10 wt%, about 10 wt% to about 20 wt%, about 20 wt% to about 30 wt%, about 30 wt% to about 40 wt%, about 40 wt% to about 50 wt%, about 10 wt% to about 30 wt%, at least about 5 wt%, at least about 10 wt%, at least about 20 wt%, at least about 30 wt%, at least about 35 wt%, about 1 wt% to about 5 wt%, about 5 wt% to about 10 wt%, about 10 wt% to about 15 wt%, about 15 wt% to about 20 wt%, less than about 50 wt%, less than about 30 wt%, less than about 20 wt%, less than about 10 wt%, or less than about 5 wt% hydrocolloid material. In some examples, the hydrocolloid infused slurry may include substantially only hydrocolloid material, ground plant hulls, water, and alkali (e.g., alkali metal ions from dissolved alkali). In some examples, the hydrocolloid infused slurry may be pumpable at 25 wt% or 30 wt% total solids content or more where conventional plant hull slurries that include hydrocolloid materials are not pumpable.

[077] In some examples, the hydrocolloid infused slurry may include hydrocolloid material, ground plant hulls, trehalose, water, and alkali. For example, a trehalose infused plant hull slurry may be infused with the hydrocolloid material (e.g., guar gum) to form the hydrocolloid infused slurry. In some examples, the trehalose content of a hydrocolloid (and trehalose) infused plant hull composition may be at least about 5 wt% of the hydrocolloid infused slurry, such as in a range from about 5 wt% to about 25 wt%, about 7 wt% to about 20 wt%, about 8.5 wt% to about 15 wt%, about 5 wt% to about 10 wt%, about 8.5 wt% to about 10 wt%, about 10 wt% to about 15 wt%, about 5 wt% to about 15 wt%, about 10 wt% to about 20 wt%, less than about 30 wt%, more than about 8.5 wt%, more than about 8.58 wt%, more than about 10 wt%, or more than about 15 wt% of the hydrocolloid infused slurry. In examples, the hydrocolloid infused slurry may include a ratio of ground plant hulls to trehalose (by weight) of about 5:1 or more (with the remainder including water), such as in a range of about 5:1 to about 5:3, about 5:1 to about 5:1.5, about 5:1.5 to about 5:2, about 5:2 to about 5:2.5, about 5:2.5 to about 5:3, about 5:1 to about 5:2, or about 5:1 to about 5:2. In some examples, the total solids content of the hydrocolloid infused slurry may be less than about 25 wt% and the ratio of ground plant hulls to trehalose in the slurry is about 5:1 to about 5:3. In some examples, any of values of the ratios disclosed above may be a ratio of ground plant hulls and hydrocolloid material to trehalose. In some examples, the hydrocolloid material and trehalose may be infused into the ground plant hulls substantially simultaneously. For example, adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry may include adding trehalose to the slurry, such as in any of the amounts disclosed herein.

[078] FIG. 4C is a schematic of the ground plant hull of FIG. 4A after the ground plant hull has been at least partially broken down and hydrocolloid material 409 infused therein. For example, the hydrocolloid infused ground plant hull 400c may include hydrocolloid material

409 infused therein. The hydrocolloid material 409 may be infused in one or more of the lignin 202, the cellulose 204, and the hemicellulose 206. In some examples, the hydrocolloid material 409 may be present in the hydrocolloid slurry or hydrocolloid infused slurry in any of the amounts disclosed herein. One or more of the hemicellulose 206 and lignin 202 may serve to at least partially maintain the bulk structure of the ground plant hull 400c. According, the hydrocolloid infused ground plant hull 400c may be a single (e.g., coherent) particle. The slurries disclosed herein may include a plurality of ground plant hulls such as any of ground plant hulls 400, 400b, or 400c (or hydrocolloid infused ground plant hulls as shown in FIG. 4D). At least some of the hydrocolloid material 409 may not be infused into the ground plant hulls. For example, the hydrocolloid material 409 may be freely dispersed or suspended in the hydrocolloid infused slurry.

[079] Returning to FIG. 3, block 360 recites "cooling the hydrocolloid infused slurry to below the selected temperature." In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to room temperature or below. For example, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to a temperature in a range between the selected temperature and above the freezing point of water. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid infused slurry to a temperature below about 45 °F. For example, cooling the hydrocolloid infused slurry to below the selected temperature may include cooling the hydrocolloid slurry to a temperature in a range from about 33 °F to about 45 °F.

[080] In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include removing the hydrocolloid infused slurry from a heat source. In some examples, cooling the hydrocolloid infused slurry to below the selected temperature may include one or more of blowing a fluid (e.g., air) across the hydrocolloid infused slurry, placing the hydrocolloid infused slurry in a refrigerated environment, or placing the hydrocolloid infused slurry in an open air environment.

[081] FIG. 4D is a schematic of the ground plant hull of FIG. 4A after the ground plant hull has been at least partially broken down and trehalose 208 and hydrocolloid material 409 is infused therein. For example, the trehalose and hydrocolloid infused ground plant hull 400d may include trehalose 208 and hydrocolloid material 409 infused therein. The trehalose 208 and hydrocolloid material 409 may be infused in one or more of the lignin 202, the cellulose 204, and the hemicellulose 206. In some examples, the trehalose 208 and hydrocolloid material 409 may be present in the hydrocolloid slurry or hydrocolloid infused slurry in any of the amounts disclosed herein. One or more of the hemicellulose 206 and lignin 202 may serve to at least partially maintain the bulk structure of the trehalose and hydrocolloid infused ground plant hull 400d. According, the trehalose and hydrocolloid infused ground plant hull 400d may be a single (e.g., coherent) particle. The slurries disclosed herein may include a plurality of ground plant hulls such as any of ground plant hulls 400, 400b, or 400c, or 400d.

[082] In some examples, the method 300 may include pumping the hydrocolloid infused slurry. In some examples, the method 300 may include at least partially filling an aseptic packaging with the hydrocolloid infused slurry.

[083] In some examples, the method 300 may include drying the hydrocolloid infused slurry (e.g., hydrocolloid and trehalose infused oat hull slurry). In some examples, the method 300 may include drying the hydrocolloid infused slurry via one or more of drum drying, flash drying, freeze drying, pulse drying, or spray drying. In some examples, drying the hydrocolloid infused slurry may include drying the slurry effective form one or more of hydrocolloid infused ground plant hull powder or trehalose and hydrocolloid infused ground plant hull powders. In some examples, the method 300 may include at least partially filling an aseptic packaging with the hydrocolloid infused slurry that has been dried. For example, the method 300 may include at least partially filling an aseptic packaging with one or more of trehalose infused plant hull powder, hydrocolloid infused ground plant hull powder, or trehalose and hydrocolloid infused ground plant hulls.

[084] In some examples, the method 300 may include adding the hydrocolloid infused slurry that has been dried to a trehalose infused ground plant hull powder to form a powder

mixture. In some examples, the method 300 may include providing the ground plant hulls, such as providing ground oat hulls or trehalose infused oat hulls. In some examples, the powder mixture may include at least some hydrocolloid material therein and at least some trehalose infused ground plant hulls therein. For example, the powder mixture may include a dry mixture of trehalose infused plant hulls and particles of a hydrocolloid material.

[085] FIG. 4E is a schematic illustration of a slurry 420 of ground plant hulls 400c or 400d, arranged in accordance with at least some embodiments described herein. FIG. 4E shows the slurry 420. The slurry 420 includes water 222, one or more of ground plant hulls 400c or 400d, and one or more of trehalose or hydrocolloid material infused into the ground plant hulls 400c or 400d.

[086] The slurry 420 may have a total solids content of at least about 30 wt%; ground plant hulls may be at least about 20 wt% of the slurry 420; hydrocolloid material may be at least about 5 wt% of the slurry 420; and the pH of the slurry 420 is in a range from about 7.0 to about 7.5. In some examples, trehalose may be at least about 5 wt% of the slurry. The slurry 420 may have a total solids content of up to about 30 wt% (e.g., about 20 wt% to about 30 wt%); ground plant hulls may be at least about 15 wt% of the slurry 420; hydrocolloid material may be at least about 1 wt% (e.g., at least 5 wt%) of the slurry 420; and the pH of the slurry 420 is in a range from about 7.0 to about 7.5. In some examples, trehalose may be at least about 5 wt% of the slurry (e.g., at least about 8.5 wt% of the slurry). The various components described in FIGS. 4A-4E are merely examples, and other variations, including eliminating components, combining components, and substituting components are all contemplated.

[087] In some examples, the ground plant hulls 400c or 400d can include any of the ground plant hulls disclosed herein. For example, the ground plant hulls 400c or 400d may be ground oat hulls. In some examples, the ground plant hulls 400c or 400d may have any of the average ground plant hull particle sizes disclosed herein.

[088] The slurry 420 may have a total solids content of at least about 20 wt% (e.g., at least about 30 wt%), such as any of the total solids content for any of the slurries disclosed herein. In some examples, the ground plant hulls may be at least about 15 wt% of the slurry 420, such as any of the ground plant hull weight percentages of any of the slurries disclosed herein. In some examples, the hydrocolloid material may be at least about 1 wt% of the slurry 420, such as any of the hydrocolloid material weight percentages of any of the slurries disclosed herein. For example, the hydrocolloid material (e.g., guar gum) may be at least 1 wt% of the slurry 420, such as in a range from about 1 wt% to about 50 wt%, about 1 wt% to about 25 wt%, about 25 wt% to about 50 wt%, about 1 wt% to about 10 wt%, about 10 wt% to about 20 wt%, about 20 wt% to about 30 wt%, about 30 wt% to about 40 wt%, about 40 wt% to about 50 wt%, about 10 wt% to about 30 wt%, about 5 wt% to about 15 wt%, at least about 5 wt%, at least about 10 wt%, at least about 20 wt%, at least about 30 wt%, at least about 35 wt%, about 1 wt% to about 5 wt%, about 5 wt% to about 10 wt%, about 5 wt% to about 30 wt%, about 10 wt% to about 15 wt%, about 15 wt% to about 20 wt%, less than about 50 wt%, less than about 30 wt%, less than about 20 wt%, less than about 10 wt%, or less than about 5 wt%.

[089] When present, the trehalose may be at least about 5 wt% of the slurry 420, such as any of the trehalose weight percentages of any of the slurries disclosed herein. In some examples, the amount of trehalose and the amount of hydrocolloid material in the slurry 420 may be substantially equal.

