

COLORING COMPOSITION FOR A MEAT ANALOGUE, A MEAT ANALOGUE
INCLUDING THE COLORING COMPOSITION, AND PROCESS FOR
TRANSFORMING THE COLOR OF A MEAT ANALOGUE

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TECHNICAL FIELD

The present disclosure relates to a coloring composition for a meat analogue, a process for preparing a meat analogue containing the coloring composition, a meat analogue containing the coloring composition, and a process for transforming the color of the meat analogue containing the coloring composition. More particularly, the present disclosure relates to a coloring composition that contains a colorant for transforming the color of a meat analogue during cooking of the meat analogue, a process for preparing a meat analogue containing a coloring composition including a colorant that is capable of transforming the color of the meat analogue, a meat analogue including the coloring composition containing the colorant that is capable of transforming the color of the meat analogue during a cooking process, and a process for transforming the color of the meat analogue including the coloring composition.

BACKGROUND

The food industry is actively seeking solutions to mimic meat-like browning during the frying of beef meat analogues. No natural and non-GMO solution has been found that is capable of matching both the red color in the raw beef patty and the brown/grey color resulting after frying the raw patty.

Spray dried colors are commonly used in various food and beverage applications as a cost-effective delivery system designed to protect natural colors to some extent during storage and to release it instantly in the food or beverage application. One shortcoming of using spray dried colors is that the color is immediately released once it comes into contact with water and hence is no longer protected and/or released in a controlled way at a desired step in the application. This can be problematic in certain fried applications, such as meat analogues, where color transformation during frying is desired. In a spray dried powder format, color is released almost immediately during the patty preparation, and therefore cannot be released in a controlled way at the desired temperature during the patty frying process.

SUMMARY

According to a first illustrative aspect, provided is a coloring composition comprising a mixture of a pH-dependent, plant-derived colorant and glycerin. The mixture has a pH of
5 less than 2.5 and is at least partially encapsulated within an encapsulant.

According to a second illustrative aspect, provided is a meat analogue comprising a non-animal derived protein base and a coloring composition comprising a pH-dependent, plant-derived colorant and glycerin. The colorant and glycerin are at least partially encapsulated within an encapsulant.

10 According to a third illustrative embodiment, provided is a process for transforming the color of a meat analogue comprising providing a plant-based meat analogue comprising a non-animal derived protein base and a coloring composition comprising a pH-dependent, plant-derived colorant and glycerin, the colorant and glycerin being at least partially encapsulated within an encapsulant, the plant-derived meat analogue product having a first pH environment
15 and a first color, heating the plant-based meat analogue at a temperature for time sufficient to melt the encapsulant and release the colorant and glycerin, and exposing the colorant active and glycerin to a second pH environment, wherein the cooked plant-derived meat analogue has a second color.

20 BRIEF DESCRIPTION OF DRAWINGS

The file of this patent contains at least one drawing/photograph executed in color. Copies of this patent with color drawing(s)/photograph(s) will be provided by the Office upon request and payment of the necessary fee.

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FIG. 1 is a visual comparison of the pH-dependent colors of black carrot juice rich in anthocyanidins at different pH levels.

FIG. 2 is a color photograph of a raw uncooked plant-based meat analogue burger patty
30 containing an illustrative embodiment of the disclosed colorant composition (black carrot juice and glycerin) comprising a spray congealed powder encapsulated within hydrogenated palm oil and further blended with beetroot powder and barley malt powder.

FIG. 3 is a color photograph of the cooked plant-based meat analogue burger patty of FIG. 2.

FIG. 4A is a color photograph of a raw uncooked plant-based meat analogue burger patty with unencapsulated black carrot juice incorporated therein.

FIG. 4B is a color photograph of a raw uncooked plant-based meat analogue burger patty containing an illustrative embodiment of a colorant composition comprising a spray congealed powder comprising black carrot juice as the colorant encapsulated within hydrogenated palm oil.

FIG. 5A is a color photograph of the cooked plant-based meat analogue burger patty of FIG. 4A.

FIG. 5B is a color photograph of the cooked plant-based meat analogue burger patty of FIG. 4B.

DETAILED DESCRIPTION

The following text sets forth a broad description of numerous different embodiments of the present disclosure. The description is to be construed as exemplary only and does not describe every possible embodiment since describing every possible embodiment would be impractical, if not impossible. It will be understood that any feature, characteristic, component, composition, ingredient, product, step or methodology described herein can be deleted, combined with or substituted for, in whole or part, any other feature, characteristic, component, composition, ingredient, product, step or methodology described herein. Numerous alternative embodiments could be implemented, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims.

