

LOW SALT, LOW VISCOSITY, FUNCTIONAL BRINE**CROSS-REFERENCE(S) TO RELATED APPLICATION(S)**

[0001] This application claims the benefit of U.S. Provisional Application No. 63/617,897, filed January 5, 2024, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] Brines and marinades are commonly injected or otherwise introduced into food products, including beef, pork, poultry, fish, and plant proteins, to help retain the moisture level and enhance the flavor of the food product after completion of cooking or other food preparation. A challenge in utilizing injected brines is retention of the brine within the food product after injection and during cooking or even before cooking if there is a delay between injection and cooking. The effect of the brine is lost if not retained within the food product.

[0003] To this end, starches, phosphates, binders such as gelatins and polysaccharides, and large amounts of salt have been added to brines to aid in retention within food products. However, consumers are desirous of lower sodium food products as well as food products that have fewer or no “artificial” ingredients without compromising taste and quality.

[0004] The present disclosure seeks to address this desire of consumers and provide other benefits.

SUMMARY

[0005] In some aspects, the techniques described herein relate to a treatment solution for a food product, including: water; salt; and ground substrate of the food product being treated; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified treatment solution, protein of the ground substrate is activated to bind water to the food product when is treated with the treatment solution, and wherein the treatment solution remains at a substantially constant viscosity after emulsification.

[0006] In some aspects, the techniques described herein relate to a brine for treating a food product by injection of the brine into the food product, including: water; salt in an amount less than 3% of the brine; and ground substrate of the food product being treated less than 25% of the brine; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified injection solution, protein of the ground substrate is activated to bind water to

the food product when is injected with the brine, and wherein the brine remains at a substantially constant viscosity after emulsification and before injection into the food product.

[0007] In some aspects, the techniques described herein relate to a method of formulating a treatment solution for a food product, including: selecting a food product to be treated; mixing water with salt in an amount that is less than about 3% by weight of the treatment solution; and emulsifying the water, salt, and ground substrate of the food product being treated to define the treatment solution, wherein the ground substrate is in an amount between about 10-25% by weight of the treatment solution.

[0008] In some aspects, the techniques described herein relate to a treatment solution for a food product, consisting essentially of: water; salt; and ground substrate of the food product being treated; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified treatment solution, protein of the ground substrate is activated to bind water to the food product when the food product is treated with the treatment solution, and wherein the treatment solution remains at a substantially constant viscosity after emulsification.

[0009] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative examples, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0011] **FIG. 1** shows a picture of foam formation for various brines.

[0012] **FIG. 2** shows an exemplary method of formulating a brine in accordance with the present disclosure.

[0013] **FIG. 3** shows an elevational view of an exemplary treatment solution assembly according to various aspects of the present disclosure.

[0014] **FIG. 4** shows an exemplary top port needle carrier used to carry injection needles for injecting brine at a treatment solution assembly.

[0015] FIG. 5A shows a side cross-sectional view of an exemplary top port manifold for use with the exemplary top port needle carrier of FIG. 4.

[0016] FIG. 5B shows a top view of the exemplary top port needle carrier of FIG. 5A.

[0017] FIG. 5C shows a side cross-sectional view of a portion of the exemplary top port needle carrier of FIG. 5A.

[0018] FIG. 6 shows an elevational view of an exemplary injection needle for use with the exemplary needle carrier of FIG. 4.

[0019] FIG. 7 shows a cross-sectional view of the exemplary injection needle of FIG. 6.

[0020] FIG. 8 shows pictures of various brines after a period of time.

DETAILED DESCRIPTION

[0021] The present disclosure relates to a low salt, low viscosity functional brine or marinade that significantly improves the quality of treated food products, including improved tenderness and juiciness of a cooked food product treated with the brine. Generally, the low salt, low viscosity functional brine is composed of ground substrate of the food product to be treated (such as meat protein from the muscle of the food product and a portion of fat), a small amount of salt, and water. A small amount of ground substrate, a small amount of salt, and water are emulsified to define the low salt, low viscosity functional brine or marinade.

[0022] In the present disclosure, the terms “brine,” “marinade,” “pickle,” “formulation,” “treatment solution,” “injection treatment solution” or the like are considered to be synonymous terms and may be used interchangeably. In some aspects, the “brine,” “marinade,” “pickle,” “formulation,” “treatment solution,” “injection treatment solution” or the like, as formulated in accordance with the systems and methods disclosed herein, may be considered a “solution” and/or an “emulsion.” The terms “stable solution” and “stable emulsion” refers to mixtures that do not substantially phase-separate (or settle) after a certain length of time at a certain temperature, such as after approximately 4 hours at 40 °F.

[0023] The terms “food product,” “work product,” “food item”, and the like are considered to be synonymous terms and may be used interchangeably. Further, the term “substrate” may refer to the ground portion of food product in the brine, and/or it may refer to the portion of the food product that is being brined (such as a chicken breast of a whole chicken). In addition, the terms “salt,” “sodium,” and “sodium chloride” are considered to be synonymous terms and may be used interchangeably.

[0024] In accordance with the compositions and techniques described herein, when the food product is treated with the low salt, low viscosity functional brine, such as by injection of the brine into the food product, the low levels of salt in the functional brine activates the ground substrate protein in the brine, allowing the ground substrate protein to bind water to protein fibers of an injected food product. Further, using the compositions and techniques described herein, a reduced amount of foam is generated during brine emulsification, and the viscosity and pH of the brine remains substantially constant after emulsification and up until injection, simplifying injection.

[0025] In that regard, throughout the disclosure, exemplary aspects of the low salt, low viscosity functional brine will be described with reference to a food product that is injected with the brine. However, it should be appreciated that beneficial effects of the low salt, low viscosity functional brine may also be appreciated by using other treatment methods, such as marination. Accordingly, the descriptions provided herein should not be seen as limiting.

[0026] The food products that may be treated with the low salt, low viscosity functional brine (or simply “brine”) of the present disclosure may include, without limitation, meat masses derived from an animal source (e.g., beef, pork, poultry (e.g., chicken or turkey)), a seafood source (e.g., commercially obtained freshwater and saltwater fish, molluscan shellfish, and crustaceans, etc.), and plant-based protein material. The food products can be primals, sub primals, portions or whole food products. One example of a whole food product may be a whole chicken. Examples of portions may include a poultry breast or a fish fillet.

[0027] For animal or seafood products, the portion or substrate of the food product to be treated may include the muscle of the food product. As such, the ground substrate for the brine may also be derived from the muscle of the food product. In that regard, the ground substrate may consist primarily of myofibrillar protein and sarcoplasmic protein. The proportion of myofibrillar protein and sarcoplasmic protein in the brine for an animal or seafood product may generally correspond to the proportion naturally occurring in the portion or substrate of the food product being brined. The ground substrate may be derived from muscle of animal or seafood products that has undergone rigor mortis induced changes or prior to rigor mortis.

[0028] The proteins of plant food products are mostly globulins and albumins. The proportion of globulin protein and albumin protein in the brine may therefore generally correspond to the proportion naturally occurring in the corresponding type of plant food product being

brined. Proteins are present over many orders of magnitude in molecular weight, ranging from a few thousand kilodaltons to several million kilodaltons.

[0029] The ground substrate can be derived from trimmings of the food product to be brined, such as trimmings left over from slicing, cutting, trimming, or portioning of the food product. For example, if the food product is boneless, skinless chicken breast, the ground substrate can be derived from trimmings of boneless, skinless chicken breasts recovered during slicing and/or portioning (such as during high-speed portioning). The trimmings can be ground up and then an emulsion formed with salt and water, so the emulsion is injectable into the food product.

[0030] A stable emulsion (or solution) has numerous advantages for use as an injectable brine. A stable emulsion (or solution) can more effectively be used in an industrial process because it does not require continuous mixing to maintain the dispersal of the components of the mixture. This allows for consistency between uses in an industrial food process and requires less specialized handling to use predictably. Additionally, a stable solution can hold onto the components of the brine after injection, rather than separating out and dripping out in parts. For example, in an unstable solution containing food proteins, protein aggregation can result in particulate formation as well as settling. This can lead to settling and loss of protein material, as well as material damage to any pumps used in transporting such solutions.

[0031] To avoid the downsides of non-stable emulsions (or solutions), various mixing techniques have been used in food manufacturing. For example, fluid agitation and high-pressure homogenization may be used to disintegrate protein aggregates. However, these techniques add material complexity to the storage and transportation systems of a food processing system. Brines formulated in accordance with the systems and methods disclosed herein can be considered a stable emulsion or a stable solution. It should be appreciated that the ground substrate can instead originate from other sources, such as by grinding an entire piece of the food product to be treated. For instance, if the food product is whole, boneless, skinless chicken breasts, one or more whole, boneless, skinless chicken breasts (optionally from the batch of chicken breasts being brined) may be ground and used to formulate the brine. The ground substrate may comprise between about 10-25% by weight of the brine. In some examples, the ground substrate may comprise between about 10-20% by weight of the brine.

[0032] As noted above, ground substrate of the food product is emulsified with salt and water (e.g., for about two minutes) to form the brine. Water will comprise a significant proportion of the brine, typically from about 70 to 90% by weight of the brine. The water may be softened

or otherwise purified or treated, for example, by reverse osmosis. Part of the water may be provided in the form of ice to result in a brine temperature after emulsification that is generally below 32° F. Desirably, the temperature of the brine at the time of injection into the food product substrate will be from about 24° to 32° F. It is desirable that the brine does not facilitate bacteria growth in the food product between injection and prior to cooking or other processing of the food product. One way to address this issue is to maintain the brine temperature below the temperature of the food product being treated.

[0033] Various flavorings, including, for example, seasonings, spices, and juices, may be utilized in the brine so as to achieve a desired taste or flavor for the food product. The flavoring can make up from about 1% to 25% of the brine by weight. Many different flavorings, spices, seasonings, and juices can be used. The following are a few examples: sugar, pepper, garlic (dehydrated, minced, fresh), parsley, thyme, mulling spices, chamushka (seeds), coriander (seeds), cinnamon, fennel (seeds), mustard (ground, seeds, etc.), old spice (berries), ginger (with or without the skin), Bengal bay, cumin (seeds), blade mace, cardamom (seeds), chilis, lemon (peel or juice), mint, bay leaf, anise (seeds), lime (peel or juice), orange (peel or juice), pomegranate, molasses, curry, ajowan (seeds), cloves, honey, vinegar, yogurt, etc. The foregoing listing is not meant to be inclusive or limiting. Also, the spices and herbs and other flavorings can be fresh or dehydrated.

[0034] A thickener may optionally be added to the brine. One type of possible thickener is a hydrocolloid such as gelatin, agar, or starch, such as rice starch. The thickening agent may be used in an amount from about 1 to 4% by weight of the brine. Of course, an amount of the thickening agent beyond this range may also be utilized. The inventor has found that the use of emulsified ground substrate, low levels of salt, and water for the brine can produce a relatively low viscosity brine. In that regard, a thickening agent may be used if a higher viscosity is desired.

[0035] A low viscosity brine formulated in accordance with the systems and methods disclosed herein, may function as a Newtonian fluid. The viscosity of a Newtonian fluid is substantially unchanged by exposure to shear conditions. In contrast, the viscosity of a non-Newtonian fluid can undergo thickening or thinning when exposed to shear stress, such as the shear stress arising from flow of the fluid across a surface. For example, sources of shear stress can include injector pumps, mixing and transportation pumps, homogenizers, and needles.

[0036] In one scenario, the exposure of a non-Newtonian fluid to shear stress can induce additional thickening of the non-Newtonian fluid to the point that it is functionally a semi-solid or solid-phase material, making injection and transportation difficult.

[0037] One advantage of a low viscosity brine is that flowing higher viscosity fluids can require additional power usage. Accordingly, one advantage of a brine that is a Newtonian fluid is that the viscosity of the LVB does not substantially change during transportation and injection into a product. A non-Newtonian fluid, on the other hand, may undergo substantial increases in viscosity during transportation, thus leading to unexpected additional power requirements as compared to transportation of lower viscosity fluids.

[0038] The brine may also optionally utilize a preservative or antioxidant. One example is sodium erythorbate. This compound serves as a preservative, but also assists in flavor stability of the treated food product. Other preservatives, for example, sodium lactate, sodium diacetate, dried vinegar, or a lemon-based product, may be used in place of sodium erythorbate. In some examples, sodium erythorbate may be employed in the brine in quantities of from about 0.2% to 0.5% of the brine by weight.

[0039] Further details regarding an exemplary composition of a brine of the present disclosure will now be described. In general, the percentages of each of the ground substrate, water, and salt (or the “brine composition”) may be chosen to at least one of minimize natural protein activation in the brine before treatment (e.g., while in the injector saddle tank), maximize natural protein activation in the brine after treatment, maximize the amount of water that binds to the to the treated food product, optimize the pH of the brine, minimize foam produced during emulsification of the brine, optimize the pH in a treated, finished food product (e.g., brined raw product, brined raw and frozen product, brined cooked product, brined cooked and frozen product, etc.), minimize salt content in a treated, finished food product, optimize the viscosity of the brine, and optimize yield of the treated, finished food product.

[0040] In some examples, the brine includes low levels of salt to activate the substrate protein in the injected brine, allowing the substrate protein to bind water to protein fibers of an injected food product. The solubility of proteins in water can vary widely based on intermolecular dynamics of the protein, solution conditions, and environmental conditions. Moreover, unlike low-molecular weight additives, like table salt (0.05844 kilodaltons), the drastic variability in the size of proteins can be an important fact in itself which can alter the solubility of proteins.