[090] In some examples, the pH of the slurry 420 may be in a range from about 7.0 to about 7.5, such as any of the pH values for any of the slurries disclosed herein. For example, the slurry 420 may have a total solids content of at least about 25 wt% or at least about 30 wt%; ground plant hulls may be at least about 20 wt% of the slurry 420; the hydrocolloid material may be at least about 1 wt% of the slurry; and the pH of the slurry is in a range from about 7.0 to about 7.5. In some examples, the ground plant hulls may be at least about 25 wt% of the slurry 420 and the hydrocolloid material may be at least about 8 wt% of the slurry 420. In some examples, the ground plant hulls may be at least about 20 wt% of the slurry 420 and the hydrocolloid material may be at least about 10 wt% of the slurry 420. In some examples, the ground plant hulls may be at least about 25 wt% of the slurry 420 and the hydrocolloid material may be at least about 10 wt% of the slurry 420. In some examples, the ground plant hulls may be at least about 20 wt% of the slurry 420, the hydrocolloid material may be at

least 1 wt% of the slurry 420, and the trehalose may be at least about 5 wt% of the slurry 420. For example, the slurry 420 may comprise at least about 20 wt% ground oat hulls, at least about 10 wt% hydrocolloid material, and at least about 10 wt% trehalose. The balance of the slurry 420 may include one or more of water or dissolved alkali(s) (e.g., sodium from sodium hydroxide).

[091] In some examples, the slurry 420 may exhibit a viscosity of at least 30,000 centipoise, such as any of the viscosities disclosed herein (e.g., at least 40,000 centipoise). The slurry 420 may be pumpable at viscosities of 30,000 centipoise or higher, such as 40,000 or at least 50,000 centipoise.

[092] In some examples, the slurry 420 may include any of the slurries or components thereof disclosed herein, such as a trehalose slurry or a hydrocolloid infused slurry (e.g., a trehalose and hydrocolloid infused slurry). In some examples, the slurry 420 may include one or more of hydrocolloid material or trehalose at least partially dissolved, suspended, or dispersed in the water 222, but not infused into the ground plant hulls 400c or 400d. For example, at least some hydrocolloid material or trehalose may be free in the slurry as a solid that is not infused into the ground plant hulls 400c or 400d.

[093] In some examples, a method to make a coated plant particle composition may include any of blocks 110-140 or 310-360, or any additional techniques disclosed herein. For example, a method to make a coated plant particle composition may include at least partially breaking down ground plant hulls in a slurry using an alkali in an amount effective to cause the slurry to have a pH in a range from about 7 to about 7.5; adding a hydrocolloid material to the slurry while heating the slurry to a selected temperature and agitating the slurry for a selected duration to form a hydrocolloid slurry without neutralizing or washing the slurry, wherein the hydrocolloid slurry comprises the hydrocolloid material and the ground plant hulls; exposing the hydrocolloid slurry to ultrasonic agitation to form hydrocolloid infused ground plant hulls in a hydrocolloid infused slurry; and cooling the hydrocolloid infused slurry to below the selected temperature. In some examples, at least partially breaking down ground plant hulls in the slurry using the alkali may include maintaining the slurry at a temperature in a range from about 160 °F to about 190 °F.

[094] The example methods disclosed herein may include drying the slurries disclosed herein into a powder via drying, such as by one or more of one or more of drum drying, flash drying, freeze drying, pulse drying, or spray drying.

[095] The example methods disclosed herein may be used to form ground plant hull containing materials, such as powder mixtures (e.g., nutraceuticals, food additives, supplements, etc.), foods, beverages, cosmetics, laxatives, lotions, shampoos, conditioners, soaps, etc. In some examples, the method 300 may include infusing one or more of an anti-fungal material, probiotic(s), flavorants, stabilizers, etc., into the ground plant particles (e.g., trehalose infused ground plant hull particles). For example, a probiotic such as *Bifidobacteria* (e.g., *Bifidobacteria animalis, Bifidobacteria breve, Bifidobacteria lactis, Bifidobacteria longum, etc.*) or *Lactobacillus* (e.g., *Lactobacillus acidophilus, Lactobacillus reuteri, etc.*) may be infused or otherwise incorporated on the ground plant hulls.

[096] FIG. 5 is a schematic illustrating an example method 500 to make a treated plant product. The treated plant product may be trehalose and/or hydrocolloid infused ground plant hulls, such as in a powder mixture. The example method 500 may include one or more operations, functions or actions as illustrated by one or more of blocks 510, 520, 530, or 540. The operations described in the blocks 510-540 may be performed in response to execution (such as by one or more processors described herein) of computer-executable instructions stored in a computer-readable medium, such as a computer-readable medium of a computing device or some other controller similarly configured.

[097] An example method may begin with block 510, which includes "forming a plurality of trehalose infused ground plant hulls." Block 510 may be followed by block 520, which includes "transporting the trehalose infused ground plant hulls to a blending location." Block 520 may be followed by block 530, which includes "dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture." Block 530 may be followed by block 540, which includes "packaging the dry mixture."

[098] The blocks included in the described example methods are for illustration purposes. In some embodiments, the blocks may be performed in a different order. In some other embodiments, various blocks may be eliminated. In still other embodiments, various blocks

may be divided into additional blocks, supplemented with other blocks, or combined together into fewer blocks. Other variations of these specific blocks are contemplated, including changes in the order of the blocks, changes in the content of the blocks being split or combined into other blocks, etc. In some examples, block 530 dries blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture, and block 540 "packaging the dry mixture" may be combined into a single block.

[099] Block 510 includes, "forming a plurality of trehalose infused ground plant hulls." In some examples, forming the plurality of trehalose infused ground plant hulls 515 may include forming any of the trehalose infused ground plant hulls disclosed herein, such as trehalose infused ground oat hulls. In some examples, forming the plurality of trehalose infused ground plant hulls 515 may include forming any of the trehalose slurries (e.g., trehalose infused slurries) disclosed herein, such as any of those disclosed in example methods 100 and 300. In some examples, any of the blocks 110-140, 310-360, or any other portions of example methods 100 or 300 may be performed at one or more locations such as in modules. For example, forming the plurality of trehalose infused ground plant hulls may include forming a slurry (e.g., of the trehalose infused ground plant hulls) at a first location and further processing the slurry to trehalose infused ground plant hulls in at least a second location. In some examples, the trehalose infused ground plant hulls may be dried at a different location than the first location.

[0100] In some examples, forming the plurality of trehalose infused ground plant hulls may include drying any of the trehalose slurries disclosed herein, such as to form the trehalose infused ground plant hulls 515. In some examples, the trehalose infused ground plant hulls 515 may be in slurry form or in powder form.

[0101] Block 520 includes, "transporting the trehalose infused ground plant hulls to a blending location." In some examples, transporting the trehalose infused ground plant hulls 515 to the blending location may include pumping the trehalose infused ground plant hulls 515, such as in a slurry, to the blending location. For example, pumping the trehalose infused ground plant hulls 515 in the slurry may include pumping a slurry that includes any of the slurries disclosed herein (e.g., trehalose slurry or hydrocolloid infused slurry), such as a slurry that has at least 25 wt% (e.g., at least 30 wt%) total solids content. For example, the slurry may include 30 wt% total solids content, at least 20 wt% ground plant hulls, at least 5 wt% trehalose (e.g., at least 8.58 wt%), and a pH of about 7.0 to about 7.5.

[0102] In some examples, transporting the trehalose infused ground plant hulls 515 to the blending location may include pumping the trehalose infused ground plant hulls 515 via a conduit to the blending location, such as to a different location (than the slurry production location) at a production plant. In some examples, transporting the trehalose infused ground plant hulls 515 to the blending location may include pumping the trehalose infused ground plant hulls 515 to a transportation vehicle such as a truck or trailer.

[0103] In some examples, the method 500 may include drying the slurry to form the trehalose infused ground plant hull powder 515. For example, transporting the trehalose infused ground plant hulls 515 to the blending location may include transporting the trehalose infused ground plant hulls 515 to the blending location in a slurry form and then drying the slurry to form the trehalose infused ground plant hull powder 515. In some examples, transporting the trehalose infused ground plant hulls 515 to the blending location may include transporting the trehalose infused ground plant hull powder 515 to the blending location.

[0104] Block 530 includes, "dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture." In some examples, dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form the dry mixture 335 may include mixing the trehalose infused ground plant hulls with the one or more of guar or guar gum (e.g., hydrocolloid material), such as via a mixer, (dry)blender, tumbler, etc. In some examples, dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form the dry mixture 335 may include blending the trehalose infused ground plant hulls 315 with guar gum infused ground plant particles 325 to form the dry mixture 335 that has trehalose infused ground plant hulls and guar gum infused ground plant particles.

[0105] In some examples, dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form the dry mixture may include forming a nutraceutical, food additive, supplement, food, beverage, laxative, cosmetic, lotion, shampoo, conditioner, soap, etc., blend of the dry mixture 535. In some examples, the dry mixture 535 may include at least about 30 wt% ground plant hulls, such as in a range from about 30 wt% to about 90 wt%, about 30 wt% to about 60 wt%, about 40 wt% to about 70 wt%, about 60 wt% to about 90 wt%, about 60 wt% to about 70 wt%, about 70 wt% to about 80 wt%, about 80 wt% to about 90 wt%, less than about 90 wt%, less than about 70 wt%, less than about 50 wt%, or less than about 30 wt% ground plant hulls. In some examples, the dry mixture 535 may include at least about 15 wt% trehalose, such as in a range from about 15 wt% to about 40 wt%, about 15 wt% to about 25 wt%, about 25 wt% to about 35 wt%, about 30 wt% to about 40 wt%, about 15 wt% to about 35 wt%, less than about 40 wt%, or less than about 30 wt% trehalose. In some examples, the dry mixture 535 may include at least about 5 wt% hydrocolloid material (e.g., guar or guar gum), such as in a range from about 5 wt% to about 40 wt%, about 5 wt% to about 20 wt%, about 20 wt% to about 40 wt%, about 10 wt% to about 20 wt%, about 20 wt% to about 40 wt%, less than about 40 wt%, less than about 30 wt%, or less than about 20 wt% hydrocolloid material. In some examples, the dry mixture may include one or more of an anti-fungal, probiotic(s), flavorant(s), stabilizer(s), or colorant(s) (e.g., dye).