The terms “comprises,” “comprising,” “has,” “having,” “includes,” “including,” “contains,” “containing,” or any other variation are open-ended and are intended to cover a non-exclusive inclusion of elements, such that an article, apparatus, compound, composition, combination, method, or process that “comprises,” “has,” or “includes,” or “contains” a recited list of elements does not include only those elements but may include other elements not expressly listed, recited or written in the specification or claims. An element or feature

proceeded by the language “comprises . . . a,” “contains . . . a,” “has . . . a,” or “includes . . . a” does not, without more constraints, preclude the existence or inclusion of additional elements or features in the article, apparatus, compound, composition, combination, method, or process that comprises, contains, has, or includes the element or feature.

5 The terms “a” and “an” are defined as one or more unless expressly stated otherwise or constrained by other language herein. An element or feature proceeded by “a” or “an” may be interpreted as one of the recited element or feature, or more than one of the element or feature.

 The terms “about,” “approximately,” “essentially,” “substantially,” any other version thereof, or any other similar relative term, or similar term of approximation, are defined as
10 being close to as understood by one having ordinary skill in the art. By way of non-limiting, illustrative embodiments, these terms are defined to be within 10% of recited value, or defined to be within 5% of a recited value, or defined to be within 4% of a recited value, or defined to be within 3% of a recited value, or defined to be within 2% of a recited value, or defined to be within 1% of a recited value, or defined to be within 0.5% of a recited value, or defined to be
15 within 0.25% of a recited value, or defined to be within 0.1% of a recited value.

 It should be understood that when an amount in weight percent is described in the present disclosure, it is intended that any and every amount within the range, including the end points, is to be considered as having been expressly disclosed. For example, the disclosure of
20 "a range of from about 1 to about 10" is to be read as indicating each and every possible number along the continuum between about 1 and about 10. It is to be understood that the inventors appreciate and understand that any and all data points within the range are to be considered to have been specified, and that the inventors have possession of the entire range and all points within the range.

 The term “color” refers to the color properties such as hue, chroma, purity, saturation,
25 intensity, vividness, value, lightness, brightness and darkness, and color model system parameters used to describe these properties, such as Commission Internationale de l’Eclairage CIE 1976 CIELAB color space L*a*b* values.

 The term “hue” refers to the color property that gives a color its name, for example, red, blue and brown.

30 The term “meat analogue” means a non-animal derived protein product that serves as an alternative or substitute for an animal meat product. According to certain illustrative embodiments, the meat analogue is a plant-protein based product.

 The term “pH-dependent colorant” means a colorant that imparts different colors to a meat analogue based on the pH to which the colorant is exposed.

The term “non-animal derived protein” means protein preparations made from raw materials including, but not limited to, grain (rice, millet, maize, barley, wheat, oat, sorghum, rye, teff, triticale, amaranth, buckwheat, quinoa); legume or pulses, beans (such as soybean, mung beans, fava beans, lima beans, runner beans, kidney beans, navy beans, pinto beans, azuki beans, and the like), peas (such as green peas, yellow peas, chickpeas, pigeon peas, cowpea, and black-eyed peas and the like), sesame, garbanzo, potatoes, lentils, and lupins; seed and oilseed (black mustard, India mustard, rapeseed, canola, safflower, sunflower seed, flax seed, hemp seed, poppy seed, pumpkin, chia, sesame); nuts (almond, walnut, Brazil, Macadamia, cashews, chestnuts, hazelnuts, pine, pecans, peanuts, pistachio and ginkgo); algal (kelp, wakame, spirulina, chlorella); mycoprotein and/or fungal protein.

Disclosed is a coloring composition for addition to a meat analogue base to prepare a meat analogue product. The coloring composition includes a color that is capable of imparting an initial color to an uncooked meat analogue product and a different color to the same meat analogue product in response to cooking meat analogue product.

The raw uncooked meat analogue product has a first color that mimics the color of a raw real animal meat product, such as a real animal beef product, and the cooked meat analogue has a second color that is different from the first color present in the raw uncooked meat analogue product. The inclusion of the coloring composition in the meat analogue base provides a meat analogue product that exhibits the red appearance of uncooked (*i.e.*, raw) beef meat before the meat analogue product is cooked and the brown appearance of cooked beef meat after the meat analogue product is cooked. The inclusion of the coloring composition within the non-animal derived protein based meat analogue products enables such analogue products to mimic the natural browning of real beef meat and to imitate the color change of beef meat from red (raw uncooked animal meat) to brown (cooked animal meat) upon cooking the analogue product.

