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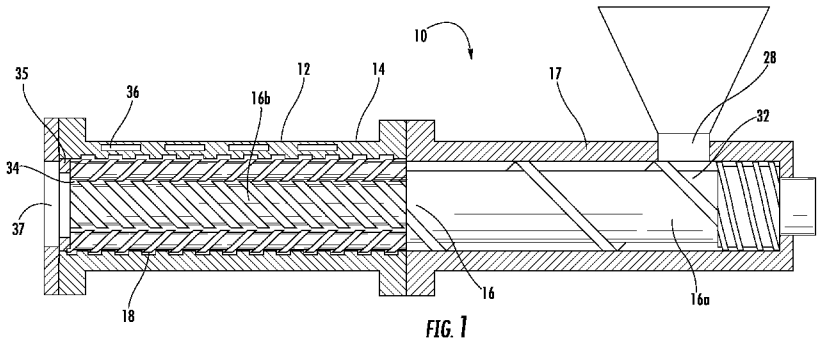

FIG. 1

(57) Abstract: Disclosed is a method for encapsulating an ingredient, the method including feeding at least one active ingredient into a planetary roller extruder; feeding at least one additional ingredient into said planetary roller extruder; creating a flow of said at least one active ingredient and said at least one additional ingredient through said planetary roller extruder towards a downstream extent of said planetary roller extruder; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said planetary roller extruder.

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SYSTEM AND METHOD FOR MANUFACTURING ENCAPSULATE COMPOSITIONS

FIELD

[0001] The disclosure relates generally to a system and method for manufacturing encapsulate compositions, and more particularly to a system and method for manufacturing encapsulate compositions via a continuous extruder.

BACKGROUND

[0002] Conventional continuous mixers and extruders used in encapsulate manufacturing can create temperatures of 130 degrees Celsius or higher during encapsulation of active ingredients with polymers. Such relatively high temperatures of 130 degrees Celsius or higher can be problematic due to the temperature sensitivity of many traditional encapsulate ingredients.

[0003] Accordingly, a continuous extruder that is better capable of efficiently mixing encapsulates without reaching such high temperatures would be desirable.

SUMMARY

[0004] Disclosed is a method for encapsulating an ingredient, the method including feeding at least one active ingredient into a planetary roller extruder; feeding at least one additional ingredient into said planetary roller extruder; creating a flow of said at least one active ingredient and said at least one additional ingredient through said planetary roller extruder towards a downstream extent of said planetary roller extruder; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said planetary roller extruder.

[0005] Further disclosed is a method for encapsulating an ingredient, the method including: feeding at least one active ingredient into a mixer; feeding at least one additional ingredient into said mixer; creating a flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said mixer, wherein a color of said flow remains substantially constant from said creating of said flow through said extrusion of said encapsulate.

[0006] Further disclosed is a method for encapsulating an ingredient, the method including: feeding at least one active ingredient into a mixer; feeding at least one additional ingredient into said mixer; creating a molten flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer, wherein a temperature of said molten flow is substantially uniform across any cross-section of said molten flow taken perpendicular to a direction of said molten flow; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said mixer.

[0007] Further disclosed is method for encapsulating an ingredient, the method including: feeding at least one active ingredient into a mixer; feeding at least one additional ingredient into said mixer; creating a flow of said at least one active ingredient and at least one additional ingredient through said mixer towards a downstream extent of said mixer; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said mixer, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

[0008] Further disclosed is a method for encapsulating an ingredient, the method including: feeding a plurality of active ingredients into a mixer; feeding at least one additional ingredient into said mixer; creating a flow of said plurality of active ingredients and said at least one additional ingredient through said mixer towards a downstream extent of said mixer; encapsulating said plurality of active ingredients via a mixing of said plurality of active ingredients and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said mixer.

[0009] Further disclosed is a method for encapsulating an ingredient, the method including: feeding at least one active ingredient into a mixer; feeding at least one additional ingredient into said mixer; creating a flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; extruding said encapsulate from said mixer; and milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

[0010] Further disclosed is a method for encapsulating an ingredient, the method including: feeding at least one active ingredient into a mixer; feeding at least one additional

ingredient into said mixer; creating a molten flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer; encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and extruding said encapsulate from said mixer, wherein a temperature of said molten flow remains within a 20 degree Celsius range from said creating to said extruding.