[0106] In some examples, the guar gum may provide a digestible fiber where trehalose and trehalose infused oat hulls may not be as digestible as the guar gum. For example, a powder mixture may include some percentage of trehalose infused oat hull fibers (e.g., powder) that have been replaced by hydrocolloid material (e.g., guar gum) to make the dry mixture more digestible. For example, a 30 wt% trehalose infused oat hull fiber powder or solution may be replaced by a 15 wt% trehalose infused oat hull and 15 wt% guar gum infused oat hull fiber powder or solution to make the powder or solution more digestible than if only trehalose infused oat hulls here present. Such a powder mixture or solution containing the same may serve as a replacement or alternative for psyllium powder. In some examples, the guar gum may provide a digestible fiber where trehalose and trehalose infused oat hulls may not be as digestible as the guar gum. For example, a powder mixture may include some percentage of trehalose infused oat hull fibers (e.g., powder) that have been replaced by guar gum or guar gum infused oat hull fibers (e.g., powder) to make the dry mixture more digestible. In some examples, the dry mixture may include a ratio of trehalose to guar gum (e.g., wt:wt) of at least about 20:1, such as in a range from about 20:1 to about 1:1, about 20:1 to about 10:1, about 10:1 to about 5:1, 5:1 to about 1:1, about 3:1 to about 1:1, at least about 10:1, or at least about 3:1.

[0107] In some examples, the method 500 may include forming guar gum infused ground plant hulls (e.g., particles), such as via the example method 300. In some examples, the guar gum infused ground plant hull particles may be similar or identical to any of the hydrocolloid infused ground plant hulls disclosed herein (e.g., particle 400c or 400d). In some examples, forming the guar gum infused ground plant hulls may include any of the blocks 110-140, 310-360, or any other portions of example methods 100 or 300. The any of the blocks 110-140, 310-360, or any other portions of example methods 100 or 300 may be performed at one or more locations such as in modules. The products thereof may be transported to a different module.

[0108] Block 540 includes, "packaging the dry mixture." In some examples, packaging the dry mixture may include packaging the dry mixture 335 in package 547. In some examples, the package 547 may include a bag, box, bucket, tin, pouch, or any other type of package. In some examples, packaging the dry mixture may include may include packaging the dry mixture in individual serving size packages. In some examples, packaging the dry mixture may include sealing the dry mixture 335 in the package 547. For example, packaging the dry mixture 525 may include form fill sealing (e.g., vertical or horizontal) the dry mixture 335 in package 547. In some examples, packaging the dry mixture may include providing a label on the packaging, such as a contents label.

[0109] In some examples, any of the blocks disclosed herein may be performed automatically, responsive to instructions from a controller (e.g., computing device). For example, the example method 500 may be performed responsive to instructions from a controller. The controller may receive feedback from one or more sensors operably coupled thereto. For example, the controller may be operably coupled to one or more temperature probes, a time, or one or more pH meters. The controller may cause heating elements to heat the slurry to be the selected temperature and the timer may cause the heating elements to cease heating the slurry upon expiration of a selected duration. In some examples, the alkali may be added to the slurry automatically and may cease to be added once the pH meter detects that the pH of the slurry is at a selected amount or in a selected range.

[0110] FIG. 6 is a block diagram illustrating an example computing device 600 that is arranged for forming compositions in accordance with the present disclosure. In a very basic configuration 601, computing device 600 typically includes one or more processors 610 and system memory 620. A memory bus 630 may be used for communicating between the processor 610 and the system memory 620.

[0111] Depending on the desired configuration, processor 610 may be of any type including but not limited to a microprocessor (μP), a microcontroller (μC), a digital signal processor (DSP), or any combination thereof. Processor 610 may include one or more levels of caching, such as a level one cache 611 and a level two cache 612, a processor core 613, and registers 614. An example processor core 613 may include an arithmetic logic unit (ALU), a floating point unit (FPU), a digital signal processing core (DSP Core), or any combination thereof. An example memory controller 615 may also be used with the processor 610, or in some implementations, the memory controller 615 may be an internal part of the processor 610.

[0112] Depending on the desired configuration, the system memory 620 may be of any type including but not limited to volatile memory (such as RAM), non-volatile memory (such as ROM, flash memory, etc.) or any combination thereof. System memory 620 may include an operating system 621, one or more applications 622, and program data 624. Application 622 may include a formation procedure 623 that is arranged to form a composition as described herein (e.g., example method 100, 300, or 500). Program data 624 may include temperature ranges, durations, pH ranges, and/or other information useful for the implementation of any of the example methods 100, 300, or 500. In some embodiments, application 622 may be arranged to operate with program data 624 on an operating system 621 such that any of the procedures described herein may be performed. This described basic configuration is illustrated in FIG. 6 by those components within dashed line of the basic configuration 601.

[0113] Computing device 600 may have additional features or functionality, and additional interfaces to facilitate communications between the basic configuration 601 and any required devices and interfaces. For example, a bus/interface controller 640 may be used to facilitate communications between the basic configuration 601 and one or more storage devices 650 via a storage interface bus 641. The storage devices 650 may be removable storage devices 651, non-removable storage devices 652, or a combination thereof. Examples of removable storage and non-removable storage devices include magnetic disk devices such as flexible disk drives and hard-disk drives (HDD), optical disk drives such as compact disk (CD) drives or digital versatile disk (DVD) drives, solid state drives (SSD), and tape drives to name a few. Example computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data.

[0114] System memory 620, removable storage 651 and non-removable storage 652 are all examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which may be used to store the desired information and which may be accessed by computing device 600. Any such computer storage media may be part of computing device 600.

[0115] Computing device 600 may also include an interface bus 642 for facilitating communication from various interface devices (e.g., output interfaces, peripheral interfaces, and communication interfaces) to the basic configuration 601 via the bus/interface controller 640. Example output devices 660 include a graphics processing unit 661 and an audio processing unit 662, which may be configured to communicate to various external devices such as a display or speakers via one or more A/V ports 663. Example peripheral interfaces 670 include a serial interface controller 671 or a parallel interface controller 672, which may be configured to communicate with external devices such as input devices (e.g., keyboard, mouse, pen, voice input device, touch input device, etc.) or other peripheral devices (e.g., printer, scanner, etc.) via one or more I/O ports 673. An example communication device 680 includes a network controller 681, which may be arranged to facilitate communications with one or more other computing devices 690 over a network communication link via one or more communication ports 682.

[0116] The network communication link may be one example of a communication media. Communication media may typically be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and may include any information delivery media. A "modulated data signal" may be a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), microwave, infrared (IR) and other wireless media. The term computer readable media as used herein may include both storage media and communication media.

[0117] Computing device 600 may be implemented as a portion of a small-form factor portable (or mobile) electronic device such as a cell phone, a personal data assistant (PDA), a personal media player device, a wireless web-watch device, a personal headset device, an application specific device, or a hybrid device that include any of the above functions. Computing device 600 may also be implemented as a personal computer including both laptop computer and non-laptop computer configurations.

[0118] FIG. 7 is a block diagram illustrating an example computer program product 700 that is arranged to store instructions for making a composition in accordance with the present disclosure. The signal bearing medium 702 which may be implemented as or include a computer-readable medium 706, a recordable medium 708, a communications medium 710, or combinations thereof, stores programming instructions 704 that may configure the processing unit to perform all or some of the processes previously described. These programming instructions 704 may include, for example, one or more executable instructions for forming a plurality of trehalose infused ground plant hulls; transporting the trehalose infused ground plant hulls to a blending location; dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture; and packaging the dry mixture.

[0119] In some examples, the programming instructions 704 may include, for example, one or more executable instructions for adding ground plant hulls to water; combining trehalose with the ground plant hulls and water to form a slurry; adjusting a pH of the slurry to a range from about 7.0 to about 7.5; and heating the slurry to a selected temperature for a first duration under agitation; wherein the slurry has a total solids content of at least about 30 wt%, the ground plant hulls is at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

[0120] In some examples, the programming instructions 704 may include, for example, one or more executable instructions for forming a slurry of ground plant hulls; treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5; heating the slurry to a selected temperature for a first duration under agitation; adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry; exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry; and cooling the hydrocolloid infused slurry to below the selected temperature.

[0121] The computer program product 700 may be used to cause an automated trehalose infused oat hull composition system to form trehalose infused oat hull compositions (e.g., powders or slurries). In some examples, the computer program product may include machine readable instructions for performing any of the methods or components thereof disclosed herein, with an automated system.

WORKING EXAMPLES 1-3 AND CONTROL SAMPLE 1

[0122] Control sample 1 and 3 are different working examples of oat hull slurries were formed. Control sample 1 had a total solids content of solely ground oat hulls (no trehalose). The working examples had different total solids amounts and different trehalose amounts. For control sample 1, ground oat hulls (about 44 µm average particle size) were combined with water to form an oat hull slurry with a 25 wt% total solids content. The pH of the slurry was set by adding a predetermined amount of NaOH solution to the water and additional amount to the slurry as required to bring pH to 7.28. The slurry was hydrated and alkalized for 15 minutes at about 175 °F with constant slow stirring in an enclosed bowl.

[0123] Three working examples were formed in accordance with examples of the present disclosure, each had a different total solids content and trehalose content. For each of working examples 1-3, ground oat hulls (about 44 μm average particle size) were combined with water to form an oat hull slurry. Each of working examples 1-3 had 25 wt% ground oat hulls. Working example 1 had a trehalose content of 5 wt% and 30 wt% total solids content. Working example 2 had a trehalose content of 8.5 wt% and 33.5 wt% total solids content. Working example 3 had a trehalose content of 10 wt% and 35 wt% total solids content. The pH of the slurry was set by adding a predetermined amount of NaOH solution to the water and additional amount to the slurry as required to bring pH to about 7.3. Working example 1 had pH of 7.32. Working example 2 had pH of 7.30. Working example 1 had pH of 7.31. The slurries were hydrated and alkalized for 15 minutes at about 175 °F with constant slow stirring in an enclosed bowl.

[0124] After formation, control sample 1 and working examples 1-3 were evaluated visually for smoothness and flowability, as well as viscosity. An AMETEK Brookfield HADV-II+Pro viscometer was used to measure the viscosity of control sample 1 and working examples 1-3. A constant shear rate was applied as the viscometer was lowered at a rate of 1 mm per second, to provide optimal contact between the respective slurries and the viscometer's spindle. Table 1 shows the measured viscosities of control sample 1 and working examples 1-3.