[0041] One means by which the solubility of a protein can be directly altered is through the salting-in and salting-out process. In the salting-in process, proteins are exposed to an aqueous salt solution, such as aqueous sodium chloride. The salt ions can stabilize protein molecules in the solution phase, such as through ion-dipole interactions between the protein and the ions in the solution. Intermolecular interactions between salt ions and proteins, such as ion-dipole interactions, compete with and thereby decrease the intramolecular interactions within individual protein molecules. Intermolecular interactions between salt ions and proteins also compete with, and thereby decrease, the intermolecular interactions between different protein molecules by stabilizing local dipoles within the protein. By thus decreasing protein-protein electrostatic interactions, water molecules are better able to solvate the protein molecules, thereby increasing the solubility of the protein molecule.

[0042] Conversely, in the salting-out process, the higher concentration of salts in an aqueous solution, such as aqueous sodium chloride, changes the intermolecular dynamics described above. High-charge low-volume ions, like salt ions, interact strongly with the large dipole moment of water. As the salt concentration increases, these ion-dipole interactions between salt and water begin to predominate over the dipole-dipole and hydrogen bonding interactions between proteins and water. With the decrease in protein-water interactions, protein-protein interactions become more dominant. This results in a decrease in solubility for the protein molecules, and even to a precipitation of the protein molecules into protein aggregates.

[0043] The inventor has unexpectedly found that a relatively low amount of salt (% grams), when emulsified with a relatively low amount of ground substrate (% grams) in water, optimally activates the protein naturally occurring in the meat substrate when the brine is injected. Without being bound by theory, the relatively low amount of salt used in the brine can take advantage of the peak solubility of proteins at the crossover point between salting-in and salting-out effects in solution (referred to sometimes herein as the maximum solubility of protein in the brine, or the salt-in/salt-out crossover point). Thus, for a given composition of ground substrate comprising naturally occurring proteins in the meat substrate, the amount of salt can be chosen to achieve maximum solubility for the meat substrate proteins. At this point, the viscosity of the solution can be at its low point, and the resulting emulsion can be maximally stable against settling or separation. This thus improves the ability of the brine to be retained in the meat substrate when the brine is injected. In some examples, salt may comprise between about 0.1-3% by weight of the brine. In some examples, salt may comprise less than 2% by

weight of the brine. In some examples, salt may comprise less than 2% by weight of the brine, and ground substrate may comprise between about 10-20% by weight of the brine.

[0044] In some examples, the level of salt used in the brine may be based on a target of about 0.25% salt content in the treated (or the brined) finished food product. The inventor has unexpectedly found that when using a brine having a sufficiently low level of salt (e.g., about 1.9% salt, injecting to a target of 15.2%) to achieve an injected substrate salt content of about 0.25%, the viscosity of the brine is optimized. For instance, the brine is of a sufficiently low viscosity to support injection and distribution within the substrate, among other benefits (e.g., minimizing natural protein activation in the brine before treatment, maximizing natural protein activation in the brine after treatment, maximizing the amount of water that binds to the to the treated food product, optimizing the pH of the brine, minimizing foam produced during emulsification of the brine, optimizing the pH in a treated food product, and optimizing yield of the treated food product).

[0045] If a higher salt content is used, the inventor has found that the brine becomes more viscous and compromises injection, distribution, and other benefits, such as texture and bite of the treated food product. In some examples, the brine composition may also/instead be chosen to maximize natural protein activation of the ground substrate in the brine after treatment (e.g., injection). Activation of the ground substrate protein in the brine may include biochemically altering the natural protein of the ground substrate such that it becomes functional for binding water to protein(s) in the treated food product substrate after injection. For instance, mechanical action from the mixing (e.g., milling) process combined with added salt may cause the natural protein to change state, become functional, and bind water to the treated food product after injection. In that regard, activation of the ground substrate protein in the brine may include optimizing self-binding properties of the natural protein of the ground substrate.

[0046] Maximizing natural protein activation of the ground substrate in the brine after treatment may necessarily maximize the amount of water that binds to the treated food product. When the natural protein is activated in the ground substrate after treatment, it will change state and become functional, causing it to bind water to the treated food product. The activated protein in the injected brine binds water to the treated food product, resulting in a tender, juicy finished food product with low salt content. These benefits and others will further become appreciated in the example(s) that follow. For instance, the viscosity of the low salt brine may also remain substantially constant after emulsification and up until

treatment. In that regard, brines formulated in accordance with the present disclosure may be considered a low viscosity brine, especially if compared to other brines using ground substrate. As such, in the examples below and elsewhere in this application, the brines formulated in accordance with the present disclosure may be identified by the designation “LVB solution” or similar, which signifies a low viscosity brine.

EXAMPLE 1

[0047] Testing was performed to ascertain yield to green (brine retention in a raw, brined food product), cook yield (brine retention in a cooked, brined food product), the level of salt and substrate in a brined, raw or cooked food product, and the bite and texture of a cooked brined food product using an LVB solution. This test was conducted using raw small and large boneless, skinless chicken breasts.

LVB Solution

[0048] An LVB solution formulated with ground substrate (“trim”), salt, and water is set forth in Table 1. The LVB solution formulation and injection amount (the quantity of brine as a percentage of the weight of the food product) was based on a target of 15.2% by weight yield or pickup after injection (e.g., adding 15.2% moisture or adding 15.2% of the LVB solution to the raw food product from the injection). As a non-limiting example, for 87 pounds of meat, about 13.2 pounds of the LVB solution may be used for the injection to result in about 15.2% yield or pickup after injection ($13.2/87=0.152$). In one example, the LVB solution may be formulated with about 11 pounds of brine and about 3 lbs of trim to result in about 15.2% yield.

[0049] The ground substrate consisted of ground trim from portioned ground large boneless, skinless chicken breasts. In that regard, the fat to lean breast meat ratio of the ground substrate was about 10%, which was substantially the same as the fat to lean breast meat ratio of the large boneless, skinless chicken breasts to be brined.

[0050] The salt was sodium chloride (NaCl), commonly known as table salt.

Table 1. LVB Solution (target of 15.2% yield after injection)

Ingredient	% in LVB Brine	% in Final	Lbs in LVB Brine
Water	79.19%		118.79
Trim	18.92%	2.50%	28.38
Salt	1.89%	0.25%	2.83
Total	100.00%		150.00

Test Procedures

[0051] The water was softened and cooled overnight. The cooled, softened water was then placed in a freezer so that part of the water was provided in the form of ice to result in a brine temperature after emulsification generally below 32°F.

[0052] The LVB solution for this test was mixed using a mill having a 1.2mm whole plate and double knife cutting head (e.g., an F-150 mill or a PFE80 triple knife.) The water/ice, and salt were first mixed in the mill for about 15 seconds. The temperature of the water/ice and salt solution was about 26°F.

[0053] Large boneless, skinless chicken breast trim was retrieved from a high speed portioner, ground, and placed in a cooler. The trim was added to the water/ice and salt solution and emulsified for 2 minutes to create a homogeneous LVB solution at around 9:00am. The trim was 34°F when added to the water/ice and salt solution. After emulsification, the temperature of the LVB solution was 33°F. Polar ice was used to control the temperature of the LVB solution to be generally below 32°F up until injection.

[0054] The raw, large boneless, skinless chicken breasts to be brined were weighed and run through an injector. Measurements of the injected raw, large boneless, skinless chicken breasts, including purge measurements, were taken. The test finished around 4:00pm.

[0055] The chicken breasts were injected using an IMAX 350 HVB injector with a 50-needle manifold having 4mm hypodermic needles. The injector settings (e.g., parameters that can be changed on injector) are set forth in Table 2 below.

[0056] The first column in Table 2 indicates the strokes per minute of the injector, based on available settings of 1-9 strokes per minute (how many times the injector head goes up and down in a minute). The second column in Table 2 indicates the pressure used by the injector, in units of bar. The third column in Table 3, referencing the “speed”, indicates the speed of the needle as it moves down into the meat and back up. The fourth column in Table 2, referencing the “advance”, is based on a full or partial advance of the belt beneath the injector for every time it moves, with a full advance in this case being 40 mm. Accordingly, the belt moved 40 mm every advance. The fifth column in Table 2 is the injection mode used, with the option in the case being a one-way spraying from the needles as they are moving down into the meat or

a two-way spraying as the needles are moving down and also back up. The injector mode used was a one-way spraying.

Table 2. Injector Settings

Pressure	Speed	Advance	Mode
1.0	9	Full	1 Way

Yield Data

[0057] Tables 3 and 4 pertain to the yield and pick up using the LVB solution to inject large and small boneless, skinless chicken breasts, respectively.

[0058] Table 3, which pertains to injected large boneless, skinless chicken breasts, includes a first column providing the initial or “green” weight in pounds of each of the large boneless, skinless chicken breasts. The second column in Table 3 indicates the weight of the large boneless, skinless chicken breasts in pounds after injection. The third column in Table 3 indicates the percentage of pickup after injection, or the percent increase in weight of the injected large boneless, skinless chicken breasts from the green weight, accounting for any purge removed. As can be seen in Table 3 below, when injecting the large boneless, skinless chicken breasts using the above LVB solution, the weight of the large boneless, skinless chicken breasts increased by an average of 18.2%.

Table 3. HVB Injected Large Boneless, Skinless Chicken Breast Data

Green Wt (lbs)	Injected Wt (lbs)	% Pickup
9.13	11.11	21.7%
9.04	10.61	17.4%
8.53	10.08	18.2%
8.41	9.9	17.7%
8.51	10.28	20.8%
8.36	9.97	19.3%
8.36	9.97	19.3%
10.57	12.66	19.8%

Average % Pickup	18.2%
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[0059] Table 4, which pertains to injected small boneless, skinless chicken breasts, includes a first column providing the green weight in pounds of each of the small boneless, skinless chicken breasts. The second column in Table 4 indicates the weight of the small boneless, skinless chicken breasts in pounds after injection. The third column in Table 4 indicates the percentage of pickup after injection, accounting for any purge removed. As can be seen in Table 4 below, when injecting the small boneless, skinless chicken breasts using the above LVB solution, the weight of the small boneless, skinless chicken breasts increased by an average of 15.2%.

Table 4. HVB Injected Small Boneless, Skinless Chicken Breast Data

Green Wt (lbs)	Injected Wt (lbs)	% Pickup
8.88	10.42	17.3%
8.55	9.83	15.0%
8.86	10.29	16.1%
8.87	10.23	15.3%
9.09	10.60	16.6%
8.68	10.02	15.4%
Average % Pickup		15.2%

[0060] Table 5 pertains to cumulative purge data for the large and small boneless, skinless chicken breasts injected with the LVB solution. The first column provides the cumulative green weight in pounds of the large and small boneless, skinless chicken breasts. The second column in Table 5 indicates the cumulative weight of the large and small boneless, skinless chicken breasts in pounds after injection. The third column in Table 5 indicates the percentage of pickup after injection for all the large and small boneless, skinless chicken breasts injected with the LVB solution, accounting for any purge removed. The purge quantity (pounds) is shown in the fourth column, and the fifth column provides the percent purge after injection for all the large and small boneless, skinless chicken breasts injected with the LVB solution. As can be seen in Table 5 below, when injecting the large and small boneless, skinless chicken breasts using the

above LVB solution, the total injected weight of the large and small boneless, skinless chicken breasts increased by 18.03%.

Table 5. Purge Data

Green Wt (lbs)	Injected Wt (lbs)	% Pickup	Purge (lbs)	% Purge
195.1	230.3	18.03%	2.3	0.98%

[0061] In this example, the inventor unexpectedly found that the LVB solution having a composition of about 1.7-2% by weight salt, about 18.9% by weight ground boneless, skinless chicken breast substrate, and about 79.2% by weight water was optimal for brining boneless, skinless chicken breasts. For instance, the percentage of pickup after injection, or the percent increase in weight for the injected large boneless, skinless chicken breasts from the green weight was 18.2%. Moreover, the percentage of pickup after injection for the injected small boneless, skinless chicken breasts from the green weight was 15.2%.

[0062] The pickup after injection is indicative of moisture retention, which is the result of the activated protein becoming functional and binding water to the injected substrate. The activated proteins also assist in binding water during the cooking process, resulting in a tender juicy cooked product. The emulsified meat substrate increases the surface area of the ground substrate, and the salt activates the natural functional meat protein in the LVB solution, helping to bind water to the injected substrate.

[0063] Although not represented in the test data set forth above, the inventor compared the bite and texture of cooked boneless, skinless chicken breasts injected with the LVB solution to the bite and texture of cooked small boneless, skinless chicken breasts injected with the LVB solution. The bite and texture of the cooked boneless, skinless chicken breasts injected with the LVB solution was like the bite and texture of cooked small boneless, skinless chicken breasts injected with the LVB solution. This was unexpected, seeing as small boneless, skinless chicken breasts injected with a brine would normally be juicier and more tender than boneless, skinless chicken breasts injected with the same brine. In that regard, boneless, skinless chicken breasts are typically injected with a brine having a higher salt content and/or a higher trim content.

[0064] Typically, a brine for boneless, skinless chicken breasts would include about 4.9% salt and about 25% substrate to achieve yield like that set forth above in Tables 3 and 4. Such a

brine formulation results in a higher level of salt (e.g., 0.50%) in the finished boneless, skinless chicken breasts. Here, the LVB solution resulted in a finished product having only about 0.25% salt, as shown in Table 1.