The coloring composition comprises a colorant that is at least partially encapsulated within a suitable encapsulant material. According to certain illustrative embodiments, the encapsulant material comprises a fat, a wax, or mixtures thereof. The fat or wax encapsulant may be any fat or wax that is safe for consumption by humans, that is capable of at least partially encapsulating the colorant and protecting the encapsulated colorant from the external environment until release of the colorant is desired, and that is capable of releasing the colorant at desired conditions. According to certain illustrative embodiments, the fat or wax encapsulant is safe for consumption by humans, is capable of encapsulating the colorant and protecting the encapsulated colorant from the external environment until release of the colorant is desired,

and that is capable of releasing the colorant at or above the melting temperature of the fat or wax encapsulant. According to the present disclosure, the composition also comprises glycerin that is at least partially encapsulated within the same encapsulant material.

5 According to the present disclosure, the coloring composition is substantially free from water being present in the dispersed phase of the emulsion. Rather, in one embodiment, glycerin is used in the dispersed phase. As used herein, references to a composition being “substantially free” of water may refer to the composition consisting of less than 1% by weight, for example, less than 0.5% or less than 0.3%, or less than 0.1%, by weight) of that composition.

10 According to certain illustrative embodiments, the coloring composition is prepared by a spray congealing process. Spray congealing is an encapsulation process by which the colorant and glycerin are dispersed homogeneously in droplets of the encapsulant material. The spray congealing process includes the steps of feeding the encapsulant material into an atomization chamber, atomizing the encapsulant material in the chamber into droplets,
15 homogeneously dispersing the colorant and glycerin in the atomized droplets of encapsulant material and solidifying the droplets. Spray congealing is also known as spray chilling, spray cooling or prilling.

Common spray congealing encapsulants are fats and waxes of various melting points in the range from about room temperature to about 90°C. Without limitation, and only by way
20 of illustration, suitable encapsulant materials for the spray congealing process include fatty acids, fatty alcohols, fatty acid esters, hydrogenated oils, hard fats, triglycerides, and waxes.

According to certain illustrative embodiments, and without limitation, suitable hydrogenated oils include coconut oil, hydrogenated palm oil, hydrogenated cotton seed oil, hydrogenated rapeseed oil, hydrogenated canola oil, hydrogenated soybean oil and mixtures
25 thereof.

According to certain illustrative embodiments, and without limitation, suitable waxes include beeswax, candelilla wax, microcrystalline wax, rice bran wax, carnauba wax and mixtures thereof.

According to certain illustrative embodiments, the weight ratio of colorant to
30 encapsulant is between about 1:1 and 1:8; in another example between about 1:1 and about 1:5; and in another example between about 1:1 and 1:3.

According to other illustrative embodiments, particulate aggregates of the coloring composition may be formed by granulation techniques known in the art. Granulation techniques include both dry and wet granulation. Wet granulation encompasses a variety of techniques that can be described under the term of fluid-bed drying or fluid-bed granulation.

- 5 There are various methods of fluid-bed drying known in the art, including so-called “top spray”, “bottom spray”, and “tangential spray” drying.

Fluid-bed drying is the process of fluidizing a powder comprising particulate aggregates and then either spraying a coating solution or dispersion to build layers or coatings around the particulate aggregate to build a larger particle (of the “coated core” type); or
10 spraying a binder solution or suspension onto a fluidized powder of particulate aggregates and causing those particulate aggregates to agglomerate and form particulate aggregates in the form of a composite of particulate aggregates. As soon as the desired particulate aggregates are formed, spraying of a coating material or a binder solution or suspension is terminated and the liquid evaporated.

- 15 The temperature-triggered coloring compositions comprising spray congealed particles comprising a colorant encapsulated within a fat or wax encapsulant material, or fat or wax coated particles prepared by fluid bed granulation are capable of releasing the colorant, or a mixture of the colorant and a flavor, at a desired temperature during the cooking process. Regardless of the fat or wax being used as the encapsulant material of the coloring composition,
20 the release mechanism of the encapsulated colorant is triggered by temperature of the medium reaching the melting point of the encapsulant material. According to certain illustrative embodiments, the melting point of the encapsulant material is from about 50°C to about 70°C, or from about 50°C to about 65°C, or from about 50°C to about 60°C, or from about 50°C to about 55°C, or from about 55°C to about 65°C, or from about 58°C to about 62°C. During
25 standard pan frying conditions of plant-based meat analogue products, such as a plant-based burger patty analogue, the core of the burger patty reaches a temperature between about 71°C and about 74°C. According to a particular embodiment, a coloring composition comprises spray congealed droplets of a colorant encapsulated within hydrogenated palm oil with a melting point of about 58°C to about 62°C as the encapsulant material releases the colorant
30 active early enough in the frying step to ensure complete release. A spray congealing encapsulant material having a melting point near or above the final temperature of the core of the burger patty would lead to an incomplete release of the colorant active. The use of a coloring composition comprising spray congealed droplets or particles of colorant composition