[0125] Table 1:

Ingredient/Parameter	Control Sample 1	Working Example 1	Working Example 2	Working Example 3
Ground Oat Hulls	250 g	250 g	250 g	250 g
Water	750 g	700 g	664.5 g	650 g
Trehalose	0	50 g	85.5 g	100 g
10% NaOH Solution	4 g	3.8 g	3.6 g	3.25 g
Measured pH	7.28	7.32	7.3	7.31

Measured Viscosity (centipoise)	27,159	40,744	48,144	54,727

[0126] The smoothness and flowability of the slurries of working examples 1-3 were found to improve at higher total solids and trehalose concentrations. The flowability of working examples 1-3 was most pronounced in working example 3 (35 wt% total solids content slurry that contained 10 wt% trehalose). In working examples 1-3, dispersing and hydrating the ground oat hulls, then adding and dissolving 5%, 8.58%, and 10% trehalose in the slurry, and adjusting the pH to 7.3-7.5, resulted in an apparent viscosity increase of about 50%, about 77%, and about 200% respectively at a constant shear rate, over control sample 1 without negatively impacting—actually enhancing—the apparent flow rate. The apparent flow rate was visually determined based upon the visual texture and the movement of the control sample and working examples on a spatula. Working example 3 had the highest apparent flow rate, followed by working example 2 and working example 1, despite having higher viscosities, respectively.

WORKING EXAMPLE 4 AND CONTROL SAMPLE 2

[0127] Samples of trehalose and guar infused oat hull compositions were formed and tested for viscosity against trehalose infused oat hull samples. Trehalose infused oat hull fibers were infused with guar gum to form working example 4 in accordance with an example of the present disclosure. Trehalose infused oat hull fibers and trehalose infused oat hull fibers that include probiotics were used to form the guar gum infused oat hull composition of working example 4. Guar gum (75 wt% guar gum and 25 wt% prehydrated guar gum blend) was added to trehalose infused oat hull fibers and trehalose in a 1:2 ratio of guar gum to oat hull fibers and trehalose (both trehalose infused and trehalose and probiotic infused oat hulls). Specifically, 1 g of guar gum was fully dispersed in a solution containing 2g trehalose infused oat hulls and trehalose and probiotic infused oat hulls. The guar gum and trehalose infused oat hulls were mixed for 15 minutes in a mixer. Working example 4 was a solution of 1 wt% ground plant hulls, 1 wt% trehalose, and 1 wt% guar gum.

[0128] Control sample 2 was formed by making a solution containing 1 wt% ground oat hulls and 1 wt% trehalose. A 1% psyllium solution was formed.

[0129] The viscosity of the guar gum infused oat hull slurry of working example 4, control sample 2, and a 1% psyllium solution were tested for viscosity and organoleptic properties. An AMETEK Brookfield HADV-II+Pro viscometer was used to measure the viscosity of control sample 2 working example 4, and the 1% psyllium solution. A constant shear rate was applied as the viscometer was lowered at a rate of 1 mm per second, to provide optimal contact between the respective slurries and the viscometer's spindle. Table 2 shows the viscosity measurements of control sample 2 and the psyllium solution over time and Table 3 shows the organoleptic properties of the body (bulk appearance), texture (e.g., graininess), flavor, and color of control sample 2 and the psyllium solution.

[0130] Table 2:

Time (minutes)	Viscosity (centipoise)	
	1% Psyllium Solution	Control Sample 2
0	13	3
5	44	5
10	53	6
15	53	7
20	54	6

[0131] As shown in Table 2, the trehalose infused oat hull solution of control sample 2 exhibited much smaller viscosities than the psyllium solution over time.

[0132] Table 3:

Time	1% Psyllium solution	Control Sample 2
Body	Mucilaginous	Not Mucilaginous
Texture	Very smooth	Smooth
Flavor	Neutral	Very Slight Oatiness
Color	Light Brown	Ivory

[0133] As shown in Table 3, the organoleptic properties of the 1% psyllium solution were different than the organoleptic properties of control sample 2.

[0134] Table 4 shows the viscosity measurements of working example 4 and the psyllium solution over time and Table 5 shows the organoleptic properties of the body (bulk appearance), texture (e.g., graininess), flavor, and color of working example 4 and the psyllium solution.

[0135] Table 4:

Time (minutes)	Viscosity (centipoise)	
	1% Psyllium Solution	Working Example 4
0	13	10
5	44	40
10	53	49
15	53	52
20	54	57

[0136] As shown in Table 4, the guar gum and trehalose infused oat hull solution of working example 4 exhibited similar viscosities compared to the psyllium solution over time.

[0137] Table 5:

Time	1% Psyllium solution	Working Example 4
Body	Mucilaginous	Mucilaginous
Texture	Very smooth	Very Smooth
Flavor	Neutral	Very Slight Oatiness
Color	Light Brown	Ivory

[0138] As shown in Table 5, the organoleptic properties of the 1% psyllium solution were very similar to the organoleptic properties of working example 4. In contrast to control sample 2, the body and texture of the oat hull composition of control sample 2 were very similar to the 1% psyllium solution, as shown by working example 4.

WORKING EXAMPLE 5

[0139] A guar gum infused ground oat hull fiber powder was formed as working example 5 in accordance with an example of the present disclosure. Ten grams of ground oat hull fiber powder (about 44 μm average particle size) was dispersed in 990 g of water at about 175 °F to form a slurry. The pH of the slurry was adjusted to between 7.3 and 7.5 by adding sodium hydroxide granules. The pH adjusted slurry was maintained at 175 °F while constant agitation was applied via stirring for fifteen minutes. Ten grams of guar gum (75 wt% guar gum and 25 wt% prehydrated guar gum blend) was added while maintaining the guar gum slurry at 175 °F while constant agitation was applied via stirring for five minutes. The guar gum slurry (containing the oath hulls and still having a pH between about 7.3 and 7.5) was agitated by sonication for 15 minutes at 175 °F. The slurry was disposed in aseptic packaging and cooled to just above the freezing point of water. The slurry contained about 1 wt% oat hulls and about 1 wt% guar gum.

[0140] A 1% psyllium solution was formed.

[0141] The viscosity of the guar gum infused oat hull slurry of working example 5 and the psyllium solution were tested and organoleptic properties were determined. An AMETEK Brookfield HADV-II+Pro viscometer was used to measure the viscosity of working example 5 and the psyllium solution. A constant shear rate was applied as the viscometer was lowered at a rate of 1 mm per second, to provide optimal contact between the respective slurries and the viscometer's spindle. Table 6 shows the viscosity measurements of working example 5 and the psyllium solution over time and Table 7 shows the organoleptic evaluation of the body (bulk appearance), texture, flavor and color of working example 5 and the psyllium solution.

[0142] Table 6:

Time (minutes)	Viscosity (centipoise)	
	1% Psyllium Solution	Working Example 5
0	13	15
5	44	41
10	53	48
15	53	54
20	54	59

[0143] As shown in Table 6, the guar gum infused oat hull solution of working example 5 exhibited similar viscosities compared to the psyllium solution over time.

[0144] Table 7:

Time	1% Psyllium solution	Working example 5
Body	Mucilaginous	Mucilaginous
Texture	Very smooth	Very smooth
Flavor	Neutral	Very slight Oatiness
Color	Light Brown	Ivory

[0145] As shown in Table 7, working example 5 exhibited similar organoleptic properties to the 1% psyllium solution. The body of both working example 5 and the 1% psyllium solution exhibited a mucilaginous body. The texture of both working example 5 and the 1% psyllium solution exhibited very smooth texture.

[0146] The present disclosure is not to be limited in terms of the particular examples described in this application, which are intended as illustrations of various aspects. Many modifications and examples can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and examples are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular examples only, and is not intended to be limiting.

[0147] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0148] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.).

[0149] It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation, no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to examples containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations).

[0150] Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general, such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general, such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and

C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0151] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0152] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 items refers to groups having 1, 2, or 3 items. Similarly, a group having 1-5 items refers to groups having 1, 2, 3, 4, or 5 items, and so forth.

[0153] While the foregoing detailed description has set forth various examples of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples, such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one example, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, those skilled in the art will recognize that some aspects of the examples disclosed herein, in whole or in part, can be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and/or firmware would be well within the skill of one of skill in the art in light of this disclosure. For example, if a user determines that speed and accuracy are paramount, the user may opt for a mainly hardware and/or firmware vehicle; if flexibility is paramount, the user may opt for a mainly software implementation; or, yet again alternatively, the user may opt for some combination of hardware, software, and/or firmware.

[0154] In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative example of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive (HDD), a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc.; and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.).

[0155] Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein can be integrated into a data processing system via a reasonable amount of experimentation. Those having skill in the art will recognize that a typical data processing system generally includes one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity; control motors for moving and/or adjusting components and/or quantities). A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems.

[0156] The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0157] While various aspects and examples have been disclosed herein, other aspects and examples will be apparent to those skilled in the art. The various aspects and examples disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

CLAIMS

What is claimed is:

1. A method to form a composition, the method comprising:

adding ground plant hulls to water;

combining trehalose with the ground plant hulls and water to form a slurry;

adjusting a pH of the slurry to a range from about 7.0 to about 7.5; and

heating the slurry to a selected temperature for a first duration under agitation;

wherein the slurry has a total solids content of at least about 30 wt%, the ground plant hulls are at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

2. The method of claim 1, wherein the ground plant hulls is at least about 25 wt% of the slurry and the trehalose is at least about 8 wt% of the slurry.

3. The method of claim 1, wherein the ground plant hulls is at least about 20 wt% of the slurry and the trehalose is at least about 10 wt% of the slurry.

4. The method of claim 1, wherein the plurality of ground plant hulls is at least about 25 wt% of the slurry and the trehalose is at least about 5 wt% of the slurry.

5. The method of claim 1, wherein adding ground plant hulls to water comprises dispersing the ground plant hulls in water that has a temperature of at least about 160 °F.

6. The method of claim 1, wherein adding ground plant hulls to water comprises dispersing the ground plant hulls in water that has a temperature of at least about 175 °F.

7. The method of claim 1, wherein adding ground plant hulls to water comprises adding ground plant hulls to water in a ratio of about 1:99 to about 1:9 of ground plant hulls to water.