[0065] In some examples, the LVB solution may be formulated to include between about 1-20% by weight ground substrate, about 70-85% by weight water, and about 0.1-3% by weight salt to achieve yield and salt content in a finished product similar to that set forth above.

[0066] In some examples, the LVB solution may be formulated to optimize the viscosity of the brine for maximizing the injection process according to known injection principles. For instance, a brine composition having a predetermined percentage of salt and ground substrate may result in an optimally viscous brine that is suitable for injecting the intended food product.

[0067] In one example, an optimally viscous brine may include a formulation that is at or below a certain level (e.g., in newton-seconds per square meter or pascal-seconds) after mixing (e.g., after emulsification of the water/ice, salt, and ground substrate). The viscosity level may be determined based on desired dispersion within the intended substrate, the needle(s) selected for injection, etc.

[0068] In some examples, an optimally viscous brine may include a formulation that remains at a substantially constant viscosity within a reasonable amount of time after mixing. In that regard, after a brine is mixed and before it is used for injection, the brine solution is often stored in an injector saddle tank. During this hold time, the viscosity of prior art brines often change, and specifically, they often increase in viscosity as they sit in the tank. Such a change in viscosity may cause issues during injection and can be difficult to control, especially when the brine is not always stored in an injector saddle tank for the same amount of time. Thus, an optimally viscous brine may include a formulation that remains at a substantially constant viscosity for at least a time generally needed between mixing and injection, such as one hour.

[0069] In some examples, the LVB solution may be formulated to include between about 1-20% ground substrate, about 70-85% water, and about 0.1-3% salt to achieve a desired viscosity.

[0070] A brine or LVB solution formulated in accordance with the present disclosure can achieve an optimal viscosity, which will further become appreciated in the example that follows.

EXAMPLE 2

[0071] Testing was performed to assess the viscosity and pH of a brine or LVB solution formulated in accordance with the present disclosure. In particular, the inventor tested the hypothesis that the viscosity and pH of an LVB solution remained substantially the same for the LVB solution after emulsification up until injection.

Brine Solutions

[0072] Brine solutions having different levels of salt were made to assess changes in the viscosity and pH of the brine solution. The brine solutions are labeled as “Brine 1”, “Brine 2”, and “Brine 3.”

[0073] Each brine solution was formulated with ground substrate (“trim”), salt, and water. The ingredient list for Brine 1, Brine 2, and Brine 3 is set forth below in Tables 6, 7, and 8, respectively. Brine 1 may be considered an LVB solution formulated in accordance with the present disclosure; and therefore, Brine 1 may be referred to as an LVB solution. The first column of Tables 6, 7, and 8 provide the ingredient in the brine solution. The second column of Tables 6, 7, and 8 provides the percentage by weight of the brine solution for each ingredient. The third column of Tables 6, 7, and 8 provides the target percentage by weight of the ingredient in the final food product. The fourth column of Tables 6, 7, and 8 provides the weight (in grams) of each ingredient in the brine, as well as the total weight (in grams) of the brine solution thus prepared.

[0074] The ground substrate consisted of ground trim from roughly four-ounce (4oz) fillets of small bird, boneless, skinless chicken breasts. The salt was sodium chloride (NaCl).

Table 6. Brine 1 (LVB Solution)

Ingredient	% in Brine	% in Final	Grams (g) in Brine
Water	79.18%		395.9
Trim	18.92%		94.6
Salt	1.9%	0.25%	9.5
Total	100.00%		500.00

Table 7. Brine 2

Ingredient	% in Brine	% in Final	Grams (g) in Brine
Water	77.3%		386.5

Trim	18.92%		94.6
Salt	3.78%	0.5%	18.9
Total	100.00%		500.00

Table 8. Brine 3

Ingredient	% in Brine	% in Final	Grams (g) in Brine
Water	75.4%		377.0
Trim	18.92%		94.6
Salt	5.68%	0.75%	28.4
Total	100.00%		500.00

Test Procedures

[0075] Softened, cooled water including 25% ice were mixed with salt and trim using a tabletop blender, blending each brine for about 60 seconds.

[0076] Viscosity and pH measurements were each taken after mixing the brine ingredients together in the blender, and then again about one hour after mixing. The viscosity was measured three times in each instance, and the average of the three measurements was recorded.

[0077] The viscosity of each brine was measured using a Stein Hall Viscosity Cup (or a “Stein Cup”). Viscosity readings were taken by recording the time, in seconds, for a set volume of each brine to drop from an upper pin in a calibrated Stein Hall Viscosity Cup to a lower pin when flowing through an orifice in the cup. The Stein Hall Viscosity Cup measurement is a common viscosity measurement technique used for measuring the viscosity of fluids in the food industry. This technique can be used by people of any technical skill level, has simple well understood measurement units (seconds), and is repeatable when conditions are held constant.

[0078] The pH of each brine was measured using a pH meter. As a baseline, the pH of each ingredient was also measured using a pH meter before the brine was formulated. For each brine, the pH of the water was 8.05, the pH of the chicken breast trim was 5.99, and the pH of the salt was between 7.04-7.29 (for Brine 1, the pH of the salt was 7.04, for Brine 2, the pH of the salt was 7.29, and for Brine 3, the pH of the salt was 7.24).

Viscosity and pH Data

[0079] Tables 9, 10, and 11 provide viscosity and pH measurements for Brines 1, 2, and 3, respectively, after mixing the brine ingredients together in the blender, and then again about

one hour after mixing. In that regard, for each of Tables 9, 10, and 11, the first column provides the viscosity reading after mixing, the second column provides the viscosity reading about one hour after mixing, the third column provides the pH reading after mixing, and the fourth column provides the pH reading about one hour after mixing.

[0080] As can be seen by comparing the data of Tables 9, 10, and 11 below, the viscosity of Brine 1, the LVB solution, remained substantially the same one hour after mixing. Specifically, the viscosity of Brine 1, the LVB solution, was 4.03 after mixing, and it was 4.0 one hour after mixing (Stein Hall Viscosity Cup measurement).

[0081] The viscosity of Brines 2 and 3 both increased after mixing. In particular, Brine 2 increased in viscosity from 5.73 to 7.2 (Stein Hall Viscosity Cup measurement), and Brine 3 increased in viscosity from 4.95 to 7.9 (Stein Hall Viscosity Cup measurement).

[0082] It is also noted that the initial viscosity level of Brine 1, the LVB solution, which was 4.03, was much lower than the initial viscosity levels of Brine 2 and 3 respectively, which was 5.73 and 4.95, respectively. For comparison, the viscosity of pure water is 4.0, whereas a high viscosity brine (“HVB”; described further herein below with respect to FIGS. 4 and 5) has a viscosity of between 12 and 25, meaning the LVB solution has a viscosity similar to the viscosity of water.

[0083] As can further be seen by comparing the data of Tables 9, 10, and 11 below, the pH of Brine 1, the LVB solution, remained substantially the same one hour after mixing. Specifically, the pH of Brine 1, the LVB solution, was 5.91 after mixing, and it was 5.96 one hour after mixing. However, the pH of Brines 2 and 3 also remained substantially the same one hour after mixing. Specifically, the pH of Brine 2 was 5.94 after mixing, and it was 5.93 one hour after mixing. Moreover, the pH of Brine 2 was 5.84 after mixing, and it was 5.84 one hour after mixing. It is also noted that the pH of each of Brines 1, 2, and 3, were all about the same.

Table 9. Brine 1 (LVB Solution) Viscosity and pH Data

Viscosity after mixing	Viscosity one hour after mixing	pH after mixing	pH one hour after mixing
4.03	4.0	5.91	5.96

Table 10. Brine 2 Viscosity and pH Data

Viscosity after mixing	Viscosity one hour after mixing	pH after mixing	pH one hour after mixing
5.73	7.2	5.94	5.93

Table 11. Brine 3 Viscosity and pH Data

Viscosity after mixing	Viscosity one hour after mixing	pH after mixing	pH one hour after mixing
4.95	7.9	5.84	5.84

[0084] As can be appreciated from the test data set forth above, Brine 1, or the LVB solution, which activates a relatively low amount of ground substrate with low levels of salt, remains at a substantially constant viscosity within a reasonable time period after mixing and before injection, such as one hour. Similar to the difference between Newtonian and non-Newtonian fluids, a brine that undergoes thickening over time can introduce challenges to a food processing system, where maintaining a consistent viscosity over the course of processing can be important to maintain proper power allocation, as well as avoiding any clogging that may occur. By selecting a salt concentration where viscosity remains relatively stable, optimal system function can be maintained.

[0085] Moreover, the viscosity level of the LVB solution is lower than the viscosity level of brines with a higher salt content (Brines 2 and 3). In that regard, increasing the salt content of the brine increased the brine viscosity both after mixing and after a reasonable time period after mixing. An LVB solution formulated in accordance with the present disclosure optimizes the viscosity of the brine without compromising the bite and texture of the injected food product (per the results of the tests using an LVB solution in Example 1 above).

[0086] The inventor calculated that an LVB solution, such as Brine 1 has a protein level of around 4%. In that regard, low levels of salt prevent the activation, swelling, and/or extracting of protein in the LVB solution, which would otherwise cause the viscosity to change or increase.

[0087] Moreover, the LVB solution remains at a substantially constant pH after mixing and within a reasonable amount of time after mixing and before injection, such as one hour. However, the pH of brines with a higher salt content (Brines 2 and 3) also remained at a substantially constant pH after mixing and within a reasonable amount of time after mixing and before injection, such as one hour. Thus, the LVB solution did not have a significant impact on pH. In other words, the pH of the LVB solution was stable and did not decline after mixing.

[0088] Additional testing, not included in the Example 2 test data set forth above, was performed to assess the viscosity of the LVB Solution (Brine 1) with phosphate added. In particular, the inventor wanted to determine whether the addition of phosphate would positively or negatively affect the viscosity of the LVB Solution after emulsification up until injection. Phosphates have been commonly used as additives in the food industry for their ability to help a meat substrate retain moisture during the brining process.

[0089] To perform the test, a small amount of phosphate was added to the LVB Solution, making a “Brine 4”. The viscosity (Stein Hall Viscosity Cup measurement) of Brine 4 was unreadable within 30 seconds of mixing the formulation. In other words, Brine 4 was so highly viscous that it did not flow from a Stein Hall Viscosity Cup within a reasonable amount of time. By comparison, the viscosity of the LVB Solution (Brine 1), which is set forth above, was at an initially low viscosity and did not change even an hour after emulsification. Thus, the inventor concluded that the addition of phosphate to the LVB Solution negatively affects the viscosity of the LVB Solution. The increased viscosity of the LVB Solution mixed with phosphate, results in a HVB that, when used to treat a chicken product, results in a finished chicken product (e.g., a treated chicken product after it is cooked) coated in a glue-like substance that looks undesirable and unacceptable. The LVB solution results in a finished chicken product that has a natural juicy bite, while the addition of phosphate results in a bite that is slightly springy and with a ham-like texture. Such a product would be undesirable to consumers, despite any advantages that may result from increased moisture retention due to the addition of phosphate.

[0090] Although also not represented in the test data set forth above, the inventor also compared the foam formation or aeration for each of Brines 1, 2, and 3 during mixing. It can be appreciated that a brine having a high foam content can either cause issues during injection, or the brine must be stored until the foam dissipates (or other measures must be taken). Thus, minimal foam formation is typically desired.

[0091] FIG. 1 shows a picture of foam formation for each of Brine 1, Brine 2, and Brine 3. Each measuring cup contains 500 grams of brine. The height of Brine 1, the LVB solution, is the lowest in the cup because it generated the least amount of foam during mixing. The height in the cup of Brines 2 and 3 are significantly higher than the height of Brine 1 because they generated more foam during mixing. Moreover, the foam of Brines 2 and 3 did not dissipate within 24 hours.

[0092] A brine or LVB solution formulated in accordance with the present disclosure can achieve an optimal solution or emulsion stability, which will further become appreciated in the example that follows.

EXAMPLE 3

[0093] Testing was performed to assess the stability of a brine or LVB solution formulated in accordance with the present disclosure, as well as cook yields on chicken breast treated with a brine or LVB solution formulated in accordance with the present disclosure. In particular, the inventor tested the hypothesis that an insufficient amount of salt in the brine leads to a more unstable brine solution.

Brine Solutions

[0094] Brine solutions having different levels of salt were made to assess changes in the viscosity and pH of the brine solution. The brine solutions are labeled as “Brine 5”, “Brine 6”, and “Brine 7.” A control solution was also prepared without the presence of trim and is labeled as “Brine 8.” A control solution was also prepared without the presence of trim and with the presence of phosphate and is labeled as “Brine 9” To compare yields of LVB to the most commonly used marinades.

[0095] Each brine solution was formulated with ground substrate (“trim”), salt, and water. The ingredient list for Brine 5, Brine 6, Brine 7, Brine 8, and Brine 9 is set forth below in Tables 12, 13, 14, 15, and 16, respectively. Brine 5 may be considered an LVB solution formulated in accordance with the present disclosure; and therefore, Brine 5 may be referred to as an LVB solution. The first column of Tables 12–16 provide the ingredient in the brine solution. The second column of Tables 12–16 provides the percentage by weight of the brine solution for each ingredient. The third column of Tables 12–16 provides the target percentage by weight of the ingredient in the final food product. The fourth column of Tables 12–16 provides the weight (in pounds) of each ingredient in the brine, as well as the total weight (in pounds) of the brine solution thus prepared.