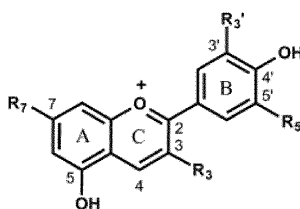
prepared by fluid bed granulation using fat/wax encapsulation materials and/or fat/wax coatings, respectively, are important to enable the release of the colorant active in a controlled manner and at a desired temperature in cooking applications of plant-based meat analogue products, such as frying of plant-based burger patty analogues, to induce a color transformation from red in the uncooked burger patty to brown-gray in the cooked burger patty upon heating. This temperature-triggered release of the colorant cannot be achieved with traditional spray drying techniques.

According to certain illustrative embodiments, the coloring composition comprises a pH-dependent colorant that is encapsulated by an encapsulating material. The coloring composition of these embodiments containing the pH-dependent colorant are prepared by the spray congealing or granulation processes described above. According to certain embodiments, the pH-dependent colorant of the coloring composition is rich in anthocyanins. The color shade of anthocyanins is highly dependent of the pH to which the colorant is exposed. The encapsulation of a pH-dependent colorant within a fat or wax provides a coloring composition having a first color at a first pH environment. The first color of the coloring composition remains the same after it is incorporated into the uncooked plant-based meat analogue burger patty since there is no pH change. Once the temperature of the burger patty is increased during cooking, such as during pan frying, to reach the melting point of the protective encapsulant, the colorant is released from the protective encapsulation and a color transformation occurs. The first color of the colorant transitions to a second color that is different from the first color in response to being exposed to a higher pH environment (a second pH) compared to the first pH the colorant was exposed to prior to encapsulation.

According to certain embodiments, the anthocyanin may be present as an extract obtained or obtainable from a plant from the *Brassicaceae*, the *Rosaceae*, the *Solanaceae*, the *Convolvulaceae*, the *Apiaceae* family, or mixtures thereof. The term mixture refers to a mixture obtained or obtainable either when the plant from the *Brassicaceae*, the plant from the *Rosaceae*, the plant from the *Solanaceae* and/or the plant from the *Apiaceae* family are extracted together using a single solvent or when the plant from the *Brassicaceae*, the plant from the *Rosaceae*, the plant from the *Solanaceae* and the plant from the *Apiaceae* family are extracted independently and the resulting extracts combined. In one example, the plant of the *Brassicaceae* family may be *Raphanus sativus* L. (red radish). In another example, the plant of the *Rosaceae* family may be the *Fragaria* (strawberry). In another example, the plant of the *Solanaceae* family may be the *Solanum tuberosum* (red potato). In yet another example, the

plant of the *Convolvulaceae* family may be *Ipomoea batatas* (purple sweet potato root). In another example, the plant of the *Apiaceae* family may be *Daucus carota ssp. sativus var. atrorubens Alef.* (black carrot).

Anthocyanins are glycosides of the sugar-free anthocyanidins (the aglycone). The sugar molecules in anthocyanins are bound via O-glycosidic bonds to one or more of the hydroxy groups typically present in an anthocyanidin molecule. Most naturally occurring anthocyanins are 3-O-glycosides.



Anthocyanidin basic structure

The most common types of anthocyanidins present in plants are cyanidin, delphinidin, pelargonidin, peonidin, petunidin and malvidin, in which hydroxy groups in the 3, 5, 7 and at least one of the 3', 4' or 5' positions are sugar-substituted. Examples of natural anthocyanins that may be used in the colorant composition include, but are not limited to pelargonidin, cyanidin and peonidin-based anthocyanins.

Examples of sugar molecules found in anthocyanin structures include arabinose, galactose, glucose, rhamnose, rutinose, sambubiose, sophorose and xylose. An anthocyanin can be substituted with hydrogen, hydroxyl, and/or methoxyl groups at various positions. Anthocyanins can also be acylated, where they can have one or more molecules esterified to the sugar molecules at the 2-, 3-, 4- and/or 6-position of a monosaccharide.