8. The method of claim 1, wherein adding ground plant hulls to water comprises dispersing ground, trehalose-infused oat hulls in water.

9. The method of claim 1, wherein adjusting the pH of the slurry to the range from about 7.0 to about 7.5 comprises dissolving an alkali in the slurry in an amount effective to adjust the slurry to have the pH in the range from about 7 to about 7.5.

10. The method of claim 1, wherein adjusting the pH of the slurry to the range from about 7.0 to about 7.5 comprises adding sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in the range from about 7 to about 7.5.

11. The method of claim 1, wherein adjusting the pH of the slurry to the range from about 7.0 to about 7.5 comprises adding sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in the range from about 7.3 to about 7.5.

12. The method of claim 1, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry to a temperature in a range from about 160 °F to about 190 °F.

13. The method of claim 1, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry to about 175 °F.

14. The method of claim 1, wherein heating the slurry to the selected temperature for the first duration under agitation comprises constantly agitating the slurry.

15. The method of claim 1, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry for at least about 10 minutes under constant agitation.

16. The method of claim 1, wherein heating the trehalose slurry to the selected temperature for the first duration under agitation comprises heating the trehalose slurry to at least about 175 °F for at least about 15 minutes under constant agitation.

17. The method of claim 1, further comprising adding a hydrocolloid material to the slurry to form a hydrocolloid slurry.

18. The method of claim 17, wherein adding the hydrocolloid material to the slurry comprises adding guar gum to the slurry.

19. The method of claim 17, wherein adding the hydrocolloid material to the slurry comprises adding guar gum to the slurry while heating and agitating the slurry for at least about 5 minutes.

20. The method of claim 17, wherein adding the hydrocolloid material to the slurry comprises dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 160 °F.

21. The method of claim 17, wherein adding the hydrocolloid material to the slurry comprises dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 175 °F and constantly agitating the slurry for at least about 5 minutes.

22. The method of claim 17, further comprising exposing the hydrocolloid slurry to ultrasonic agitation to form a hydrocolloid infused slurry.

23. The method of claim 22, wherein exposing the hydrocolloid slurry to ultrasonic agitation comprises exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes while maintaining the temperature of the hydrocolloid slurry at at least about 175 °F.

24. The method of claim 22, further comprising cooling the hydrocolloid infused slurry to below the selected temperature.

25. The method of claim 24, wherein cooling the hydrocolloid infused slurry to below the selected temperature comprises cooling the hydrocolloid infused slurry to a temperature in a range from above the freezing point of water to about 45 °F.

26. The method of claim 22, further comprising at least partially filling an aseptic packaging with the hydrocolloid infused slurry.

27. The method of claim 22, further comprising drying the hydrocolloid infused slurry via one or more of drum drying, flash drying, or pulse drying.

28. The method of claim 1, wherein the slurry has a viscosity of at least about 30,000 centipoise.

29. The method of claim 1, wherein the slurry has a viscosity of at least about 40,000 centipoise.

30. The method of claim 1, further comprising pumping the slurry.

31. A slurry, comprising:

water;

ground plant hulls; and

trehalose infused into the ground plant hulls;

wherein the slurry has a total solids content of at least about 30 wt%, the ground plant hulls are at least about 20 wt% of the slurry, the trehalose is at least about 5 wt% of the slurry, and the pH of the slurry is in a range from about 7.0 to about 7.5.

32. The slurry of claim 31, wherein the ground plant hulls comprise ground oat hulls.

33. The slurry of claim 31, wherein the ground plant hulls are at least about 25 wt% of the slurry and the trehalose is at least about 8 wt% of the slurry.

34. The slurry of claim 31, wherein the ground plant hulls are at least about 20 wt% of the slurry and the trehalose is at least about 10 wt% of the slurry

35. The slurry of claim 31, wherein the ground plant hulls are at least about 25 wt% of the slurry and the trehalose is at least about 5 wt% of the slurry.

36. The slurry of claim 31, wherein the ground plant hulls comprise ground oat hulls and are at least about 25 wt% of the slurry and the trehalose is at least about 5 wt% of the slurry.

37. The slurry of claim 31, wherein the slurry has a pH in a range from about 7.0 to about 7.3.

38. The slurry of claim 31, wherein the slurry has a pH in a range from about 7.3 to about 7.5.

39. The slurry of claim 31, wherein the slurry has a viscosity of at least 30,000 centipoise.

40. The slurry of claim 31, wherein the slurry has a viscosity of at least 40,000 centipoise.

41. The slurry of claim 31, further comprising a hydrocolloid material infused in the slurry.

42. The slurry of claim 41, wherein the hydrocolloid material comprises guar gum.

43. The slurry of claim 41, wherein the hydrocolloid material is at least 10 wt% of the slurry.

44. A method to form a composition, the method comprising:

forming a slurry of ground plant hulls;

treating the slurry with an alkali to adjust the pH of the slurry to a range from about 7 to about 7.5;

heating the slurry to a selected temperature for a first duration under agitation;

adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry;

exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry; and

cooling the hydrocolloid infused slurry to below the selected temperature.

45. The method of claim 44, wherein forming the slurry of ground plant hulls comprises dispersing the ground plant hulls in water that has a temperature of at least about 160 °F.

46. The method of claim 44, wherein forming the slurry of ground plant hulls comprises dispersing the ground plant hulls in water that has a temperature of at least about 175 °F.

47. The method of claim 44, wherein forming the slurry of ground plant hulls comprises adding ground plant hulls to water in a ratio of about 1:99 to about 1:9 of ground plant hulls to water.

48. The method of claim 44, wherein forming the slurry of ground plant hulls comprises dispersing ground, trehalose-infused oat hulls in water.

49. The method of claim 44, wherein treating the slurry with the alkali comprises adding sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in the range from about 7 to about 7.5.

50. The method of claim 44, wherein treating the slurry with the alkali comprises adding sodium hydroxide to the slurry in an amount effective to adjust the pH of the slurry to be in a range from about 7.3 to about 7.5.

51. The method of claim 44, wherein treating the slurry with the alkali comprises dissolving the alkali in the slurry in an amount effective to adjust the slurry to have the pH in a range from about 7 to about 7.5.

52. The method of claim 44, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry to a temperature in a range from about 160 °F to about 190 °F.

53. The method of claim 44, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry to about 175 °F.

54. The method of claim 44, wherein heating the slurry to the selected temperature for the first duration under agitation comprises constantly agitating the slurry.

55. The method of claim 44, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry for at least about 10 minutes under constant agitation.

56. The method of claim 44, wherein heating the slurry to the selected temperature for the first duration under agitation comprises heating the slurry to at least about 175 °F for at least about 15 minutes under constant agitation.

57. The method of claim 44, wherein adding the hydrocolloid material to the slurry comprises adding the hydrocolloid material to the slurry in an amount effective to cause the hydrocolloid slurry to have a ratio of hydrocolloid material to slurry in a range from about 1:99 to about 1:9.

58. The method of claim 44, wherein adding the hydrocolloid material to the slurry comprises adding guar gum to the slurry.

59. The method of claim 44, wherein adding the hydrocolloid material to the slurry comprises adding guar gum to the slurry while heating and agitating the slurry for at least about 5 minutes.

60. The method of claim 44, wherein adding the hydrocolloid material to the slurry comprises dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 160 °F.

61. The method of claim 44, wherein adding the hydrocolloid material to the slurry comprises dissolving guar gum in the slurry while maintaining the slurry at a temperature of at least about 175 °F and constantly agitating the slurry for at least about 5 minutes.

62. The method of claim 44, wherein exposing the hydrocolloid slurry to ultrasonic agitation comprises exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes.

63. The method of claim 44, wherein exposing the hydrocolloid slurry to ultrasonic agitation comprises exposing the hydrocolloid slurry to ultrasonic agitation for at least 15 minutes while maintaining the temperature of the hydrocolloid slurry at a temperature of at least about 175 °F.

64. The method of claim 44, wherein cooling the hydrocolloid infused slurry to below the selected temperature comprises cooling the hydrocolloid infused slurry to a temperature in a range between the selected temperature and above the freezing point of water.

65. The method of claim 44, wherein cooling the hydrocolloid infused slurry to below the selected temperature comprises cooling the hydrocolloid slurry to a temperature in a range from about 33 °F to about 45 °F.

66. The method of claim 44, further comprising at least partially filling an aseptic packaging with the hydrocolloid infused slurry.

67. The method of claim 44, further comprising drying the hydrocolloid infused slurry via one or more of drum drying, flash drying, or pulse drying.

68. The method of claim 67, further comprising at least partially filling an aseptic packaging with the hydrocolloid infused slurry that has been dried.

69. The method of claim 67, further comprising adding the hydrocolloid infused slurry that has been dried to a trehalose infused ground plant hull powder to form a powder mixture.