BRIEF DESCRIPTION OF THE FIGURES

[0011] The accompanying drawings incorporated in and forming a part of the specification embodies several aspects of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

[0012] Figure 1 is a schematic elevation view of a planetary roller extruder in accordance with an exemplary embodiment;

[0013] Figure 2 is a partial perspective view of a planetary roller extruder such as that shown in Figure 1;

[0014] Figure 3 is a front elevation view of a planetary roller extruder such as that shown in Figure 1;

[0015] Figure 4 is a block diagram illustrating an exemplary method for manufacturing encapsulate compositions;

[0016] Figure 5 is a schematic representation illustrating an exemplary system for manufacturing encapsulate compositions;

[0017] Figure 6 is a schematic representation illustrating an alternative exemplary system for manufacturing encapsulate compositions; and

[0018] Figure 7 is a chart comparing dissolution release over time of encapsulates produced in a twin screw extruder and a planetary roller extruder

DETAILED DESCRIPTION

[0019] The following disclosure will detail particular embodiments according to the present invention, which provides methods and systems for manufacturing encapsulate compositions, particularly for use in chewing gum and other such confections.

[0020] As used herein, a product referred to as "chewing gum" or "gum" includes, but is not limited to, compositions ranging from and inclusive of compounded elastomer to finished gum, which may include compounded elastomer in addition to some compounding aids, master batch gum base, compounded elastomer in addition to some subsequent gum

ingredients, compounded elastomer in addition to some gum base ingredients and some subsequent gum ingredients, gum base, gum base in addition to some subsequent gum ingredients, master batch finished gum, and finished gum.

[0021] Before explaining the various systems and methods according to the present invention, it is helpful to discuss the general composition of several typical stages of chewing gum manufacture in which encapsulate may be used, namely finished gum.

[0022] A "finished chewing gum" or "finished gum," as used herein, will refer to chewing gum that is generally ready for preparation to distribute the product to the consumer. As such, a finished gum may still require temperature conditioning, forming, shaping, packaging and coating. However, from a compositional standpoint, the chewing gum itself is generally finished. Not all finished gums have the same ingredients or the same amounts of individual ingredients. By varying the ingredients and amounts of ingredients, textures, flavor and sensations, among other things, can be varied to provide differing characteristics to meet the needs of users.

[0023] As is generally well known, a finished gum typically includes a water soluble bulk portion, a water insoluble gum base portion, and one or more flavoring agents. The water soluble portion dissipates over a period of time during chewing. The gum base portion is retained in the mouth throughout the chewing process. A finished gum is to be defined as a chewing gum that is ready for user consumption.

[0024] A "finished chewing gum base" or "finished gum base", as used herein, will refer to chewing gum that includes a sufficient combination of gum base ingredients that need only be combined with subsequent gum ingredients to form a finished gum. A finished gum base is a visco-elastic material that includes at least a viscous component, an elastic component, and a softener component. For example, a typical gum base may include elastomer, at least some of the filler, resin and/or plasticizer, polyvinyl acetate, and a softener (such as an oil, fat or wax). Merely compounded elastomer without the addition of any softener, for example, would not be a finished gum base because it would not be considered useable in a finished gum structure because of its difficulty, if not impossibility, to chew.

[0025] A "partial chewing gum base" or "partial gum base", as used herein, will refer to chewing gum that includes a gum base ingredient or combination of gum base ingredients that need be combined with further gum base ingredients and subsequent, non-base gum ingredients to form a finished gum. A partial gum base includes at least an elastic component, and will require addition of at least a viscous and/or softener component to form a finished gum base.

[0026] Chewing gum may include a vast number of ingredients in various categories. The systems and methods discussed below may be used to mix any and all known ingredients including, but not limited to, ingredients in the following ingredient categories: elastomers, bulking agents, elastomer plasticizers (which includes resins), elastomer solvents, plasticizers, fats, waxes, fillers, antioxidants, sweeteners (e.g. bulk sweeteners and high intensity sweeteners), syrups/fluids, flavors, sensates, potentiators, acids, emulsifiers, colors, and functional ingredients.