[0096] The ground substrate consisted of ground trim from roughly four-ounce (4oz) fillets of small bird, boneless, skinless chicken breasts. The salt was sodium chloride (NaCl).

Table 12. Brine 5 (LVB)

Ingredient	% in Brine	% in Final	Pounds (lb) in Brine
Water	82.31		123.46
Salt	1.61	0.25%	2.41
Trim	16.08		24.13
Total	100.00%		150.00

Table 13. Brine 6

Ingredient	% in Brine	% in Final	Pounds (lb) in Brine
Water	83.11		124.67
Salt	0.80	0.125%	1.21
Trim	16.08		24.13
Total	100.00%		150.00

Table 14. Brine 7

Ingredient	% in Brine	% in Final	Pounds (lb) in Brine
Water	83.92		125.87
Salt	0.00	0.00%	0.00
Trim	16.08		24.13
Total	100.00%		150.00

Table 15. Brine 8 (Control)

Ingredient	% in Brine	% in Final	Pounds (lb) in Brine
Water	96.17		96.17
Salt	3.83	0.50%	3.83
Total	100.00%		100.00

Table 16. Brine 9 (Control + Phosphate)

Ingredient	% in Brine	% in Final	Pounds (lb) in Brine
Water	93.10		209.48
Salt	3.83	0.50%	8.63
Phosphate	3.07	0.40%	6.90
Total	100.00%		225.00

Test Procedures

[0097] Stability of Brine 5, Brine 6, and Brine 7 were evaluated by preparing batches of brine as indicated above. Approximately 3 cups was taken as a sample from the 150-pound batch in a glass container and set in a cooler for approximately 3 hours and observed for signs of separation into phases.

[0098] The effect on cooked chicken was determined by injecting Brine 5, Brine 6, and Brine 7 into chicken breast fillets, which were then tumbled and portioned into strips before cooking to an internal temperature of 165 °F. Control Brine 8 was tumbled with portioned chicken breast fillets (i.e., strips).

[0099] Retention of Brine 5, Brine 6, and Brine 7 was determined by measuring the mass increase (percent increase in weight) of the chicken strips after injection, tumbling, and portioning and then again 48 hours later (see Table 17). Retention of Brine 8 was determined by measuring the mass increase (percent increase in weight) of the chicken strips after portioning and tumbling and then again 48 hours later (see Table 17). Cook yield was determined as the ratio between post-cook weight and the post-tumble weight, and final yield was determined as the ratio between post-cook weight and the green weight (see Table 18).

[0100] An overall process yield comparing the retention of Brine 5 (LVB) after injection, tumbling, and portion and a phosphate-included control Brine 9 (salt and phosphate Control) after portioning and tumbling was determined (see Table 19).

Stability Data

[0101] FIG. 8 shows pictures of Brine 5, Brine 6, and Brine 7 after approximately three hours in a cooler. Each measuring cup contains approximately 3 cups of brine. Brine 5 was the most

stable of these three solutions over the time period monitored, demonstrating no phase separation. Brine 6 has a notable phase separation line, with a substantively-water-based phase settling on the bottom and with a less dense trim phase rising to the top. Brine 7 similarly has a phase separation line, but in this brine the substantively-water-based phase rose to the top of the container and the trim phase settled to the bottom.

[0102] In this example, the inventor unexpectedly found that salt, in addition to providing for retention of moisture in the chicken, also provides a stabilizing effect in the brine solution. This demonstrates the salting-in effect discussed further herein above, where additional salt can increase the solubility of proteins in the trim and improve the stability of the brine during use in a food process. This further demonstrates the importance of designing the brine in view of the salt-in/salt-out crossover point, as both too much and too little salt prevents the optimal functioning of the brine with respect to viscosity and stability.

Retention Data

[0103] Table 17 below shows the retention of Brine 5, Brine 6, and Brine 7 48 hours after the chicken has been injected with brine, tumbled, and portioned into strips. Table 17 below also shows the retention of Brine 8 48 hours after the chicken has been portioned into strips and tumbled. Table 18 shows the injected, tumble, and cook yields for Brine 5, Brine 6, Brine 7, and Brine 8.

Table 17. 48-Hour Brine Retention

Treatment	Post Tumble Yield	48-Hour Retention
Brine 5 (0.25% salt)	18.17%	17.12%
Brine 6 (0.125% salt)	21.02%	15.43%
Brine 7 (0.00% salt)	19.59%	11.28%
Brine 8 (0.5% salt control)	11.96%	5.77%

Table 18. Inject, Tumble, and Cook Yields: Brines 5, 6, 7, and 8

	Brine 5	Brine 6	Brine 7	Brine 8
Green Weight	24.93	10.16	10.80	26.62
Inject Weight	29.91	12.39	13.17	
Inject %	19.98%	21.95%	21.99%	

Tumble Weight	29.46	12.3	12.91	29.8
Tumble %	18.17	21.02%	19.59%	11.96%
Cook Weight	21.3	8.9	9.11	23.15
Cook Yield	72.30%	72.36%	70.57%	77.68%
Final Yield	85.44%	87.57%	84.39%	86.97%

[0104] Notably, Table 17 shows that neither high salt content (e.g., 0.50% of Brine 8) nor low salt content (e.g., 0.0% of Brine 7) leads to long-term retention of brine. Rather, a brine formulated with a salt content of about 0.25% (Brine 5) demonstrated optimal retention. In particular, while post-tumble yields of Brine 6 and Brine 7 exceeded that of Brine 5, after 48 hours, Brine 5 demonstrated superior retention. Moreover, 48-hour retention at all salt content levels exceeded that of Brine 8, and with a smaller relative fall in retention as compared to the post-tumble yield.

[0105] As shown in Table 18, it was Brine 6 that had the highest final yield and not Brine 5. However, the tumble yield on Brine 5 was also several percentage points lower than Brine 6 and the cook yield was approximately the same, and so the lower final yield is likely due to this lower post-tumble percentage. In fact, this suggests that were the post-tumble percentages to be comparable, the cook and final yields would have been higher for Brine 5. And while the control results demonstrated even higher cook yield and final yields, the phosphate used in the control increases the cost of the brine from 2 cents per pound for Brine 5 to 20 cents per pound for Brine 8. Moreover, phosphate is an artificial ingredient that is undesirable by many consumers.

[0106] Next, Table 19 below compares the process yields for chicken strips that were injected, tumbled, then portioned into strips with Brine 5, as compared to chicken strips that were portioned then tumbled in a control Brine 9 with 0.5% salt and 0.4% phosphate. The were injected, tumbled, and portioned Brine 5 strips shows a 3.18% process yield increase over the control portioned then tumbled Brine 9 strips process in a lab situation. Additionally, the inventor has noted that inconsistencies in the tumbling process during food processing often results in 10% to 20% down grades in process yield over what is accomplished in a lab; such inconsistencies are less likely to occur with the injection/tumbling/portioning process described herein. This demonstrates that the LVB solutions described herein can achieve superior results with more natural ingredients at a lower cost than traditional salt-phosphate marinades.

Table 19. Injected-Tumbled-Portioned versus Portioned-Tumbled Strips

	Injected-Tumbled- Portioned (Brine 5 – LVB)		Portioned-Tumbled (Control, Brine 9 – salt and phosphate)
Green Weight	51.72	Green Weight	53.78
Inject Weight	60.91	Portion Weight	47.36
Inject %	17.77%	Portion Yield	88.06%
Post-Tumble Weight	60.57	Marinate Weight	11.06%
Tumble %	17.11%	Marination %	11.06%
Portion Weight	52.23%	Process Yield	97.81%
Portion Yield	86.23%		
Process Yield	100.99%	Difference	3.18%

EXAMPLE 4

[0107] Testing was performed to assess the water activity of the LVB brine as compared with pure water and the HVB brine. Water activity is determined as the ratio of the partial vapor pressure of water in a particular solution to the standard vapor pressure of water, such that the water activity of pure distilled water has a water activity of 1. As described above in Example 2, the stein cup reading of the LVB brine was very similar to water as they both read approximately 4 seconds.

[0108] To further characterize the physical properties of the LVB, water activity was measured using an Aqua Lab 4TE dew point water activity meter. In this Example, LVB, HVB and Standard Clear Brine were made up with a food processor to a weight of 500g, as indicated below in Tables 20, 21, and 22. The first column of Tables 20, 21, and 22 provide the ingredient in the brine solution. The second column of Tables 20, 21, and 22 provides the target percentage by weight of the ingredient in the final food product. The third column of Tables 20, 21, and 22 provides the percentage by weight of the brine solution for each ingredient. The fourth column of Tables 20, 21, and 22 provides the weight (in grams) of each ingredient in the brine, as well as the total weight (in grams) of the brine solution thus prepared.

Table 20. LVB Composition for Water Activity Measurements

Ingredients	% in Final	% in Formula	Mass in Formula (g)
Water		69.19	345.95
Ice		10.00	50.00
Trim	2.50	18.92	94.60
Salt	0.25	1.89	9.45
Total		100.00	500.00

Table 21. HVB Composition for Water Activity Measurements

Ingredients	% in Final	% in Formula	Mass in Formula (g)
Water		64.18	320.90
Ice		10.00	50.00
Trim	2.50	18.92	94.60
Salt	0.50	3.83	19.15
Phosphate	0.40	3.07	15.35
Total		100.00	500.00

Table 22. Standard Clear Brine for Water Activity Measurements

Ingredients	% in Final	% in Formula	Mass in Formula (g)
Water		83.10	415.50
Ice		10.00	50.00
Salt	0.50	3.83	19.15
Phosphate	0.40	3.07	15.35
Total		100.00	500.00

[0109] Samples were then placed in the water activity meter. For each brine, two readings were taken and averaged to determine the average water activity for that sample, as is presented in Table 23 below.

Table 23. Water Activity Meter Data

	First Reading	Second Reading	Average
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LVB	0.978	0.980	0.979
Standard Clear Brine	0.982	0.979	0.981
HVB	0.966	0.968	0.967
Water			0.9773

[0110] Water activity is a scale that runs from 0.0 to 1.0, where 1.0 represents the water activity of pure water. All three brines tested had a water activity between 0.96 and 0.99; however, there was a notable difference between the LVB and Standard Clear Brine (which had a water activity average on the order of 0.98) as opposed to the HVB (which had an average water activity of 0.967). This highlights that the LVB has properties more similar to water than the HVB, which is consistent with the Stein Cup readings described above in Example 2.

EXAMPLE 5

[0111] Testing was performed to assess the post tumble and long-term resting stability of an LVB solution or brine formulated in accordance with the present disclosure injected into pork loins. In particular, the inventor tested the hypothesis that the LVB brine would have a superior performance to a traditional saltwater brine when injected into pork loin, similar to a chicken breast.

Control Test

[0112] The control brine (Brine 10) was mixed using a PBM mixer (**Dale, what does PBM stand for?**) according to the formulation of Table 24. Approximately 25 pounds of pork loin portions were injected with the control brine to a target of 15% using an IMAX 300SL. Following injection, the pork loins were tumbled for 30 minutes at 7 RPM. The brine retention percentage for the pork loins was calculated 1 hour post tumble as well as at 24, 48, 96, 120 and 188 hours post tumble. Water activity was taken of the water, the saltwater solution, the raw meat, and the injected meat.

LVB Test

[0113] The LVB brine (Brine 11) was mixed using an F-150 emulsifier and included 2.5% pork trim in the final solution according to the formulation of Table 25. The portioned loins were injected to a target of 17.5% using an IMAX 350HVB injector. Like the control test, following injection, the product was tumbled for 30 minutes at 7 RPM. After tumble, the brine retention

percentage was calculated at 1, 24, 48, 96, 120, and 188 hours. Again, the water activity was taken of the water, the LVB solution, the raw meat, and the injected meat.

[0114] The first column of Tables 24 and 25 provides the ingredient in the brine solution. The second column of Tables 24 and 25 provides the target percentage by weight of the ingredient in the final food product. The third column of Tables 24 and 25 provides the percentage by weight of the brine solution for each ingredient. The fourth column of Tables 24 and 25 provides the weight (in pounds) of each ingredient in the brine, as well as the total weight (in pounds) of the brine solution thus prepared.

Table 24. Brine 10 (Saltwater Brine Control), 15% Target Inject

Ingredients	% in Final	% in Final	Lbs in Formula
Water		98.08%	147.13
Salt	0.25%	1.92%	2.88
Total		100%	150.00

Table 25. Brine 11 (LVB Pork Loin Formula), 17.5% Target Inject

Ingredients	% in Final	% in Final	Lbs in Formula
Water		64.17%	96.26
Ice		15.00%	22.50
Salt	0.25%	1.83%	2.75
Trim	2.50%	19.00%	28.50
Total		100.00%	150.00

Injection, Tumbling, and Retention Results

[0115] The initial injection and tumble data is reflected in Table 26 below. After injection and tumbling, the pork loin portions that were injected with the LVB (Brine 11) had retained 3.78% more brine than the control saltwater brine (Brine 10).