Many anthocyanins are acylated (generally at the C6-OH group of a glucose moiety), with either aliphatic acids (e.g., acetic, malic, malonic, oxalic, or succinic acid) or phenolic acids (e.g., p-hydroxybenzoic, caffeic, p-coumaric, ferulic, or sinapic acid). Thus, the anthocyanins may be in the form of an acylated glycoside anthocyanin. For example, and without limitation, pelargonidin-based acylated anthocyanins, cyanidin-based acylated anthocyanins and peonidin-based acylated anthocyanins or structural analogues of

pelargonidin-based acylated anthocyanins, cyanidin-based acylated anthocyanins and peonidin-based acylated anthocyanins.

Red radishes (*Raphanus sativus L.*) and red-fleshed potatoes (*Solanum tuberosum L.*) provide color characteristics similar to FD&C Red #40. According to embodiments, the
5 anthocyanin is a red radish derived color.

The major pigments of red radish and red-fleshed potatoes have been identified as pelargonidin-3-sophoroside-5-glucoside acylated with malonic acid and either p-coumaric and/or ferulic acids and pelargonidin-3-rutinoside-5-glucoside acylated with p-coumaric acid, respectively (Rodríguez-Saona, L.E. et al., J. Food Sci. 1999, 64, 451-456, the disclosure of
10 which is herein incorporated by reference). According to certain embodiments, the anthocyanins used in the colorant composition may comprise pelargonidin-3-sophoroside-5-glucoside acylated with malonic acid and either p-coumaric and/or ferulic acids, and/or pelargonidin-3-rutinoside-5-glucoside acylated with p-coumaric acid.

According to certain illustrative embodiments, the anthocyanin is a black carrot derived
15 color.

Recently, cyanidin 3-xylosyl(glucosyl)galactosides acylated with sinapic acid, ferulic acid, and coumaric acid were identified as the major anthocyanins in black carrot (Cuevas Montilla, E., et al., J. Agric. Food Chem. 2011, 59, 3385–3390, the disclosure of which is
20 herein incorporated by reference). According to certain embodiments, the anthocyanins used in the colorant composition comprises cyanidin 3-xylosyl(glucosyl)galactosides acylated with sinapic acid, ferulic acid, and coumaric acid.

According to certain illustrative embodiments, the anthocyanin (0.1% in pH 3.0) such as a red radish derived color (0.1% in water) has a L* value of 58.89 +/-5%, a* value of 69.81 +/-5% and b* value of 51.43 +/- 5%.

25 According to certain illustrative embodiments, the anthocyanin (0.1% in pH 3.0) such as a black carrot derived color has a L* value of 38.24 +/-5%, a* value of 62.95 +/-5% and b* value of 25.24 +/- 5%.

According to certain illustrative embodiments, the coloring composition comprises black carrot juice as the pH-dependent colorant and glycerin. The black carrot juice and

glycerin are encapsulated by an encapsulating material comprising hydrogenated palm oil. The coloring composition of these embodiments containing the pH-dependent colorant and glycerin are prepared by the spray congealing and granulation processes described above. The encapsulation of the colorant comprising black carrot juice and glycerin in hydrogenated palm
5 oil results in a red free flowing powder. According to one embodiment, the pH of the encapsulated colorant including black carrot juice and glycerin is less than 2.5. In another embodiment, the pH is 2.25 or less. These pH values can be achieved by adjusting the pH by using an acid such as for example, hydrochloric acid.

In one embodiment, the plant-derived colorant may be present in an amount from about
10 0.5% to about 3%, in another embodiment from about 0.2% to about 2%, in another embodiment from about 0.1% to about 1%, or any individual number within the range, by weight of the coloring composition.

The colorant of the coloring composition remains red once the spray congealed black carrot juice composition is incorporated into the uncooked plant-based meat analogue burger
15 patty since there is no pH change. Once the temperature of the burger patty is increased during cooking, such as by pan frying, the black carrot juice is released from the protective encapsulation and a color transition occurs. The black carrot juice transitions from a red color that mimics raw uncooked animal meat to a dark purple/grey color that mimics a cooked animal meat burger patty in response to being exposed to a higher pH environment (about pH 5)
20 compared to the pH to which the colorant active was exposed prior to encapsulation.

In another embodiment, one or more additional colorants may be mixed or blended with the red free flowing powder discussed above. The one or more additional colorants are not encapsulated and may be selected from the group consisting of a red colorant and a brown colorant. In one embodiment, the additional red colorant is selected from the group consisting
25 of betalain, phycoerythrin, monanscin, athraquinone derivative and combinations thereof. In another embodiment, the additional brown colorant is selected from the group consisting of beetroot powder, barley malt powder, caramels, caramelized fruit or vegetable powder and combinations thereof.