[0027] The insoluble gum base in its finished gum base form generally includes ingredients falling under the following categories: elastomers, elastomer plasticizers (resins or solvents), plasticizers, fats, oils, waxes, softeners and fillers. Further discussion of representative ingredients within each category will be provided later on. The gum base may constitute between 5-95% by weight of a finished gum, more typically 10-50% by weight of the finished gum, and most commonly 20-30% by weight of the finished gum.

[0028] The water soluble portion of finished gum will be referred to as subsequent ingredients in this disclosure (as they are added subsequent to manufacture of a) finished gum base, and may include subsequent gum ingredients falling under the following categories: softeners, bulk sweeteners, high intensity sweeteners, flavoring agents, acids, additional fillers, functional ingredients and combinations thereof. Softeners are added to the gum in order to optimize the chewability and mouth feel of the gum. The softeners, which are also known as plasticizers, plasticizing agents or emulsifiers, generally constitute between about 0.5-15% by weight of the finished gum. Bulk sweeteners constitute between 5-95% by weight of the finished gum, more typically 20-80% by weight of the finished gum and most commonly 30-60% by weight of the finished gum. High intensity sweeteners may also be present and are commonly used with sugarless sweeteners. When used, high intensity sweeteners typically constitute between 0.001-5% by weight of the finished gum, preferably between 0.01-3% by weight of the finished gum. Typically, high intensity sweeteners are at least 20 times sweeter than sucrose.

[0029] Flavor should generally be present in the gum in an amount within the range of about 0.1-15% by weight of the finished gum, preferably between about 0.2-5% by weight of the finished gum, most preferably between about 0.5-3% by weight of the finished gum. Natural and artificial flavoring agents may be used and combined in any sensorially acceptable fashion.

[0030] When included, acids typically constitute between about 0.001-5% by weight of the finished gum.

[0031] Optional ingredients such as colors, functional ingredients and additional flavoring agents may also be included in gum.

[0032] Now that a more general overview has been provided as to general common ingredients, more details about individual categories of ingredients and examples of specific ingredients with in various categories will be provided below.

[0033] The elastomers (rubbers) employed in gum will vary greatly depending upon various factors such as the desirable gum type, desirable gum consistency, and the other desirable gum components to be used in the gum. The elastomer may be any water-insoluble polymer known in the art, and includes those polymers utilized for chewing gums and bubble gums. Illustrative examples of suitable polymers in gum structures, and particularly gum bases, include both natural and synthetic elastomers. For example, those polymers which are suitable in chewing gum include, without limitation, natural substances (of vegetable origin) such as caspi, chicle, natural rubber, crown gum, nispero, rosidinha, jelutong, guayule, perillo, niger gutta, tunu, balata, guttapercha, lechi capsi, sorva, gutta kay, and the like, and combinations thereof. Examples of synthetic elastomers include, without limitation, styrene-butadiene copolymers (SBR), polyisobutylene, isobutylene-isoprene copolymers, polyethylene, polyvinyl acetate and the like, and combinations thereof. Elastomers constitute between about 10% to about 60% by weight and more commonly between about 35-40% by weight of the finished gum.

[0034] Additional useful polymers include: crosslinked polyvinyl pyrrolidone, polymethylmethacrylate; copolymers of lactic acid, polyhydroxyalkanoates, plasticized ethylcellulose, polyvinyl acetatephthalate and combinations thereof.

[0035] Chewing gum may additionally contain elastomer solvents, also referred to herein as elastomer plasticizers, to aid in softening the elastomeric materials. Such elastomer solvents may include those elastomer solvents known in the art, for example, terpinene resins such as polymers of alpha-pinene, beta-pinene or d-limonene, methyl, glycerol and pentaerythritol esters of rosins and modified rosins and gums such as hydrogenated, dimerized and polymerized rosins, and mixtures thereof. Examples of elastomer solvents suitable for use herein may include the pentaerythritol ester of partially hydrogenated wood and gum rosin, the pentaerythritol ester of wood and gum rosin, the glycerol ester of wood rosin, the glycerol ester of partially dimerized wood and gum rosin, the glycerol ester of polymerized wood and gum rosin, the glycerol ester of tall oil rosin, the glycerol ester of wood and gum rosin and the partially hydrogenated wood and gum rosin and the partially hydrogenated methyl ester of wood and rosin, and the like, and mixtures thereof. The

elastomer solvent may be employed in the gum in amounts from about 2% to about 15%, and preferably from about 7% to about 11%, by weight of the finished gum.