Table 26. Initial Injection and Tumble Data

Test	Green Wt	Inject Wt	Inject %	Tumble Wt	Post Tumble Retention %
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Clear Brine	22.07	25.42	15.18%	24.98	13.19%
LVB	16.77	19.92	18.78%	19.60	16.88%

[0116] The retention data is reflected in Tables 27 and 28 below. After 24 hours, the difference in retention remained the same at 3.73%. By 188 hours, however, the difference in retention between the LVB (Brine 11) and salt water (Brine 10) injected pork loins grew to 5% (10.44% retention of the LVB vs 5.44% retention of the salt water brine). Accordingly, pork loins injected with LVB retained 55.59% of the initially injected brine compared to only 35.84% retention of the saltwater brine. Such a difference in brine retention demonstrates how the LVB solution can be used to retain added moisture in the pork loin.

Table 27. Retention Percentages of Saltwater and Low Viscosity Brine Through 24 Hours

Test	Green Wt	Tumbled Wt	Post Tumble Retention %	1 Hour Wt	1 Hour Retention %	24 Hour Wt	24 Hour Retention %
Clear Brine	22.07	25.11	13.77%	24.97	13.14%	24.68	11.83%
LVB	16.77	19.60	16.88%	19.55	16.58%	19.38	15.56%

Table 28. Retention Percentages of Saltwater and Low Viscosity Brine 48 Hours Through 188 Hours

Test	48 Hour Wt	48 Hour Retention %	96 Hour Wt	96 Hour Retention %	120 Hour Wt	120 Hour Retention %	188 Hour Wt	188 Hour Retention %
Clear Brine	24.29	10.06%	23.72	7.48%	23.46	6.30%	23.27	5.44%
LVB	19.22	14.61%	18.89	12.64%	18.70	11.51%	18.52	10.44%

[0117] The results of Example 5 highlight the superior performance and versatility of LVB in treating different meat substrates, exemplified here with chicken breast and pork loins. In both cases, the LVB provided superior retention to the clear brines, as reflected in Table 29, below.

Table 29. Comparison of Brine Retention between Chicken (Data Source Table 17) and Pork Loin (Data Source Tables 27 and 28)

		Post Tumble Retention	48 Hour Retention
Chicken	Clear Brine (0.5% salt control)	11.96%	5.77%
	LVB	18.17%	17.12%
Pork	Clear Brine (0.25% salt control)	13.19%	10.06%
	LVB	16.88%	14.61%

[0118] Various amounts of brine as prepared using the present disclosure may be injected into the food product. The quantity of brine may be from about 8% to 100% of the weight of the food product. As a more specific example, the quantity of brine may be from about 15% to 25% of the weight of the food product. As another more specific example, the quantity of brine may be from about 17% to 22% of the weight of the food product. Specific examples of the amounts of brine utilized are provided below.

[0119] In some examples, the amount of brine (either in grams or as a percentage of the weight of the food product) injected into a food product may be chosen depending on the desired level of salt in the finished food product (e.g., the injected food product after it is cooked and/or frozen). In some examples, the amount of brine injected into a food product may be chosen depending on the target yield or pickup after injection. In some examples, the amount of brine injected into a food product may be chosen depending on the target yield or pickup after the injected food product is cooked and/or frozen. In general, the amount of brine injected into a food product may be optimized to maximize yield or pickup after injection and/or after the injected food product is cooked and/or frozen while staying within a preferred range of the amount of salt in the food product and without compromising quality. In one example, the amount of brine injected into a food product may be about 20% to 25 % of the weight of the food product.

[0120] A food product treated with an LVB solution formulated in accordance with the present disclosure significantly improves the bite and texture (or taste) of the treated food product, including improved tenderness and juiciness of the cooked food product. In that regard, additional treatments to tenderize the food product may be minimized or avoided. For instance, a food product treated with an LVB solution may not require any further massaging, tumbling with a solution, tenderizing, macerating, etc.

[0121] At the same time, the LVB solution optimizes yield relative to salt content. As can be appreciated from the test data set forth in Example 1 above, when injecting large boneless, skinless chicken breasts using the LVB solution, the weight of the large boneless, skinless chicken breasts increased by an average of 18.2%. Moreover, when injecting small boneless, skinless chicken breasts using the LVB solution, the weight of the small boneless, skinless chicken breasts increased by an average of 15.2%. Such an increase in yield is remarkable for such a low finished food product salt content (around 0.25%).

[0122] Further, no artificial ingredients, such as starches, phosphates, and binders such as gelatins and polysaccharides are needed to achieve the yield or taste when using an LVB solution formulated in accordance with the present disclosure. Typically, phosphates have been needed to “open” the muscle fibers of the food product and the salt then extracts the protein from the muscle fibers to be available to bind with the liquid component of the brine/marinade. Absent the use of phosphates, the brine/marinade would typically leach or purge back out of the food product, for example, during cooking or even prior thereto.

[0123] In an effort to stay more natural, some prior art methods of brine formulation include fermenting the trimmings before injection. However, such a step can be time-consuming and requires additional space and equipment in a facility. Thus, fermentation adds to the overall cost of the product. Moreover, many times such brine formulation methods still require the use of phosphates or other artificial ingredients.

[0124] Here, the inventor found, through testing, that mixing low levels of salt and ground substrate to formulate an LVB solution in accordance with the present disclosure results in sufficient yield (minimal purge) without the need for any artificial ingredients. Further, as noted above, using the LVB solution significantly improves the bite and texture (or taste) of the treated food product, without needing further processing (e.g., massaging). In addition, formulating the LVB solution requires no complicated steps, such as fermentation. As such, a “clean label” can be used without compromising production efficiency, yield, or taste.

[0125] The LVB solution is also optimal for injecting a food product. For instance, an LVB solution formulated in accordance with the present disclosure generates a minimal amount of foam and does not increase in viscosity after mixing. Accordingly, complications with the injector are minimized. Further, a lower viscosity brine can more easily disperse within a product after injection.

[0126] Further, as noted above, the LVB solution does not decline or otherwise change in pH after mixing. As is well known, if a pH of a brine lowers, the retention of the added moisture in the injected substrate would be adversely affected. To prevent this, an acid or base reactant is typically added to the brine after emulsification and before injection to control the pH. When using an LVB solution in accordance with the present disclosure the pH does not need to be adjusted before injection because the pH remains substantially constant after emulsification. Thus, the LVB solution again simplifies the treatment/injection process.

[0127] Referring to FIG. 2, a method 10 of formulating an LVB solution (or a low salt, low viscosity functional brine) in accordance with the present disclosure will now be described. The method may be carried out using any of the techniques described herein. It should be noted that the method should not be limited to the precise steps described or illustrated. Moreover, the method may be adapted to formulate a brine in accordance with the present disclosure that is suitable for the intended application or food product.

[0128] At block 12, the method 10 may include selecting a food product to be treated with a brine. For instance, the food product may be large, boneless, skinless chicken breasts, as described herein, or instead another animal, fish, or plant product. In some examples, the food product has not received any previous tenderizing/moisturizing treatments. For instance, although the food product may have been cleaned, cut, portioning, trimmed, etc., in some examples the food product has not otherwise been treated with any brines, flavorings, or other ingredients, and/or the food product has not been physically tenderized, such as by massage, tumbling, etc. In that regard, using the techniques described herein, the food product may be tenderized/moisturized using only an LVB solution formulated in accordance with the present disclosure.

[0129] At block 14, the method 10 may include mixing water (optionally with ice) and a low level of salt, such as between about 0.1-3% salt by weight of the brine. In one example, the method includes mixing softened, cooled water (optionally with ice) with salt, wherein the water is in the amount between about 70-90% by weight of the brine, and the salt is in an amount less than about 3% by weight of the brine. In one example, the method includes mixing softened, cooled water (optionally with ice) with salt, wherein the water is in the amount of about 80% by weight of the brine, and the salt is in an amount less than about 2% by weight of the brine. In one example, the method includes mixing softened, cooled water (optionally with ice) with salt, wherein the water is in the amount of about 80% by weight of the brine, and the

salt is in an amount, or percentage by weight of the brine, configured to produce a treated (or brined) finished food product having about 0.25% salt content. For instance, the method may include using about 1.9% salt, injecting to a target of 15.2%, to achieve an injected substrate salt content of about 0.25%.

[0130] At block 16, the method 10 may include emulsifying (e.g., for two minutes) a water/ice/salt mixture with a low level of ground substrate of the food product being treated to define an emulsified treatment solution. The low level of ground substrate may be between about 10-20% by weight of the brine. In one example, the method includes emulsifying water/ice/salt mixture with ground substrate, wherein the water is in an amount of between about 70-90% by weight of the brine (e.g., about 80%), salt is in an amount less than about 3% by weight of the brine (e.g., less than about 2%), and ground substrate is in an amount between about 10-20% by weight of the brine (e.g., about 20%). In some examples, the method includes emulsifying water/ice/salt mixture with ground substrate, wherein the water is in an amount of about 80% by weight of the brine, salt is in an amount between about 1.5-2% weight of the brine (e.g., about 1.9%), and ground substrate is in an amount between about 15-20% by weight of the brine (e.g., about 19%).

[0131] The method 10 may include storing the emulsified treatment solution in a storage tank for a substantial period of time before injection or treatment, such as between about 1-5 hours. Storage of the emulsified treatment solution is possible because the emulsified treatment solution does not significantly increase in viscosity, nor does it significantly change in pH during storage. Typically, prior art brines change in viscosity (and/or pH) after emulsification, and storage before injection or treatment is not optimal.

[0132] In some examples, the method 10 excludes or minimizes steps to reduce foam formation during emulsification. As noted above, an LVB solution formulated in accordance with the present disclosure generates a minimal amount of foam during emulsification. As such, no steps or minimal steps may be needed to reduce foam before injection. Moreover, because the emulsified treatment solution may be stored for a substantial period of time before injection or treatment, the foam may simply dissipate during storage. Thus, the process for making an LVB solution is simple and efficient.

[0133] The method 10 described herein may be carried out to formulate an LVB solution for treating a food product to achieve the benefits described herein. For instance, an LVB solution may be used to enhance the quality, bite/texture (or taste), and/or yield of treated food products

without requiring artificial ingredients or a high amount of salt. Moreover, the process of making the brine and injecting the brine is simple and efficient.

[0134] An exemplary treatment solution assembly suitable for supporting injection of the LVB solution or similar treatment solutions will now be described with reference to FIGS. 3-7. In general, the treatment solution assembly may be configured to support LVB solution preparation and formulation, storage and delivery of an LVB solution to a treatment application assembly, application of the LVB solution, and recycling of or recirculation of the LVB solution.

[0135] FIG. 3 depicts an exemplary treatment solution or brine assembly 20 having a brine preparation station 24, an emulsifier 28, and an injector (and associated mixing and/or storage tank) 32. Ingredients from the brine preparation station 24 may be added to the emulsifier 28, and the combined ingredients may be run for a predetermined amount of time (e.g., about two minutes) through an emulsifier plate of the emulsifier 28. The emulsified solution may be stored in the mixing and/or storage tank until ready to be used by the injector 32.

[0136] Referring to FIGS. 4 and 5, the injector 32 includes an array of injection needles 40 supported by a needle carrier 44. FIGS. 6 and 7 show an example of an injection needle 40 for use with the needle carrier 44. In general, the injection needles 40 are constructed with an elongated hollow shank 70 having an upper end 76 defining a top opening 72. The upper end 76 is securely engaged within an inner opening of a stepped needle head 78, which is constructed to receive the plunging force used to insert a needle tip 88 (opposite the upper end 76) into the food product being treated. An upper, substantially flat surface of the elongated hollow shank 70 (surrounding the top opening 72) is substantially flush with the upper, substantially flat surface of the stepped needle head 78.

[0137] Referring back to FIGS. 4 and 5, the exemplary needle carrier 44 includes a carrier upper section 50 and a carrier lower section 52 to define a feeder supply chamber 56 therebetween. As is standard, the feeder supply chamber 56 is connected to a source of brine and in brine flow communication with the injection needles 40. In the example shown, the needle carrier 44 includes an inlet port 58 configured for connecting the feeder supply chamber 56 to a source of brine, such as a brine storage tank.

[0138] The array of injection needles 40 are supported by the carrier lower section 52 of the needle carrier 44. Specifically, the injection needles 40 extend vertically and transversely through a lower, horizontal body portion 60 of the carrier lower section 52. A sealing

assembly 62 may be used to sealingly secure the elongated hollow shank 70 of each of the needles within the horizontal body portion 60 of the carrier lower section 52 in a manner well known. For instance, the sealing assembly 62 may include a sealing member 64 disposed within a counter bore 66 extending upwardly from a bottom surface of the horizontal body portion 60. Seal rings 68 are retained within the counter bore 66 between the needle elongated hollow shank 70 and the sealing member 64 to closely receive the needles 40.

[0139] The exemplary needle carrier 44 is configured to support an optimal delivery of LVB solution to the injection needles 40 for the food product to be treated. The needle carrier 44 may be configured as either a side port entry manifold carrier, where a side inlet port in the needle is in registry with the feeder supply chamber 56, or a top port entry manifold carrier, where a top opening of the needle is in registry with the feeder supply chamber 56.

[0140] Side port entry manifold carriers support retraction of the injection needles. Accordingly, side port entry manifold carriers are suitable for injecting food products having bones or other materials that would necessitate retraction of the needles. Side port entry manifold carriers are also typically used to inject brines having a viscosity higher than water or a clear (e.g., broth) brine, such as the LVB solution described herein, or a high viscous brine (HVB) solution (such as one or more of the brines described in U.S. Patent Application No. 16/887075, entitled “High Viscosity Brine For Whole Poultry”, U.S. Patent Application No. 18/065148, entitled “Brine Without Phosphates And Either Salt Free Or Low Salt”, and U.S. Patent Application No. 18/417551, entitled “System and Method for Treating Shrimp and Other Crustaceans”, incorporated by reference herein in their entireties). An exemplary injection system having a side port entry manifold carrier is disclosed in US2022/0110348 A1, entitled “Pork belly processing”, which is incorporated herein by reference in its entirety.