70. The method of claim 69, further comprising at least partially filling an aseptic packaging with the powder mixture.

71. The method of claim 44, wherein the ground plant hulls comprise trehalose infused oat hulls.

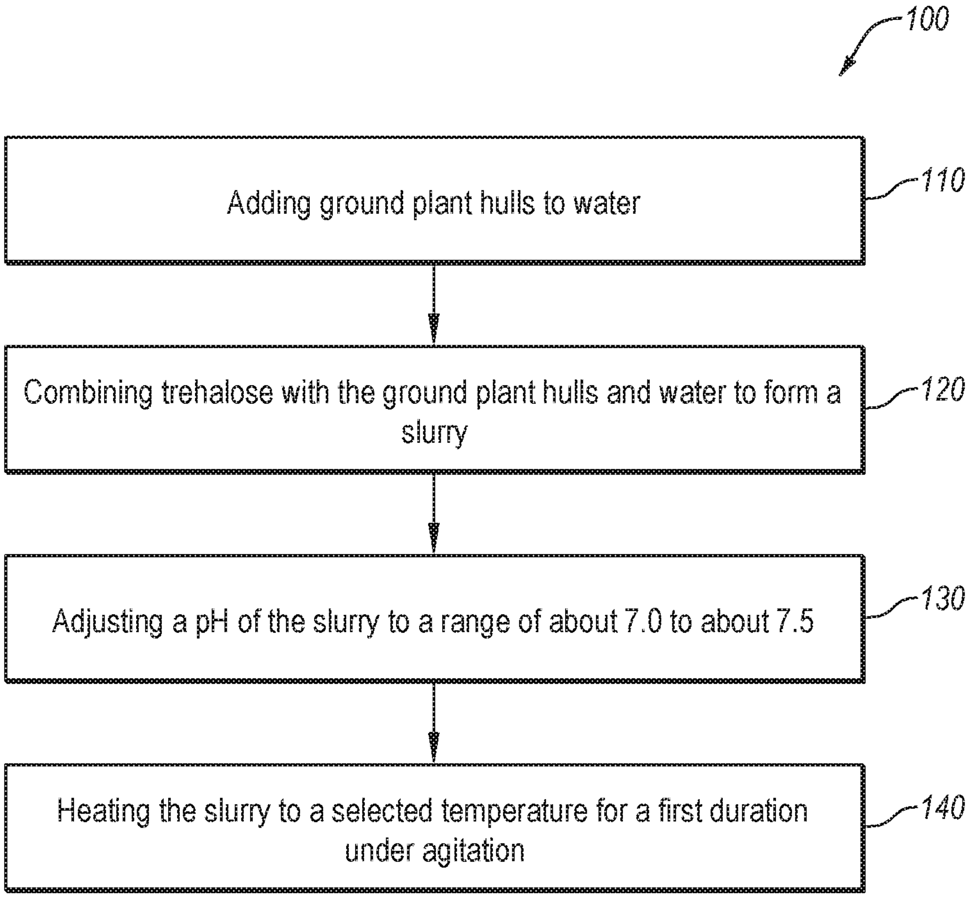
100
Adding ground plant hulls to water
110
Combining trehalose with the ground plant hulls and water to form a slurry
120
Adjusting a pH of the slurry to a range of about 7.0 to about 7.5
130
Heating the slurry to a selected temperature for a first duration under agitation
140

FIG. 1

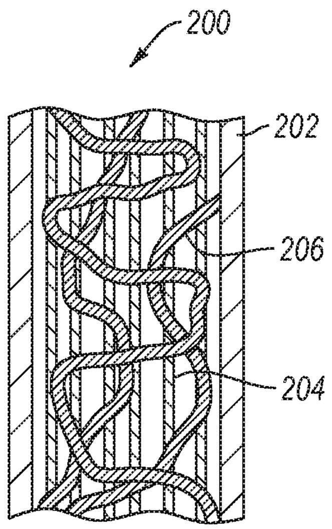

FIG. 2A

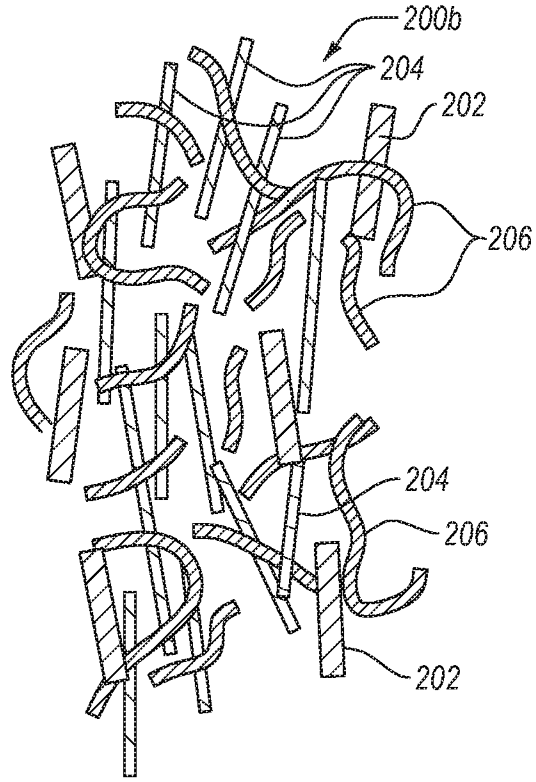

FIG. 2B

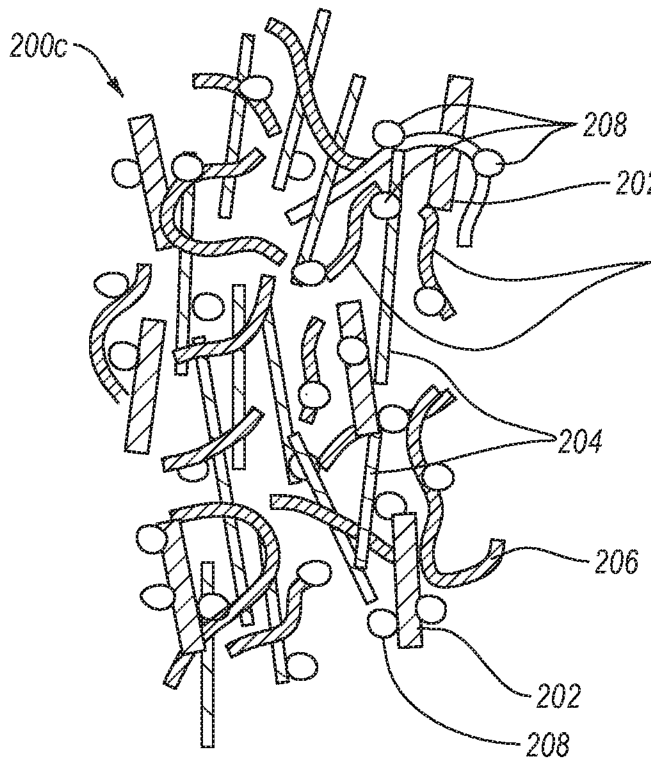

FIG. 2C

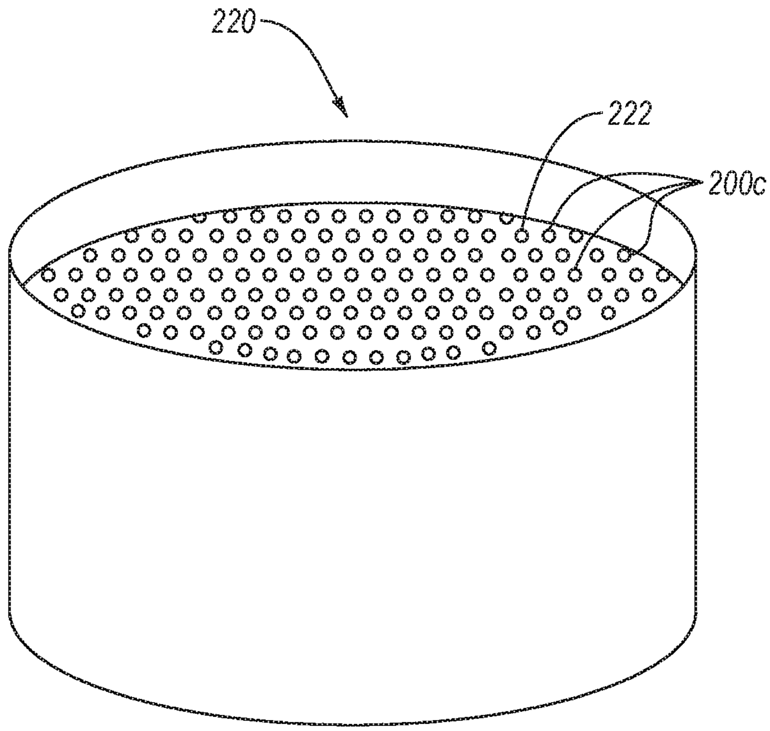

FIG. 2D

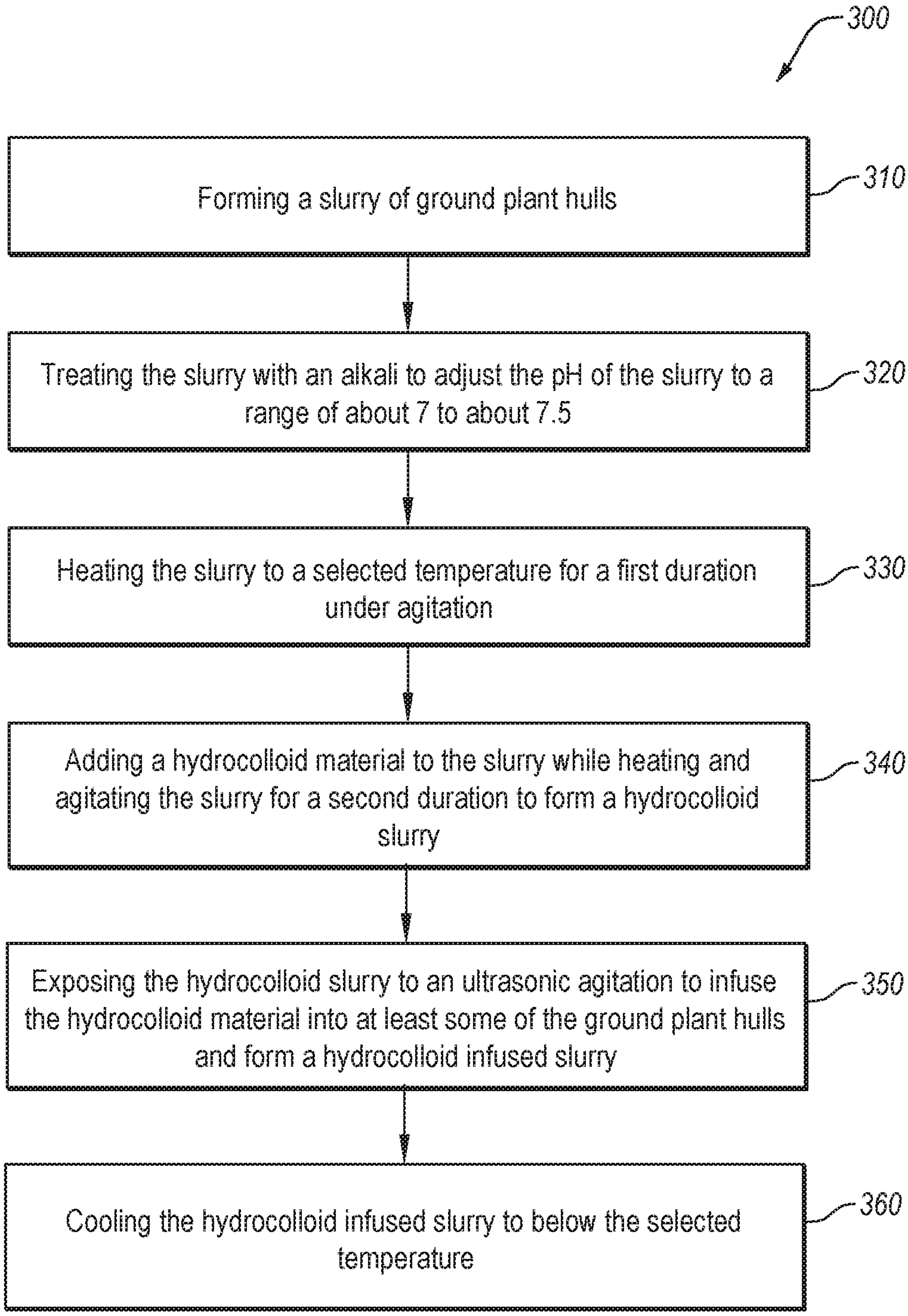
300
Forming a slurry of ground plant hulls
310
Treating the slurry with an alkali to adjust the pH of the slurry to a range of about 7 to about 7.5
320
Heating the slurry to a selected temperature for a first duration under agitation
330
Adding a hydrocolloid material to the slurry while heating and agitating the slurry for a second duration to form a hydrocolloid slurry
340
Exposing the hydrocolloid slurry to an ultrasonic agitation to infuse the hydrocolloid material into at least some of the ground plant hulls and form a hydrocolloid infused slurry
350
Cooling the hydrocolloid infused slurry to below the selected temperature
360