[0036] Chewing gum may also include plasticizers or softeners, which also fall under the Wax category described below, to provide a variety of desirable textures and consistency properties. Because of the low molecular weight of these ingredients, the plasticizers and softeners are able to penetrate the fundamental structure of the gum making it plastic and less viscous. Useful plasticizers and softeners include triacetin, medium chain triglycerides of non-hydrogenated, partially hydrogenated cotton seed oil, soybean oil, palm oil, palm kernel oil, coconut oil, safflower oil, tallow oil, cocoa butter, terepene resins derived from alpha-pinene, lanolin, palmitic acid, oleic acid, stearic acid, sodium stearate, potassium stearate, glyceryl triacetate, glyceryl lecithin, glyceryl monostearate, propylene glycol monostearate, acetylated monoglyceride, glycerine, and the like, and mixtures thereof. Waxes, for example, natural and synthetic waxes, hydrogenated vegetable oils, petroleum waxes such as polyurethane waxes, polyethylene waxes, paraffin waxes, sorbitan monostearate, tallow, propylene glycol, mixtures thereof, and the like, may also be incorporated into chewing gum. The plasticizers and softeners are generally employed in gum in amounts up to about 20% by weight of the finished gum, and more specifically in amounts from about 9% to about 17%, by weight of the finished gum.

[0037] Plasticizers may also include hydrogenated vegetable oils, soybean oil and cottonseed oil which may be employed alone or in combination. These plasticizers provide chewing gum with good texture and soft chew characteristics. These plasticizers and softeners are generally employed in amounts from about 5% to about 14%, and more specifically in amounts from about 5% to about 13.5%, by weight of the finished gum.

[0038] Suitable oils and fats include partially hydrogenated vegetable or animal fats, such as coconut oil, palm kernel oil, beef tallow, and lard, among others. These ingredients when used are generally present in amounts up to about 7%, and preferably up to about 3.5%, by weight of the finished gum.

[0039] In some embodiments, chewing gum may include wax. Waxes that are used may include synthetic waxes such as waxes containing branched alkanes and copolymerized with monomers such as, but not limited to, polypropylene and polyethylene and Fischer-Tropsch type waxes, petroleum waxes such as paraffin, and microcrystalline wax, and natural waxes such as beeswax, candellia, carnauba, and polyethylene wax, rice bran and petroleum.

[0040] Waxes soften the polymeric mixture and improves the elasticity of the gum. When present, the waxes employed will have a melting point below about 60° C., and

preferably between about 45° C. and about 55° C. The low melting wax may be a paraffin wax. The wax may be present in a finished gum in an amount from about 6% to about 10%, and preferably from about 7% to about 9.5%, by weight of the finished gum.

[0041] In addition to the low melting point waxes, waxes having a higher melting point may be used in the finished gum in amounts up to about 5%, by weight of the finished gum. Such high melting waxes include beeswax, vegetable wax, candelilla wax, carnuba wax, most petroleum waxes, and the like, and mixtures thereof.

[0042] In some embodiments, chewing gum that is formed using the systems and methods discussed below may also include effective amounts of bulking agents such as mineral adjuvants which may serve as fillers and textural agents. Useful mineral adjuvants include calcium carbonate, magnesium carbonate, alumina, aluminum hydroxide, aluminum silicate, talc, clay, titanium oxide, ground limestone, monocalcium phosphate, tricalcium phosphate, dicalcium phosphate, calcium sulfate and the like, and mixtures thereof. These fillers or adjuvants may be used in various amounts in chewing gum. The amount of filler, may be present in an amount from about zero to about 40%, and more specifically from about zero to about 30%, by weight of the finished gum. In some embodiments, the amount of filler will be from about zero to about 15%, more specifically from about 3% to about 11%.