[0141] A viscous brine can more easily flow into a side port inlet of a needle that is in registry with the feeder supply chamber 56 (as with a side top port entry manifold) than through a small top opening in the needle (as with a top port entry manifold). Thus, many viscous brines are injected into food products with a side top port entry manifold carrier, whether the food product includes bones or not. However, as will become further appreciated below, components of a viscous brine, including a brine with emulsified protein, such the LVB solution described herein, can build up in a side port entry manifold carrier due at least in part to bends/turns/edges in the brine flow path. Moreover, side port entry manifold carriers are more difficult to clean

and maintain. Thus, if injecting food products without bones or the like (e.g., boneless chicken breast fillets or chicken butterflies), a top portion entry manifold carrier may be preferred.

[0142] As noted above, however, top portion entry manifold carriers are not typically used to inject brines having emulsified protein or other viscous brines. The top portion entry manifold carrier 44 shown and described herein overcomes the typical limitations associated with the flow of brines. In other words, in examples where the food product to be treated is boneless or otherwise does not require needle retraction, the needle carrier 44 may be configured with an improved top port entry manifold configured to support flow of a brine having emulsified protein, such as the LVB solution. Exemplary aspects of the improved top port entry manifold needle carrier 44 suitable to support flow of a brines having emulsified protein, such as the LVB solution, will now be described.

[0143] As generally noted above, in a top port manifold carrier, the top opening 72 in the upper end 76 of each of the injection needles 40 is in fluid communication with the feeder supply chamber 56. In this manner, fluid may flow through the feeder supply chamber 56 into the needle top opening 72, through the elongated hollow shank 70, and out a needle tip opening (not shown in FIG. 4). In the exemplary needle carrier 44, the injection needles 40 are secured within the carrier lower section 52 and positioned relative to the feeder supply chamber 56 with a top port needle manifold plate assembly 80.

[0144] The top port needle manifold plate assembly 80 includes a substantially planar bottom plate 82 that rests against an upper surface of the carrier lower section 52. The bottom plate 82 includes a plurality of openings sized and configured to receive and vertically restrain, in a first direction, a corresponding number of injection needles 40. For instance, the bottom plate 82 includes openings sized and shaped to receive the stepped needle head 78 such that the injection needles 40 are vertically restrained from moving downward when received within the lower plate. In that regard, the openings in the bottom plate 82 are inversely stepped to substantially match the size and shape of the stepped needle head 78.

[0145] The openings in the bottom plate 82 are also configured to dispose an upper, substantially flat surface of the stepped needle head 78 of each of the injection needles 40 substantially flush with an upper, substantially flat surface of the bottom plate. In this manner, the upper, substantially flat surface of the elongated hollow shank 70 (surrounding the top opening 72) is substantially flush with the upper, substantially flat surface of the bottom plate 82.

[0146] The top port needle manifold plate assembly 80 further includes a substantially planar top plate 84 configured to vertically restrain, in a second, opposite direction, the injection needles 40. The top plate 84 is secured against the bottom plate 82, such as with a plurality of fasteners, such that a body 86 of the top plate 84 at least partially interferes with the stepped needle head 78 of each of the injection needles 40. In this manner, the top plate 84 prevents the stepped needle head 78 from moving vertically upward.

[0147] The top plate 84 is also configured to allow treatment solution or brine to flow from the feeder supply chamber 56 into the top opening 72 of each of the injection needles 40. In a typical top port manifold carrier, the upper plate (or similar) includes cylindrical openings extending transversely through the upper plate that have substantially the same diameter as an inner diameter of the injection needles 40. In that regard, the cylindrical openings in the top plate can essentially form an extension of the elongated hollow shank 70 of the needle, allowing brine to make a 90 degree turn and flow downwardly into the needle from the feeder supply chamber 56.

[0148] In the exemplary top port manifold needle carrier 44 disclosed herein, the top plate 84 includes specially designed, upper plate through-holes 92 configured to support an efficient and optimized flow of brine from the feeder supply chamber 56 into the needles 40. More specifically, the upper plate through-holes 92 are designed to facilitate a low shear, low heat brine flow path into the injection needles 40. In that regard, the upper plate through-holes 92 are designed to transition the flow of brine into the corresponding injection needles 40 smoothly and efficiently.

[0149] In the depicted exemplary embodiment, the upper plate through-holes 92 are generally an inverted frusto-conical shape. A larger end opening 96 of each of the upper plate through-holes 92 intersects the top surface of the top plate 84, and a smaller end opening 98 of each of the upper plate through-holes 92 is located near the bottom surface of the top plate 84.

[0150] The brine can flow along a top surface of the top plate 84 and thereafter into the inverted frusto-conical shaped opening without encountering a sharp turn in the flow path. In that regard, the upper plate through-holes 92 are essentially splayed out as they extend to the top surface of the top plate 84. The brine can flow gently downwardly at an angle into the upper plate through-holes 92 towards the injection needles 40.

[0151] The soft turn in the brine flow path as it enters the upper plate through-holes 92 substantially prevents build-up at the intersection of the upper plate through-hole 92 and the

top surface of the top plate 84. By comparison, a typical, cylindrically-shaped top plate opening defines a brine flow path having a 90 degree turn (i.e., from the top surface of the top plate 84 into the opening). Build-up can occur on a cylindrically-shaped top plate opening when using anything but a clear brine, such as a brine containing ground substrate like the LVB solution described herein. The substrate in the brine can build up at the corner of the turn. The frusto-conical design of the upper plate through-holes 92 substantially prevents build-up at the top of the upper plate through-holes 92 by eliminating the sharp turn. It should be appreciated that any other suitable shape may instead be used to substantially prevent build-up.

[0152] The upper plate through-holes 92 may also be designed to support a substantially smooth, low-shear flow of brine from the feeder supply chamber 56 toward the injection needles 40. In that regard, each of the upper plate through-holes 92 may be curved at its upper edge, or at the intersection between the larger end opening 96 and the top surface of the top plate 84. In this manner, brine can flow along the top surface of the top plate 84 and into the upper plate through-holes 92 without encountering a sharp edge that could induce shear.

[0153] The upper plate through-hole 92 is also configured to interface with the corresponding injection needle 40 in a manner that continues a smooth, low-shear flow path of the brine into the needle. In the depicted example, a cylindrical section 102 extends from the smaller end opening 98 of each of the upper plate through-holes 92. The cylindrical section 102 extends to the bottom surface of the top plate 84. A bottom, substantially flat surface of the cylindrical section 102 may be substantially flush with a bottom surface of the top plate 84. In this manner, the substantially flat upper surface of the needle upper end 76, positioned substantially flush with the top surface of the bottom plate 82, can abut up against the bottom surface of the cylindrical section 102. Thus, the upper plate through-holes 92 are designed to facilitate a vertical brine flow path that has substantially no gaps between components defining the path. It can be appreciated that any gaps between the top plate 84 and the injection needles 40 could result in leakage and disruption of flow, among other issues.

[0154] The brine flow path defined between the upper plate through-holes 92 and the injection needles 40 is also substantially free of any sharp edges or protrusions that could generate a shear force on the brine. In one aspect, the interior walls of the upper plate through-holes 92 and the injection needles 40 are substantially free from sharp edges or protrusions that would disturb the brine flow path. In that regard, the larger end opening 96 of each of the upper plate through-holes 92 may be curved at its upper edge, as noted above. In this manner, brine can

flow along the top surface of the top plate 84 and into the upper plate through-holes 92 without encountering a sharp edge that could induce shear. The intersection or transition between the smaller end opening 98 and the cylindrical section 102 may be similarly curved.

[0155] Moreover, the interior walls defining the upper plate through-holes 92 and the upper end 76 of the injection needles 40 may be substantially aligned, thereby eliminating sharp edges or protrusions between components. For instance, the cylindrical section 102 may be substantially the same diameter as an inner diameter of the needle elongated hollow shank 70 along at least a portion of the upper end 76.

[0156] In other examples, such as in the needle 40 shown in FIG. 6, the upper end of the elongated hollow shank 70 may include a chamfered top opening 72, and the cylindrical section 102 may be substantially the same diameter as an outer diameter of the chamfer defined at the top surface of the elongated hollow shank 70. In that regard, the chamfer can define a smooth, gentle transition between the cylindrical section 102 and the interior of the needle elongated hollow shank 70. In any event, a longitudinal axis of the upper plate through-hole 92 may be substantially aligned with a longitudinal axis of the corresponding injection needle 40, as shown. As a result, a substantially smooth, uninterrupted vertical flow path is defined between the top plate 84 and the injection needle 40.

[0157] It should be appreciated that in some examples, the cylindrical section 102 is eliminated, and an aligned, uninterrupted interface is instead defined between the smaller end opening 98 of the upper plate through-hole 92 and the upper end 76 of the injection needle 40. In any event, brine can flow smoothly and easily through the upper plate through-hole 92 and into the respective needle, without any gaps, edges, or the like causing a disruption in flow or shear force on the brine.

[0158] Further details of the exemplary injection needles 40 for use with the needle carrier 44 and an LVB solution, such as that described herein, will now be described with reference to FIGS. 6 and 7. As noted above, each of the injection needles 40 includes an elongated hollow shank 70 having a top opening 72 defined in an upper end 76. The upper end 76 is tightly received within a stepped needle head 78, which is configured to receive a plunging force of the injector when secured within the bottom plate 82, as described above. A needle tip 88 is defined on the end of the elongated hollow shank 70 opposite the upper end 76. The needle tip 88 is configured to penetrate a food product and direct brine out an outlet opening into the food product.

[0159] Generally, the construction of the needle tip 88, as well as other aspects of the injection needle 40, may be any type suitable for a top port injection manifold carrier, such as the needle carrier 44 described herein. For instance, the needle configuration may be in the form of a hypodermic needle having an outlet opening at the bottom or distal end of the needle tip 88, as shown in FIG. 6. A hypodermic needle configuration is capable of directing brine downward and sometimes laterally into the food product.

[0160] Another type of needle tip configuration is a side port exit tip needle, which has one or more side outlets at a location spaced above a bottom or distal end of the needle tip, to release brine laterally or sideways out of the needle. The side port exit tip needle configuration functions well to direct the brine sideways into the food product from the one or more needle side outlets. Various types of injection needle tips are shown and described in U.S. Patent App. Pub. No. US2022/0110348 A1 and U.S. Patent App. No. 18/326366, entitled “Hypodermic Injection Needle and Systems and Methods Including the Same”, incorporated herein by reference in its entirety.

[0161] As can be appreciated, a needle array that uses one or more types of needles can advantageously be employed to distribute the brine uniformly throughout the depth or thickness of certain types of food products, for example, plant-based food products. For instance, a needle array that uses both side port exit tip and hypodermic needles may help distribute the brine throughout both the upper and lower portions of the food product. Specifically, the side port exit tip needles may help distribute the brine throughout the upper portions of the food product, while the hypodermic needles may help distribute the brine throughout the lower portions of the food product.

[0162] Regardless of the type of needle used, the injection needle 40 may be configured for use with a top port manifold carrier configured to allow optimal flow of brine through the carrier manifold and into the needle, such as the needle carrier 44 described herein. For instance, as noted above, the inner diameter of the upper end 76 of the needle elongated hollow shank 70 may be substantially the same as the inner diameter of the cylindrical section 102 of the upper plate through-hole 92 (and/or the same size as the diameter of the smaller end opening 98 if the cylindrical section 102 is omitted). In that regard, the injection needles 40 may be substantially aligned with the cylindrical section 102, thereby eliminating sharp edges or protrusions between components. In the examples shown herein, the upper end of the elongated hollow shank 70 includes a chamfered top opening 72, and the cylindrical section 102 may be

substantially the same diameter as an outer diameter of the chamfer defined at the top surface of the elongated hollow shank 70.

[0163] A typical injection needle has an outer diameter of about 3mm with walls about 0.75mm in thickness, leaving an internal bore of about 1.5mm. Corresponding upper plate openings for a prior art top port manifold would include bored cylindrical openings that match the internal bore size of the needles, or 1.5mm.

[0164] An internal bore size of only 1.5mm for the upper plate through-holes 92 may be insufficient for supporting flow of a brine having emulsified protein. Thus, in examples described herein, the needle carrier 44 is designed to have upper plate through-holes 92 having an internal bore (e.g., the inner diameter of the cylindrical section 102 and/or the smaller end opening 98 of the upper plate through-hole 92) that is larger than prior art top port manifold openings. For instance, the cylindrical section 102 and/or the smaller end opening 98 of the upper plate through-hole 92 may have an inner diameter of 2 mm.

[0165] The injection needles 40 may be designed to correspondingly include a larger internal bore to match a larger diameter upper plate opening, such as 2mm. In some aspects, a design constraint may include the outer diameter of the elongated hollow shank 70. For instance, using a needle that has an outer diameter of 3.5mm to accommodate an internal bore of 2mm may not be desired for various reasons. For instance, a larger diameter needle may cause damage to the food product during penetration.