FIG. 3

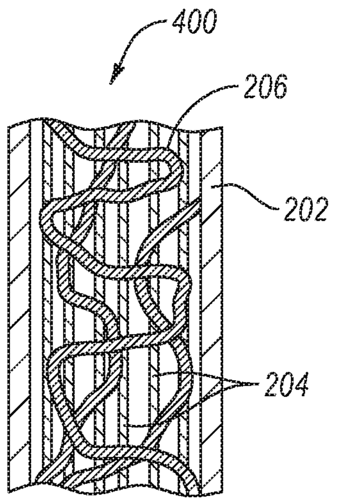

FIG. 4A

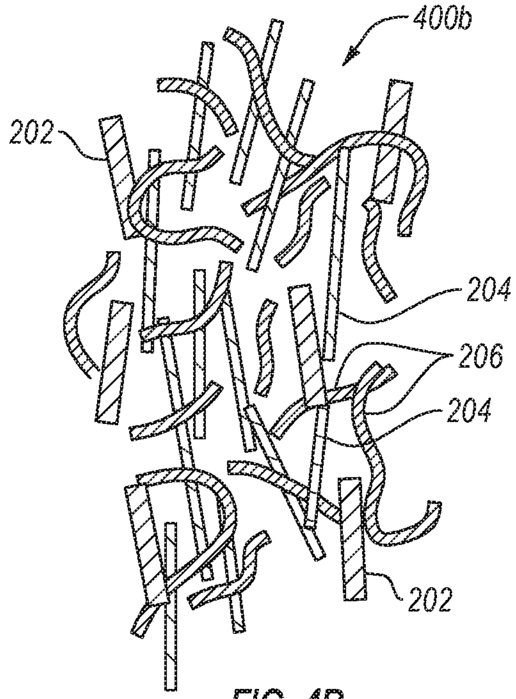

FIG. 4B

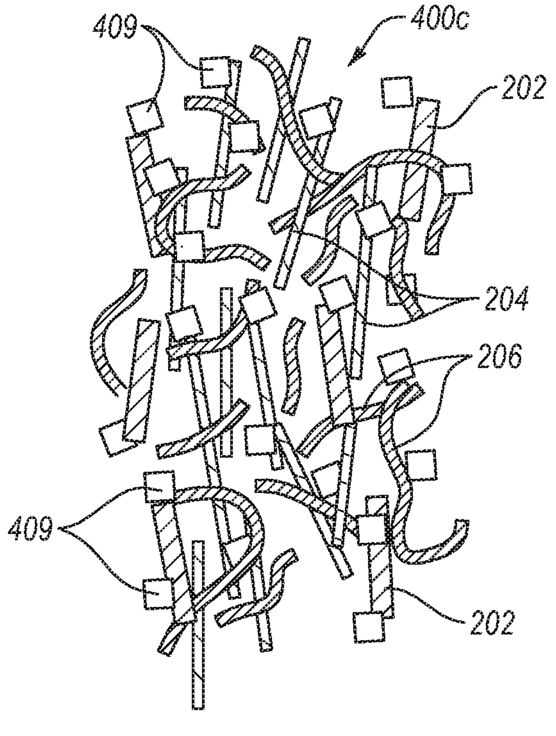

FIG. 4C

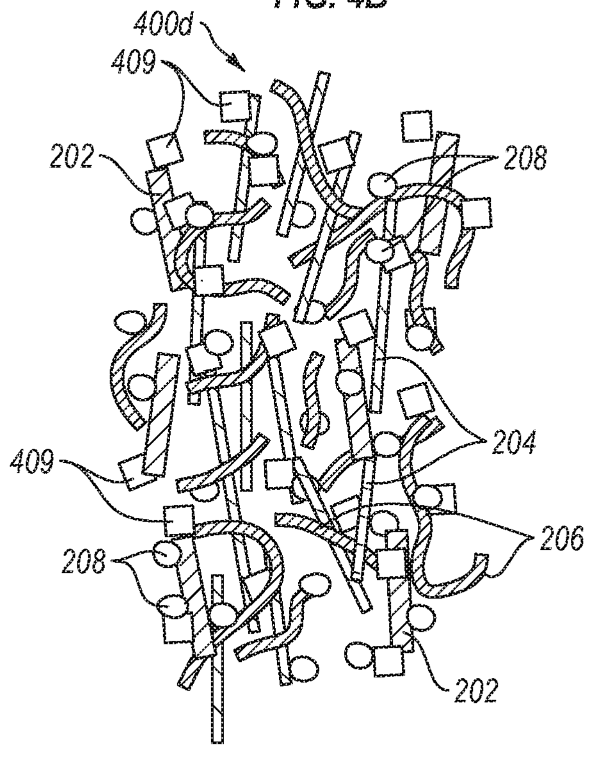

FIG. 4D

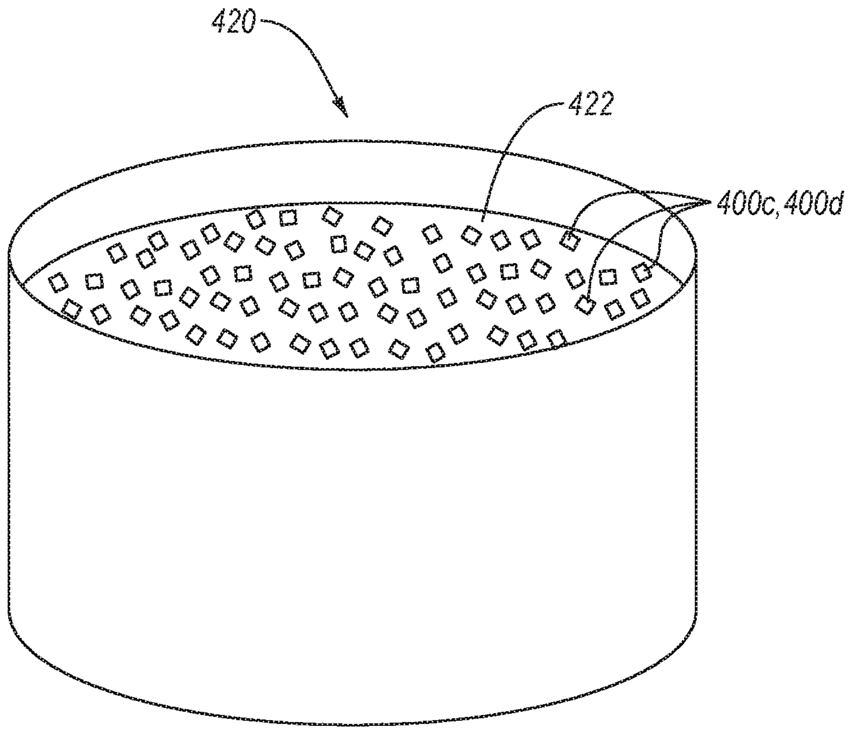

FIG. 4E

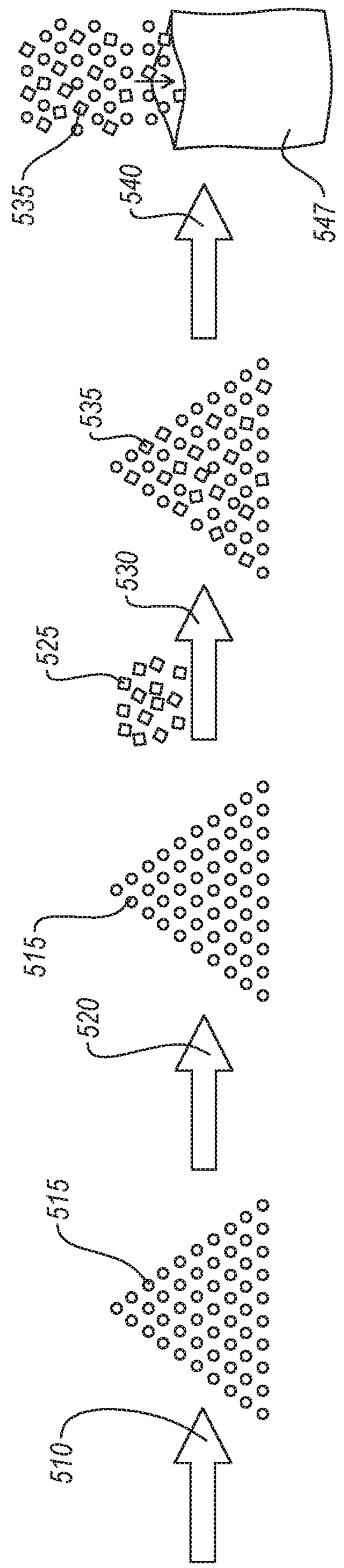

FIG. 5

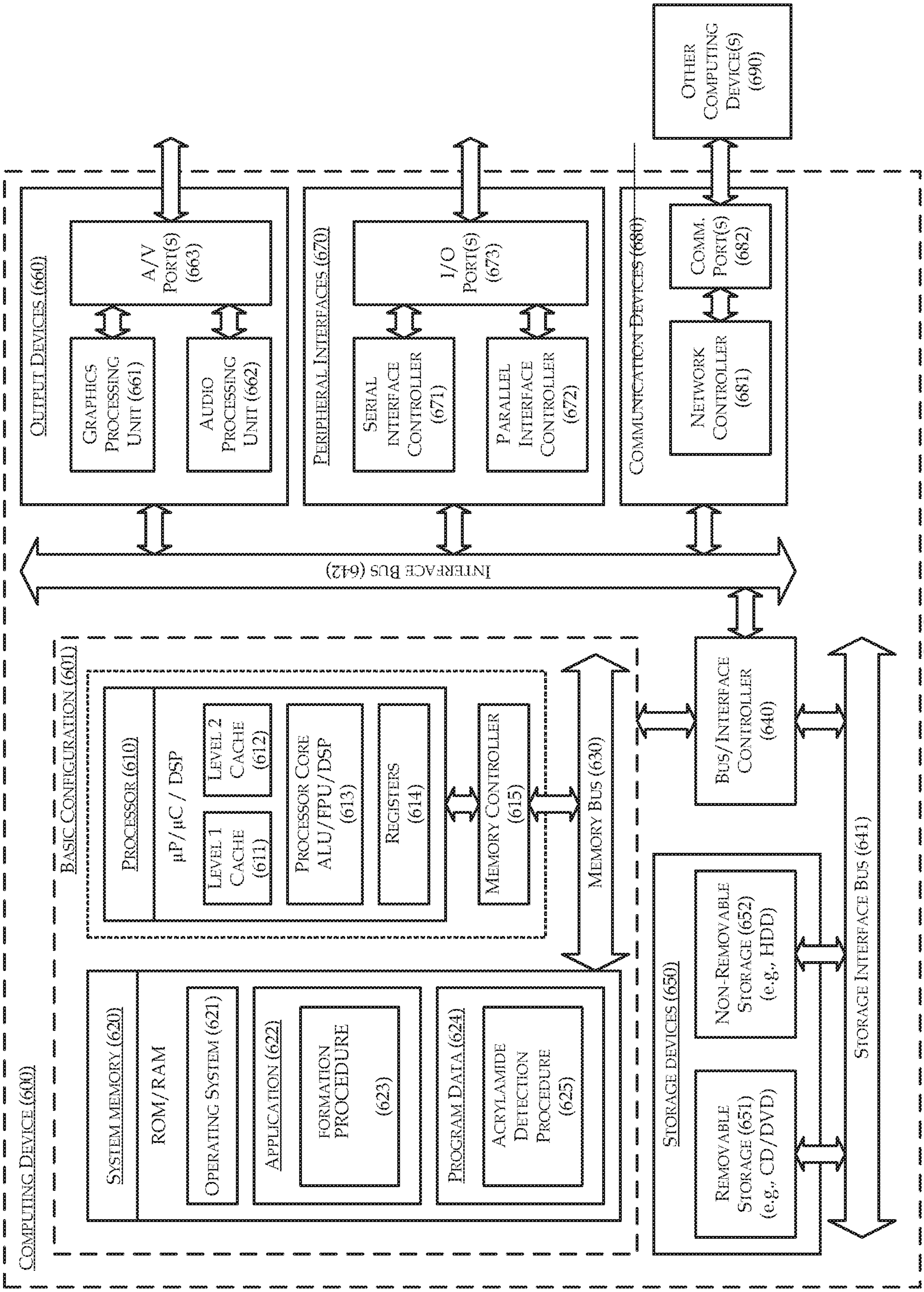
OTHER COMPUTING DEVICE(S) (690)
OUTPUT DEVICES (660)
A/V PORT(S) (663)
GRAPHICS PROCESSING UNIT (661)
AUDIO PROCESSING UNIT (662)
PERIPHERAL INTERFACES (670)
I/O PORT(S) (673)
SERIAL INTERFACE CONTROLLER (671)
PARALLEL INTERFACE CONTROLLER (672)
COMMUNICATION DEVICES (680)
COMM. PORT(S) (682)
NETWORK CONTROLLER (681)
INTERFACE BUS (642)
BASIC CONFIGURATION (601)
PROCESSOR (610)
μP / μC / DSP
LEVEL 1 CACHE (611)
LEVEL 2 CACHE (612)
PROCESSOR CORE ALU/FPU/DSP (613)
REGISTERS (614)
MEMORY CONTROLLER (615)
MEMORY BUS (630)
BUS/INTERFACE CONTROLLER (640)
SYSTEM MEMORY (620)
ROM/RAM
OPERATING SYSTEM (621)
APPLICATION (622)
FORMATION PROCEDURE (623)
PROGRAM DATA (624)
ACRYLAMIDE DETECTION PROCEDURE (625)
STORAGE DEVICES (650)
NON-REMOVABLE STORAGE (652) (e.g., HDD)
REMOVABLE STORAGE (651) (e.g., CD/DVD)
STORAGE INTERFACE BUS (641)
COMPUTING DEVICE (600)

FIG. 6

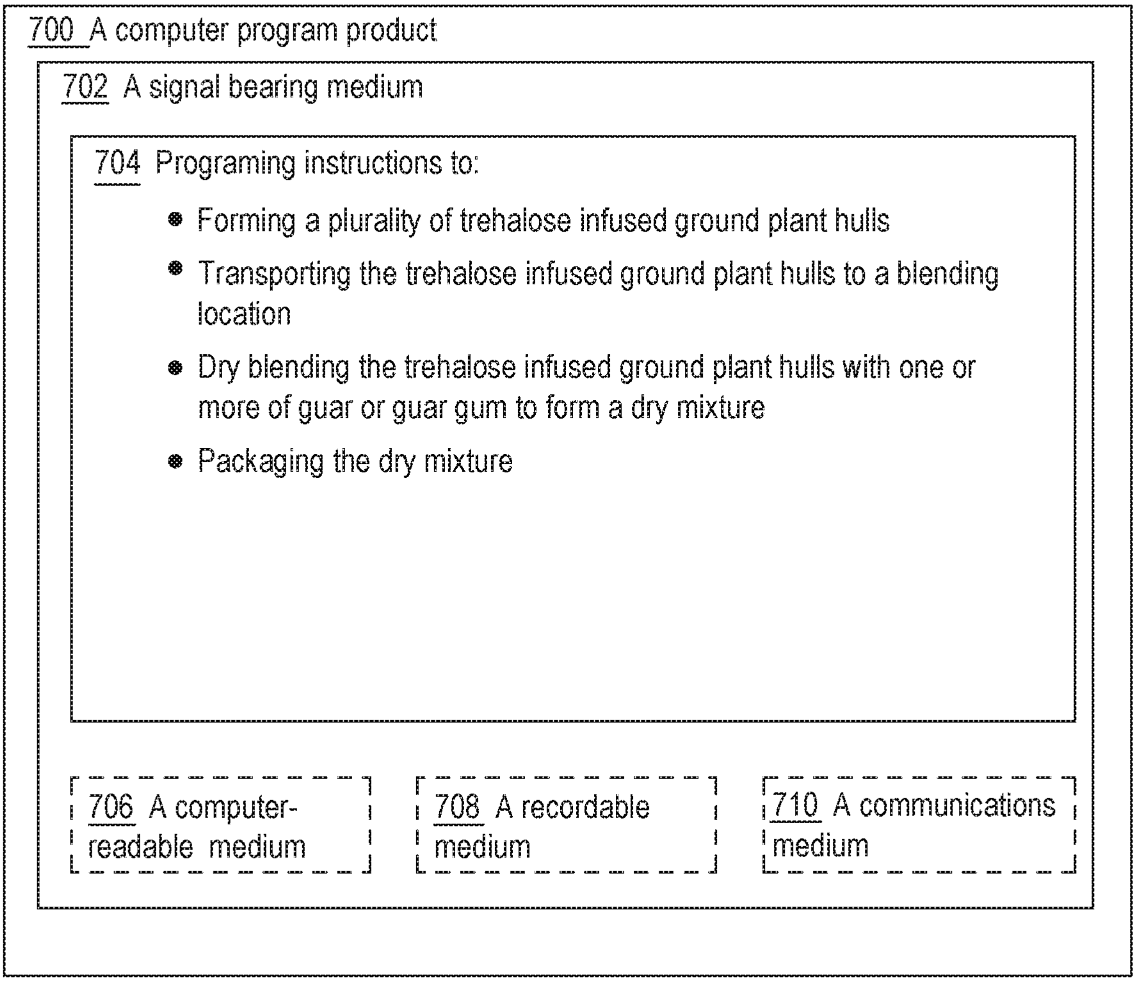
700 A computer program product
702 A signal bearing medium
704 Programing instructions to:
Forming a plurality of trehalose infused ground plant hulls
Transporting the trehalose infused ground plant hulls to a blending location