In one embodiment, once both the encapsulated and non-encapsulated colorants are
30 blended together, they may be incorporated into the uncooked plant-based meat analogue burger patty since there is no pH change. Once the temperature of the burger patty is increased during cooking, such as by pan frying, the blended black carrot juice and glycerin are released from the protective encapsulation and a color transition occurs. The combination of the

blended colorants transitions from a red color that mimics raw uncooked animal meat to a dark purple/grey color that mimics a cooked animal meat burger patty.

In one embodiment, the one or more additional colorants may be present in an amount from about 0.05% to about 3%, in another embodiment from about 0.2% to about 2%, in
5 another embodiment from about 0.2% to about 1%, or any individual number within the range, by weight of the coloring composition.

According to certain illustrative embodiments, the colorant composition may further include one or more flavors. According to another embodiment, the colorant composition may further include an emulsifier, such as soy lecithin.

10 According to the present disclosure, the coloring composition may be added in a sufficient amount to a meat analogue base to create a meat analogue product. A meat analogue product is a food product that approximates the aesthetic properties (for example, appearance, flavor, and texture), chemical characteristics and cooking properties of certain types of real meat, such as beef. Meat analogues are also referred to in the food industry as animal protein
15 analogues, meat alternatives, meat substitutes, mock meat, faux meat, imitation meat, vegetarian meat or vegan meat.

The coloring composition may be used to prepare a wide variety of non-animal based (for example, plant-based) consumable or otherwise edible meat analogue products. According to certain illustrative embodiments, the colorant composition may be used to prepare a wide
20 variety of consumables or otherwise edible non-animal based meat analogue products, meat replica, or meat substitute products. Suitable consumable or otherwise edible food products can be formulated, for example, without limitation, as hot dogs, burgers, ground meat, sausage links, sausage patties, steaks, filets, roasts, meatballs, meatloaf, and cubes.

According to certain embodiments, the meat analogue product comprises a non-animal
25 based burger patty comprising a non-animal food base and the colorant composition. The consumable or edible meat analogue product may comprise a non-animal based burger patty comprising a plant-derived protein base and the coloring composition. The consumable or edible meat analogue product may comprise a plant-based burger patty comprising a plant-derived protein base and the colorant composition. Without limitation, the plant-based protein
30 base may comprise a textured vegetable protein. According to further embodiments, the consumable or edible meat analogue product may comprise a plant-based burger patty comprising a plant-derived protein base and the colorant composition. Without limitation, the plant-based protein base may comprise a textured vegetable protein.

In certain embodiments, meat analogs include a high concentration of non-animal derived protein. The total amount of protein may be between about 2% by weight and about 15% by weight, or between about 2% and about 12% by weight, or between about 3% and about 10% by weight, or between about 4% and about 8% by weight, or between about 5% and about 7% by weight, or between about 6.4% to 6.5%, or about 6.4% protein by weight, or greater than 3% by weight, greater than 4% by weight, greater than 5% by weight, or greater than 6% by weight of the consumable, or any percentage ranges or specific percentages within these ranges.

According to certain embodiments, the method for making a burger patty product comprises mixing together an edible plant-derived protein base and the coloring composition to form a mixture, and forming the mixture into a burger patty. According to certain embodiments, the coloring composition may be included in the plant-based burger patty in an amount greater than 0 to about 10 weight percent, based on the total weight of the plant-based burger patty. According to certain embodiments, the coloring composition may be included the plant-based burger patty in an amount of 10 weight percent, or 9 weight percent, or 8 weight percent, or 7 weight percent, or 6 weight percent, or 5 weight percent, or 4 weight percent, or 3 weight percent, or 2 weight percent, or 1 weight percent, or 0.9 weight percent, or 0.8 weight percent, or 0.7 weight percent, or 0.6 weight percent, or 0.5 weight percent, or 0.4 weight percent, or 0.3 weight percent, or 0.2 weight percent, or 0.1 weight percent, based on the total weight of the plant-based burger patty.

According to other embodiments, a plant-based burger patty including the colorant composition may be prepared by an additive manufacturing or 3D printing process. A digital image of a three-dimensional burger patty is created with 3D modeling computer software. The 3D model of the digital file is then sliced into many thin, 2 dimensional (2D) layers using slicing software and then converted into a set of instructions in machine readable language for the 3D printer to execute. The digital file with the set of instructions in machine readable code is communicated to the additive manufacturing equipment (i.e., a 3D printer). The 3D printer prints a burger patty by laying down successive thin layers of materials through one or more nozzles.