[0166] In one example, the wall of the injection needles 40 along the elongated hollow shank 70 are reduced in thickness to increase the internal bore of the needle. For instance, referring to the cross-sectional view of the injection needles 40 shown in FIG. 7, the walls 104 and 106 of the elongated hollow shank 70 on each side of the internal bore 110 may be reduced to 0.5mm, leaving an internal bore size of 2mm and the same outer diameter of 3mm. Any suitable material may be used to make a “thin-walled” needle, such as a needle having a wall thickness of 0.5mm. For instance, a material that is sufficiently flexible and designed to bend rather than break upon insertion may be used. The improved needle design supports the flow of brines having emulsified protein or another type of viscous brine through the top port needle manifold plate assembly 80 and into the injection needles 40 without compromising injection quality.

[0167] It can be appreciated that the top port manifold design of the needle carrier 44 helps support optimal flow of brines having emulsified protein through the carrier. For instance, the

flared upper plate through-holes 92 allow the brine to easily and gently flow into the injection needles 40, reducing the change of buildup and shear stress. The needles are also uniquely designed to support a larger internal upper plate openings bore, allowing a thicker, viscous brine to more easily flow therethrough.

[0168] The improved design of the top port manifold needle carrier 44 and the injection needles 40 reduces the shear stress placed on the brine during injection. This has the advantage of minimizing the loss of functionality of the active substrate protein (e.g., ground trim) in the brine. Further, heat build-up in the needles is kept to a minimum. Such heat can denature, or otherwise damage, the active substrate protein in the brine. Thus, the improved top port manifold and needle design described herein supports an optimal low shear, low heat brine flow.

[0169] Other aspects of the brine assembly 20 may also be advantageously configured to support an optimal low shear, low heat brine flow. For instance, components of the brine assembly 20 configured to supply formulated brine to the needle carrier 44 (e.g., from the storage tank) may be designed to induce minimal shear on the brine.

[0170] In some examples, the brine supply system uses a single, simple valve located between the brine storage tank (or saddle tank) and the needle carrier 44 for supplying brine to the carrier. The single, simple valve opens and closes to flood the manifold in the needle carrier 44. Using only a simple, single valve reduces the chance of brine protein build-up.

[0171] In some examples, the brine supply system of the brine assembly 20 uses a diaphragm pump rather than a centrifugal pump or other type of pump utilizing a rotating impeller. A rotating impeller or the like continuously cuts through the brine, damaging and/or altering the nature of the active substrate protein in the brine. Moreover, a centrifugal pump or similar continues to run and induce shear (and generate heat) in the brine, even when the valve is closed and no brine is flowing to the needle carrier 44. A diaphragm pump, on the other hand, need only operate when called upon to direct brine to the needle carrier 44 and through the injection needles 40 (e.g., during a pressure drop). As such, less shear stress is placed on the brine when using a diaphragm pump or similar. Thus, it can be appreciated that the low complicated, optimally designed brine supply system minimizes opportunities to induce shear in the brine and cause build-up.

[0172] A brine return system of the brine assembly 20 may also be advantageously configured to support an optimal flow of the LVB solution. A brine return system is configured to recover

a return solution (“unused brine”) and return the unused brine back to the storage tank and/or injector for reuse. Often the unused brine contains particles resulting from the injection process, which can clog the needles. Conventional return systems remove these particles with a filter or separator in the storage tank. However, such filters and separators are difficult to clean. Moreover, any discarded particles reduces the overall yield. Thus, the brine return system may instead be configured to reduce the particle size to form a reduced return solution suitable for reuse. For instance, the brine return system may incorporate one or more aspects of the system and method described in U.S. Patent No. 7,645,472, entitled “Method for Recycling Liquids for Treating Food”, hereby incorporated by reference in its entirety.

[0173] Although the present systems and methods are described herein with reference to an injector, in some examples, the food product may instead be marinated or soaked in an LVB solution. For instance, if the food product is of a small size, relatively thin, delicate, etc., the food product may be marinated instead of injected. For instance, chicken breast nuggets may instead be soaked in the LVB solution.

[0174] In the present application the terms “functional protein”, “natural protein”, “activated protein”, or the like may include proteins that corresponds to that which is naturally occurring in the food product, whether a beef, pork, poultry, fish, plant-based product or otherwise.

[0175] While the concepts of the present disclosure are susceptible to various modifications and alternative forms, specific examples thereof have been shown by way of example in the drawings and will be described herein in detail. It should be understood, however, that there is no intent to limit the concepts of the present disclosure to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives consistent with the present disclosure and the appended claims.

[0176] References in the specification to “one example,” “an example,” “an illustrative example,” etc., indicate that the example described may include a particular feature, structure, or characteristic, but every example may or may not necessarily include that particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same example. Further, when a particular feature, structure, or characteristic is described in connection with an example, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other examples whether or not explicitly described. Additionally, it should be appreciated that items included in a list in the form of “at least one A, B, and C” can mean (A); (B); (C); (A and B); (B and C); (A and

C); or (A, B, and C). Similarly, items listed in the form of “at least one of A, B, or C” can mean (A); (B); (C); (A and B); (B and C); (A and C); or (A, B, and C).

[0177] As used herein, the terms “about” and “approximately,” in reference to a number, is used herein to include numbers that fall within a range of 10%, 5%, or 1% in either direction (greater than or less than) the number unless otherwise stated or otherwise evident from the context (except where such number would exceed 100% of a possible value).

[0178] Language such as “top”, “bottom”, “upper”, “lower”, “vertical”, “horizontal”, “lateral”, etc., in the present disclosure is meant to provide orientation for the reader with reference to the drawings and is not intended to be the required orientation of the components or to impart orientation limitations into the claims.

[0179] In the drawings, some structural or method features may be shown in specific arrangements and/or orderings. However, it should be appreciated that such specific arrangements and/or orderings may not be required. Rather, in some embodiments, such features may be arranged in a different manner and/or order than shown in the illustrative FIGS. Additionally, the inclusion of a structural or method feature in a particular FIG. is not meant to imply that such feature is required in all examples, and in some instances, it may not be included or it may be combined with other features.

[0180] The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Alternative language and synonyms may be used for any one or more of the terms discussed herein, and no special significance should be placed upon whether or not a term is elaborated or discussed herein. In some cases, synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only and is not intended to further limit the scope and meaning of the disclosure or of any example term.

[0181] Likewise, the disclosure is not limited to various example examples given in this specification. Unless otherwise defined, technical and scientific terms used herein have the meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

[0182] Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure.

[0183] While illustrative examples have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the disclosure.

LISTING OF INNOVATIONS

[0184] Clause 1. A treatment solution for a food product, comprising: water; salt; and ground substrate of the food product being treated; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified treatment solution, protein of the ground substrate is activated to bind water to the food product when is treated with the treatment solution, and wherein the treatment solution remains at a substantially constant viscosity after emulsification.

[0185] Clause 2. The treatment solution of Clause 1, wherein the food product being treated is large, boneless, skinless chicken breast, and the ground substrate is large boneless, skinless chicken breast.

[0186] Clause 3. The treatment solution of Clause 1, wherein the food product being treated is pork loin, and the ground substrate is pork loin.

[0187] Clause 4. The treatment solution of Clause 1, wherein the food product is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0188] Clause 5. The treatment solution of Clause 1, wherein the ground substrate is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0189] Clause 6. The treatment solution of Clause 1, wherein an amount of salt is between about 0.1-3% of the treatment solution.

[0190] Clause 7. The treatment solution of Clause 2 or 3, wherein the amount of ground substrate is 15-20% of the treatment solution.

[0191] Clause 8. The treatment solution of Clause 2 or 3, wherein the amount of salt is between about 1.5-2.0% of the treatment solution.

[0192] Clause 9. The treatment solution of Clause 6, wherein the amount of salt is selected to achieve a level of about 0.25% salt in a treated food product.

[0193] Clause 10. The treatment solution of Clause 1, wherein an amount of salt is less than about 2% of the treatment solution.

[0194] Clause 11. The treatment solution of Clause 10, wherein the amount of ground substrate is less than about 20% of the treatment solution.

[0195] Clause 12. The treatment solution of Clause 1, wherein an amount of ground substrate is between about 10-25% of the treatment solution.

[0196] Clause 13. The treatment solution of Clause 1, wherein the treatment solution remains at a substantially constant pH after emulsification.

[0197] Clause 14. The treatment solution of Clause 1, wherein activation of the protein of the ground substrate includes biochemically altering natural protein of the ground substrate such that it becomes functional for binding water to protein fibers in the treated food product.

[0198] Clause 15. The treatment solution of Clause 1, wherein a fat to lean ratio of the ground substrate is substantially the same as the fat to lean ratio of the food product being treated.

[0199] Clause 16. The treatment solution of Clause 15, wherein the fat to lean ratio is about 10%.

[0200] Clause 17. The treatment solution of Clause 1, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is treated with the treatment solution.

[0201] Clause 18. The treatment solution of Clause 1 or 17, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is treated with the treatment solution.

[0202] Clause 19. The treatment solution of Clause 1, 17, or 18, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is treated with the treatment solution.

[0203] Clause 20. The treatment solution of Clause 1, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when is treated with the treatment solution.

[0204] Clause 21. The treatment solution of Clause 1, further comprising at least one of a preservative, antioxidant, thickener, and flavoring.

[0205] Clause 22. A treatment solution for treating a food product by injection of the treatment solution into the food product, comprising: water; salt in an amount to achieve a level of about 0.25% salt in a treated food product; and ground substrate of the food product being treated less than 25% of the treatment solution; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified injection solution, protein of the ground substrate is activated to bind water to the food product when is injected with the

treatment solution, and wherein the treatment solution remains at a substantially constant viscosity after emulsification and before injection into the food product.

[0206] Clause 23. The treatment solution of Clause 22, wherein the food product being treated is large, boneless, skinless chicken breast, and the ground substrate is large boneless, skinless chicken breast.

[0207] Clause 24. The treatment solution of Clause 22, wherein the food product being treated is pork loin, and the ground substrate is pork loin.

[0208] Clause 25. The treatment solution of Clause 22, wherein the food product is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0209] Clause 26. The treatment solution of Clause 22, wherein the ground substrate is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0210] Clause 27. The treatment solution of Clause 23 or 24, wherein the amount of ground substrate is 15-20% of the treatment solution.

[0211] Clause 28. The treatment solution of Clause 23 or 24, wherein the amount of salt is between about 1.5-2.0% of the treatment solution.

[0212] Clause 29. The treatment solution of Clause 22, wherein the amount of salt is selected to achieve a desired level of salt in a treated food product that is cooked and/or frozen.

[0213] Clause 30. The treatment solution of Clause 22, wherein the amount of salt is less than 2% of the treatment solution.

[0214] Clause 31. The treatment solution of Clause 30, wherein the amount of ground substrate is between 10- 30% of the treatment solution.

[0215] Clause 32. The treatment solution of Clause 22, wherein the treatment solution remains at a substantially constant pH after emulsification and during injection.

[0216] Clause 33. The treatment solution of Clause 22, wherein activation of the protein of the ground substrate includes biochemically altering natural protein of the ground substrate such that it becomes functional for binding water to protein fibers when injected into the food product.

[0217] Clause 34. The treatment solution of Clause 22, wherein a fat to lean ratio of the ground substrate is substantially the same as the fat to lean ratio of the food product being injected.

[0218] Clause 35. The treatment solution of Clause 34, wherein the fat to lean ratio is about 10%.

[0219] Clause 36. The treatment solution of Clause 22, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is injected with the treatment solution.

[0220] Clause 37. The treatment solution of Clause 22 or 36, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is injected with the treatment solution.

[0221] Clause 38. The treatment solution of Clause 22, 36, or 37, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is injected with the treatment solution.

[0222] Clause 39. The treatment solution of Clause 22, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when is injected with the treatment solution.

[0223] Clause 40. The treatment solution of Clause 22, further comprising at least one of a preservative, antioxidant, thickener, and flavoring.

[0224] Clause 41. A method of formulating a treatment solution for a food product, comprising: selecting a food product to be treated; mixing water with salt in an amount to achieve a level of about 0.25% salt in a treated food product; and emulsifying the water, salt, and ground substrate of the food product being treated to define the treatment solution, wherein the ground substrate is in an amount between about 10-25% by weight of the treatment solution.

[0225] Clause 42. The method of Clause 41, wherein the food product being treated is large, boneless, skinless chicken breast, and the ground substrate is large boneless, skinless chicken breast.

[0226] Clause 43. The method of Clause 41, wherein the food product being treated is pork loin, and the ground substrate is pork loin.

[0227] Clause 44. The method of Clause 41, wherein the food product is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0228] Clause 45. The method of Clause 41, wherein the ground substrate is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0229] Clause 46. The method of Clause 42 or 43, wherein the amount of ground substrate is 15-20% of the treatment solution.

[0230] Clause 47. The method of Clause 42 or 43, wherein the amount of salt is between about 1.5-2.0% of the treatment solution.

[0231] Clause 48. The method of Clause 41, further comprising storing the treatment solution for at least one hour before treatment of the food product.

[0232] Clause 49. The method of Clause 41 or 48, wherein the treatment solution can be used for injection of the food production without reducing foam of the treatment solution.

[0233] Clause 50. The method of Clause 41, 48, or 49, wherein the food product has not received any previous tenderizing/moisturizing treatments.

[0234] Clause 51. The method of Clause 41, 48, 49, or 50 wherein the salt is in an amount less than about 2% by weight of the treatment solution.

[0235] Clause 52. The method of Clause 41, 48, 49, 50, or 51 wherein the ground substrate is in an amount less than about 20% by weight of the treatment solution.