Dry blending the trehalose infused ground plant hulls with one or more of guar or guar gum to form a dry mixture
Packaging the dry mixture
706 A computer-readable medium
708 A recordable medium
710 A communications medium

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 17/60706

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - D21D 1/32, C12N 5/04, B02B 1/00 (2017.01)
CPC - B29C 47/0026, B29C 47/0004, B29C 47/0021, B09B 3/0033

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.
Y --- A	US 5,085,883 A (Garleb et al.) 04 February 1992 (04.02.1992) col 6, ln 15-17; col 7, ln 14-18; col 10; col 11, ln 6-7; col 12, ln 17-20, 31-39; col 17, ln 8-27	1-68, 71 ------------ 69-70
Y	WO 2014/138196 A2 (Aggredyne, Inc.) 12 September 2014 (12.09.2014) pg 12, ln 28-29	1-27, 30-38, 41-43, 48, 71
Y --- A	US 2013/0115344 A1 (Konuklar) 09 May 2013 (09.05.2013) para [0007]; [0031]	22-27, 44-68, 71 ----------------------- 69-70
Y	US 2006/0286268 A1 (Shukla) 21 December 2006 (21.12.2006) para [0021]; [0038]; [0040]-[0041]; [0072]	28-29, 39-40
Y --- A	US 2003/0194473 A1 (Redding, Jr. et al.) 16 October 2003 (16.10.2003) para [0037]; [0043]-[0044]	27, 67-68 -------------- 69-70
A	US 2006/0093720 A1 (Tatz) 04 May 2006 (04.05.2006) whole document	1-71
A	US 5,766,662 A (Inglett) 16 June 1998 (16.06.1998) whole document	1-71

☐ 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
03 January 2018	29 JAN 2018

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