The color compositions and the meat analogue products of the present disclosure can be analyzed with a spectrophotometer, and CIELAB $L^*a^*b^*$ values can be calculated from the spectral data, as described in greater detail below. The $L^*a^*b^*$ values provide a means of representing color characteristics and assessing the magnitude of difference between two colors. The $L^*a^*b^*$ values also provide a means of representing color characteristics and

assessing the magnitude of difference between two colors not only of solutions, but also of products. Measurements of color compositions and products in solid form are accomplished using reflectance measurements from the surface of the product.

For example, $L^*a^*b^*$ values consist of a set of coordinate values defined in a three-dimensional Cartesian coordinate system. L^* is the lightness coordinate and provides a scale of lightness from black (0 L^* units) to white (100 L^* units) on a vertical axis. a^* and b^* are coordinates related to both hue and chroma. a^* provides a scale for greenness (- a^* units) to redness (+ a^* units), with neutral at the center point (0 a^* units), on a horizontal axis; b^* provides a scale for blueness (- b^* units) to yellowness (+ b^* units), with neutral at the center point (0 b^* units), on a second horizontal axis perpendicular to the first horizontal axis. The three axes cross where L^* has a value of 50 and a^* and b^* are both zero.

ΔE is a measure of the magnitude of total color difference between two colors represented in CIELAB $L^*a^*b^*$ color space. It has been reported that an experienced color observer cannot distinguish any difference between two colors when the ΔE is about 2.3 or less. The ΔE of two different colors with $L^*a^*b^*$ values, $L^*_1a^*_1b^*_1$ and $L^*_2a^*_2b^*_2$, is calculated using Equation 1:

$$\Delta E_{ab}^* = \sqrt{(L^*_1 - L^*_2)^2 + (a^*_1 - a^*_2)^2 + (b^*_1 - b^*_2)^2}$$

Equation 1

EXAMPLES

Example 1 - Plant-based Burger Patty

The plant-based burger patty of example 1 was prepared by adding 2 weight percent of a coloring composition (per 100 g of burger patty) comprising a spray congealed powder comprising black carrot juice and glycerin as the colorant encapsulated within hydrogenated palm oil to the plant-derived protein base to form a mixture. 0.05 weight percent of beetroot powder and 0.25 weight percent of barley malt powder were also added to the mixture. The mixture was formed into a burger patty. The burger patty was cooked by pan frying until the burger patty had a surface temperature of 177°C and an internal temperature of 71°C-74°C. The color of the plant-based burger patty was visually inspected before and after cooking. As shown in FIG. 2, the raw uncooked plant-based burger patty exhibited a red color that mimics the red color of an uncooked real animal meat burger. As shown in FIG. 3, the cooked burger patty exhibited a brown-gray color that mimics the color of a fully cooked real animal meat burger patty. These results demonstrate that the coloring composition is capable of initially

imparting a red color that approximates or mimics the red color of a raw animal meat burger patty and that the initial red color transforms to a brown-gray color in the cooked burger patty.

Comparative Example 2 – Plant-based Burger Patty

5 The plant-based burger patty of comparative example 2 was prepared by adding 0.2 weight percent of black carrot juice to the plant-derived protein base to form a mixture. The mixture was formed into a burger patty. The burger patty was cooked by pan frying until the burger patty had a surface temperature of 177°C and an internal temperature of 71°C-74°C. The color of the plant-based burger patty was visually inspected before and after cooking. As shown in FIG. 4A, the raw uncooked plant-based burger patty exhibited a purple color that does not resemble the typical red color of an uncooked real animal meat burger. As shown in FIG. 5A, the cooked burger patty fell short of the brown-gray color of Example 1, FIG. 3.

15 Comparative Example 3 - Plant-based Burger Patty

 The plant-based burger patty of comparative example 3 was prepared by adding 2 weight percent of a coloring composition comprising a spray congealed powder comprising black carrot juice as the colorant encapsulated within hydrogenated palm oil to the plant-derived protein base to form a mixture. The mixture was formed into a burger patty. The burger patty was cooked by pan frying until the burger patty had a surface temperature of 177°C and an internal temperature of 71°C-74°C. The color of the plant-based burger patty was visually inspected before and after cooking. As shown in FIG. 4B, the raw uncooked plant-based burger patty exhibited a slightly reddish color that mimics the red color of an uncooked real animal meat burger. As shown in FIG. 5B, the cooked burger patty fell short of the brown-gray color of Example 1, FIG. 3.