[0236] Clause 53. A treatment solution for a food product, consisting essentially of: water; salt in an amount to achieve a level of about 0.25% salt in a treated food product; and ground substrate of the food product being treated; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified treatment solution, protein of the ground substrate is activated to bind water to the food product when the food product is treated with the treatment solution, and wherein the treatment solution remains at a substantially constant viscosity after emulsification.

[0237] Clause 54. The treatment solution of Clause 53, wherein the food product being treated is large, boneless, skinless chicken breast, and the ground substrate is large boneless, skinless chicken breast.

[0238] Clause 55. The treatment solution of Clause 53, wherein the food product being treated is pork loin, and the ground substrate is pork loin.

[0239] Clause 56. The treatment solution of Clause 53, wherein the food product is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0240] Clause 57. The treatment solution of Clause 53, wherein the ground substrate is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0241] Clause 58. The treatment solution of Clause 54 or 55, wherein the amount of ground substrate is 15-20% of the treatment solution.

[0242] Clause 59. The treatment solution of Clause 54 or 55, wherein the amount of salt is between about 1.5-2.0% of the treatment solution.

[0243] Clause 60. The treatment solution of Clause 53, wherein an amount of salt is between about 0.1-3% of the treatment solution.

[0244] Clause 61. The treatment solution of Clause 60, wherein the amount of salt is selected to achieve a desired level of salt in a treated food product that is cooked and/or frozen.

[0245] Clause 62. The treatment solution of Clause 53, wherein an amount of salt is less than about 2% of the treatment solution.

[0246] Clause 63. The treatment solution of Clause 58, wherein the amount of ground substrate is less than about 20% of the treatment solution.

[0247] Clause 64. The treatment solution of Clause 53, wherein an amount of ground substrate is between about 10-30% of the treatment solution.

[0248] Clause 65. The treatment solution of Clause 53, wherein the treatment solution remains at a substantially constant pH after emulsification.

[0249] Clause 66. The treatment solution of Clause 53, wherein activation of the protein of the ground substrate includes biochemically altering the protein such that it becomes functional for binding water to protein fibers in the treated food product.

[0250] Clause 67. The treatment solution of Clause 53, wherein a fat to lean ratio of the ground substrate is substantially the same as the fat to lean ratio of the food product being treated.

[0251] Clause 68. The treatment solution of Clause 67, wherein the fat to lean ratio is about 10%.

[0252] Clause 69. The treatment solution of Clause 53, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is treated with the treatment solution.

[0253] Clause 70. The treatment solution of Clause 53 or 69, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is treated with the treatment solution.

[0254] Clause 71. The treatment solution of Clause 53, 69, or 70, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is treated with the treatment solution.

[0255] Clause 72. The treatment solution of Clause 53, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when is treated with the treatment solution.

[0256] Clause 73. A top port needle carrier for a treatment solution injection assembly, comprising: a carrier upper section and a carrier lower section defining a feeder supply chamber therebetween that is in fluid communication with an inlet port; and a top port needle manifold plate assembly located between the carrier upper section and the carrier lower section, the top port needle manifold plate assembly defining a plurality of plate through-holes configured to substantially vertically align with top openings of a plurality of needles received in the carrier lower section, wherein the plate through-holes are shaped and sized to guide treatment solution having emulsified protein from the feeder supply chamber into the top openings of the plurality of needles without inducing substantial shear on the treatment solution.

[0257] Clause 74. The treatment solution assembly of Clause 73, wherein the plate openings are an inverted frusto-conical shape having a larger end opening opposite a smaller end opening, the smaller end opening configured to interface a top opening of a corresponding needle.

[0258] Clause 75. The treatment solution assembly of Clause 74, wherein the smaller end openings of each of the plate openings have a diameter of about 2 mm.

[0259] Clause 76. The treatment solution assembly of Clause 74 or 75, further comprising a curved edge defined at the larger end opening of each of the plate openings.

[0260] Clause 77. The treatment solution assembly of Clause 74 or 75, wherein the plate openings include a cylindrical portion extending from the smaller end opening having substantially the same inner diameter as an inner diameter of the top opening of the corresponding needle.

[0261] Clause 78. The treatment solution assembly of Clause 74, 75, 76, or 77, wherein the top port needle manifold plate assembly includes a bottom plate configured to vertically restrain the plurality of needles in a first direction and a top plate configured to vertically restrain the plurality of needles in a second, opposite direction, the plate openings defined in the top plate.

[0262] Clause 79. The treatment solution assembly of Clause 74, 75, 76, 77, or 78, wherein the treatment solution has a viscosity higher than water.

[0263] Clause 80. An injection treatment solution assembly for a treatment solution having emulsified protein, comprising: a storage tank for holding the treatment solution; an injector for injecting the treatment solution into a food product, the injector comprising: a plurality of needles received in a needle carrier, each needle having a top opening opposite a needle tip outlet; and a top port needle manifold plate assembly defining a plurality of plate through-holes configured to substantially vertically align with each of the top openings of the plurality of needles, wherein the plate through-holes are shaped and sized to guide the treatment solution into the top openings of the plurality of needles without inducing substantial shear on the treatment solution; and a treatment solution supply system configured to supply the treatment solution from the storage tank to the needle carrier of the injector without inducing substantial shear on the treatment solution.

[0264] Clause 81. The treatment solution assembly of Clause 80, wherein the plate openings are an inverted frusto-conical shape having a larger end opening opposite a smaller end opening, the smaller end opening configured to interface a top opening of a corresponding needle.

[0265] Clause 82. The treatment solution assembly of Clause 81, wherein the smaller end openings of each of the plate openings have a diameter of about 2 mm.

[0266] Clause 83. The treatment solution assembly of Clause 81 or 82, further comprising a curved edge defined at the larger end opening of each of the plate openings.

[0267] Clause 84. The treatment solution assembly of Clause 81 or 82, wherein the plate openings include a cylindrical portion extending from the smaller end opening having substantially the same inner diameter as an inner diameter of the top opening of the corresponding needle.

[0268] Clause 85. The treatment solution assembly of Clause 81, 82, 83, or 84, wherein the top port needle manifold plate assembly includes a bottom plate configured to vertically restrain the plurality of needles in a first direction and a top plate configured to vertically restrain the plurality of needles in a second, opposite direction, the plate openings defined in the top plate.

[0269] Clause 86. The treatment solution assembly of Clause 81, 82, 83, 84, or 85, wherein the treatment solution has a viscosity higher than water.

[0270] Clause 87. The treatment solution assembly of Clause 86, wherein the treatment solution supply system includes a diaphragm pump configured to flow the treatment solution from the storage tank to the needle carrier.

[0271] Clause 88. The treatment solution assembly of Clause 87, wherein the treatment solution supply system includes a single valve located between the storage tank and the needle carrier.

[0272] Clause 89. The treatment solution assembly of Clause 80, 81, 82, 84, or 85, further comprising a treatment solution return system configured to reduce protein particle size in used treatment solution before returning the used treatment solution to the storage tank.

[0273] Clause 90. A treatment solution for treating a food product by injection of the treatment solution into the food product, comprising: water; ground substrate of the food product being treated less than 25% of the treatment solution; and salt; wherein when the water, salt, and ground substrate are emulsified together to define an emulsified injection solution, protein of the ground substrate is activated to bind water to the food product when is injected with the treatment solution.

[0274] Clause 91. The treatment solution of Clause 90, wherein the amount of salt is selected to achieve maximum solubility of proteins of the ground substrate in the treatment solution.

[0275] Clause 92. The treatment solution of Clause 90 or 91, wherein the treatment solution remains at a substantially constant viscosity after emulsification and before injection into the food product.

[0276] Clause 93. The treatment solution of Clause 90, 91, or 92, wherein the treatment solution remains substantially well mixed after emulsification and before injection into the food product.

[0277] Clause 94. The treatment solution of Clause 90, wherein the food product being treated is large, boneless, skinless chicken breast, and the ground substrate is large boneless, skinless chicken breast.

[0278] Clause 95. The treatment solution of Clause 90, wherein the food product being treated is pork loin, and the ground substrate is pork loin.

[0279] Clause 96. The treatment solution of Clause 90, wherein the food product is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0280] Clause 97. The treatment solution of Clause 90, wherein the ground substrate is selected from the group consisting of beef, pork, poultry, freshwater fish, saltwater fish, molluscan shellfish, crustaceans, and plant-based protein material.

[0281] Clause 98. The treatment solution of Clause 94 or 95, wherein the amount of ground substrate is 15-20% of the treatment solution.

[0282] Clause 99. The treatment solution of Clause 94 or 95, wherein the amount of salt is between about 1.5-2.0% of the treatment solution.

[0283] Clause 100. The treatment solution of Clause 90, wherein the amount of salt is selected to achieve a desired level of salt in a treated food product that is cooked and/or frozen.

[0284] Clause 101. The treatment solution of Clause 90, wherein the amount of salt is less than 2% of the treatment solution.

[0285] Clause 102. The treatment solution of Clause 101, wherein the amount of ground substrate is between 10- 30% of the treatment solution.

[0286] Clause 103. The treatment solution of Clause 90, wherein the treatment solution remains at a substantially constant pH after emulsification and during injection.

[0287] Clause 104. The treatment solution of Clause 90, wherein activation of the protein of the ground substrate includes biochemically altering natural protein of the ground substrate such that it becomes functional for binding water to protein fibers when injected into the food product.

[0288] Clause 105. The treatment solution of Clause 90, wherein a fat to lean ratio of the ground substrate is substantially the same as the fat to lean ratio of the food product being injected.

[0289] Clause 106. The treatment solution of Clause 105, wherein the fat to lean ratio is about 10%.

[0290] Clause 107. The treatment solution of Clause 90, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is injected with the treatment solution.

[0291] Clause 108. The treatment solution of Clause 90 or 107, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is injected with the treatment solution.

[0292] Clause 109. The treatment solution of Clause 90, 107, or 108, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is injected with the treatment solution.

[0293] Clause 110. The treatment solution of Clause 90, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when is injected with the treatment solution.

[0294] Clause 111. The treatment solution of Clause 90, further comprising at least one of a preservative, antioxidant, thickener, and flavoring.

CLAIMS

WHAT IS CLAIMED IS:

1. A treatment solution for a food product, comprising:
water;
salt;
ground substrate of the food product being treated; and
wherein when the water, salt, and ground substrate are emulsified together to define an emulsified treatment solution, protein of the ground substrate is activated to bind water to the food product when treated with the treatment solution, and
wherein the treatment solution remains at a substantially constant viscosity after emulsification.
2. The treatment solution of Claim 1, wherein an amount of salt is selected to achieve a level of about 0.25% salt in a treated food product.
3. The treatment solution of Claim 2, wherein an amount of ground substrate is less than about 20% of the treatment solution.
4. The treatment solution of Claim 1, wherein the treatment solution remains at a substantially constant pH after emulsification.
5. The treatment solution of Claim 1, wherein activation of the protein of the ground substrate includes biochemically altering natural protein of the ground substrate such that it becomes functional for binding water to protein fibers in the treated food product.
6. The treatment solution of Claim 1, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is treated with the treatment solution.
7. The treatment solution of Claim 1, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is treated with the treatment solution.

8. The treatment solution of Claim 1, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is treated with the treatment solution.

9. The treatment solution of Claim 1, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when treated with the treatment solution.

10. A method of formulating a treatment solution for a food product, comprising:
selecting a food product to be treated;
mixing water with salt in an amount to achieve a level of about 0.25% salt in a treated food product; and
emulsifying the water, salt, and ground substrate of the food product being treated to define the treatment solution, wherein the ground substrate is in an amount between about 10-25% by weight of the treatment solution.

11. The method of Claim 10, further comprising storing the treatment solution for at least one hour before treatment of the food product without further emulsification before treatment of the food product.

12. A treatment solution for treating a food product by injection of the treatment solution into the food product, comprising:
water;
ground substrate of the food product being treated less than 25% of the treatment solution; and
salt;
wherein when the water, salt, and ground substrate are emulsified together to define an emulsified injection solution, protein of the ground substrate is activated to bind water to the food product when injected with the treatment solution.

13. The treatment solution of Claim 12, wherein an amount of salt is selected to achieve maximum solubility of proteins of the ground substrate in the treatment solution.

14. The treatment solution of Claim 12, wherein the treatment solution remains at a substantially constant viscosity after emulsification and before injection into the food product.

15. The treatment solution of Claim 12, wherein an amount of salt is less than 2% of the treatment solution.

16. The treatment solution of Claim 12, wherein the treatment solution remains at a substantially constant pH after emulsification and during injection.

17. The treatment solution of Claim 12, wherein activation of the protein of the ground substrate includes biochemically altering natural protein of the ground substrate such that it becomes functional for binding water to protein fibers when injected into the food product.

18. The treatment solution of Claim 12, wherein an amount of salt and ground substrate is chosen to maximize natural protein activation of the ground substrate in the treatment solution when the food product is injected with the treatment solution.

19. The treatment solution of Claim 12, wherein an amount of salt and ground substrate is chosen to minimize natural protein activation of the ground substrate in the treatment solution before the food product is injected with the treatment solution.

20. The treatment solution of Claim 12, wherein an amount of salt and ground substrate is chosen to maximize the amount of water that binds to the food product when it is injected with the treatment solution.

21. The treatment solution of Claim 12, wherein protein of the ground substrate is activated to bind water to protein fibers of the food product when is injected with the treatment solution.