 The coloring composition of Example 1 imparted a darker red color to the plant-based protein burger patty, as compared to the coloring composition of Examples 2 and 3. The burger patty of Example 1 exhibits a better gray interior and brown exterior that mimics the color of a fully cooked real animal meat burger patty, as compared to Examples 2 and 3.

 While the coloring composition, process for preparing the coloring composition, process for coloring a meat analogue, and meat analogue products including the coloring composition have been described in connection with various embodiments, it is to be

understood that other similar embodiments may be used or modifications and additions may be made to the described embodiments for performing the same function. Furthermore, the various illustrative embodiments may be combined to produce the desired results. Therefore, the coloring composition, process for preparing the coloring composition, process for coloring

5 a meat analogue, and meat analogue products including the coloring composition should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims. It will be understood that the embodiments described herein are merely exemplary, and that one skilled in the art may make variations and modifications without departing from the spirit and scope of the invention. All such variations

10 and modifications are intended to be included within the scope of the invention as described hereinabove. Further, all embodiments disclosed are not necessarily in the alternative, as various embodiments of the invention may be combined to provide the desired result.

CLAIMS

1. A coloring composition comprising a mixture of a pH-dependent, plant-derived colorant and glycerin, the mixture has a pH of less than 2.5; and wherein the mixture is at least
5 partially encapsulated within an encapsulant.
2. The coloring composition of claim 1, wherein the plant-derived colorant is selected from anthocyanin, pyranoanthocyanin and anthocyanidin.
- 10 3. The coloring composition of claim 2, wherein the anthocyanin is derived from a plant from the *Brassicaceae*, the *Rosaceae*, the *Solanaceae*, the *Convolvulaceae*, the *Apiaceae* family or from expressing in micro-organism such as yeast, bacteria or in microalgae or mixtures thereof.
- 15 4. The coloring composition of claim 3, wherein the anthocyanin is derived from a plant from the *Apiaceae* family.
5. The coloring composition of claim 4, wherein the plant is black carrot.
- 20 6. The coloring composition of claim 1 further comprising at least one or more additional non-encapsulated colorants.
7. The coloring composition of claim 6, wherein the at least one or more additional non-encapsulated colorants are selected from the group consisting of a red colorant and a brown
25 colorant.
8. The coloring composition of claim 7, wherein the red colorant is selected from the group consisting of betalain, phycoerythrin, monanscin, athraquinone derivative, and combinations thereof.
- 30 9. The coloring composition of claim 7, wherein the brown colorant is selected from the group consisting of beetroot powder, barley malt powder, caramels, caramelized fruit or vegetable powder, and combinations thereof.

10. The coloring composition of claim 2, wherein the anthocyanin (0.1% in water; pH 3.0) has a L* value of 38.24 +/-5%, a* value of 62.95+/-5% and b* value of 25.24 +/- 5%.
11. The coloring composition of claim 1, wherein said encapsulant is selected from a fat or
5 a wax.
12. The coloring composition of claim 11, wherein the fat is selected from the group consisting of fatty acids, fatty alcohols, fatty acid esters, hydrogenated oils, hard fats, triglycerides, and mixtures thereof.
- 10
13. The coloring composition of claim 12, wherein the hydrogenated oil is selected from the group consisting of coconut oil, hydrogenated palm oil, hydrogenated cotton seed oil, hydrogenated rapeseed oil, hydrogenated canola oil, hydrogenated soybean oil, and mixtures thereof.
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14. The coloring composition of claim 13, wherein the hydrogenated oil is hydrogenated palm oil.
15. The coloring composition of claim 11, wherein the wax is selected from the group
20 consisting of beeswax, candelilla wax, microcrystalline wax, rice bran wax, carnauba wax, and mixtures thereof.
16. The coloring composition of claim 1, wherein the composition is prepared by a spray congealing process.
- 25 17. A meat analogue comprising:
a non-animal derived protein base; and
the coloring composition according to claim 1 dispersed in said non-animal derived protein base.
- 30 18. A process for transforming the color of a meat analogue comprising:

providing a non-animal derived meat analogue comprising a non-animal derived protein base and a coloring composition comprising a pH-dependent, plant-derived colorant and glycerin, wherein the colorant and glycerin are at least partially encapsulated within an encapsulant, the non-animal derived meat analogue having a first pH environment and a first color;

heating the non-animal derived meat analogue at a temperature for time sufficient to melt the encapsulant and release the colorant and glycerin; and

exposing the colorant and glycerin to a second pH environment, wherein the cooked non-animal derived meat analogue has a second color.