[0043] Antioxidants can include materials that scavenge free radicals. In some embodiments, antioxidants can include but are not limited to ascorbic acid, citric acid (citric acid may be encapsulated), rosemary oil, vitamin A, vitamin E, vitamin E phosphate, butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), propyl gallate, tocopherols, di-alpha-tocopheryl phosphate, tocotrienols, alpha lipoic acid, dihydrolipoic acid, xanthophylls, beta cryptoxanthin, lycopene, lutein, zeaxanthin, astaxanthin, beta-carotene, carotenes, mixed carotenoids, polyphenols, flavonoids, and combinations thereof.

[0044] In order to produce a finished gum, chewing gum may also include amounts of conventional additives selected from the group consisting of sweetening agents (bulk and high intensity sweeteners), softeners, emulsifiers, fillers, bulking agents (carriers, extenders, bulk sweeteners), flavoring agents (flavors, flavorings), coloring agents (colorants, colorings), functional ingredients, and the like, and mixtures thereof. Some of these additives may serve more than one purpose. For example, in sugarless gum structure, a sweetener, such as maltitol or other sugar alcohol, may also function as a bulking agent and particularly a water soluble bulking agent.

[0045] Suitable Bulk Sweeteners include monosaccharides, disaccharides and polysaccharides such as xylose, ribulose, glucose (dextrose), lactose, mannose, galactose,

fructose (levulose), sucrose (sugar), maltose, invert sugar, partially hydrolyzed starch and corn syrup solids, sugar alcohols, randomly bonded glucose polymers such as those polymers distributed under the tradename Litesse™ which is the brand name for polydextrose and is manufactured by Danisco Sweeteners, Ltd. of 41-51 Brighton Road, Redhill, Surryey, RH16YS, United Kingdom.; isomalt (a racemic mixture of alpha-D-glucopyranosyl-1,6-mannitol and alpha-D-glucopyranosyl-1,6-sorbitol manufactured under the tradename PALATINIT™ by Palatinit Sussungsmittel GmbH of Gotlieb-Daimler-Strause 12 a, 68165 Mannheim, Germany); maltodextrins; hydrogenated starch hydrolysates; hydrogenated hexoses; hydrogenated disaccharides; minerals, such as calcium carbonate, talc, titanium dioxide, dicalcium phosphate; celluloses; and mixtures thereof.

[0046] Suitable sugarless bulk sweeteners include sorbitol, xylitol, mannitol, galactitol, lactitol, maltitol, erythritol, isomalt and mixtures thereof. Suitable hydrogenated starch hydrolysates include those disclosed in U.S. Pat. No. 4,279,931 and various hydrogenated glucose syrups and/or powders which contain sorbitol, maltitol, hydrogenated disaccharides, hydrogenated higher polysaccharides, or mixtures thereof. Hydrogenated starch hydrolysates are primarily prepared by the controlled catalytic hydrogenation of corn syrups. The resulting hydrogenated starch hydrolysates are mixtures of monomeric, dimeric, and polymeric saccharides. The ratios of these different saccharides give different hydrogenated starch hydrolysates different properties. Mixtures of hydrogenated starch hydrolysates, such as LYCASIN®, a commercially available product manufactured by Roquette Freres of France, and HYSTAR®, a commercially available product manufactured by SPI Polyols, Inc. of New Castle, Del., are also useful.

[0047] In some embodiments, chewing gum may include a specific polyol composition including at least one polyol which is from about 30% to about 80% by weight of the finished gum, and specifically from 50% to about 60%. In some embodiments, chewing gummay have low hygroscopicity. The polyol composition may include any polyol known in the art including, but not limited to maltitol, sorbitol, erythritol, xylitol, mannitol, isomalt, lactitol and combinations thereof. Lycasin™ which is a hydrogenated starch hydrolysate including sorbitol and maltitol, may also be used.

[0048] The amount of the polyol or combination of polyols used in chewing gum will depend on many factors including the type of elastomers used in the gum or gum base and the particular polyols used. For example, wherein the total amount of the polyol composition is in the range of about 40% to about 65% based on the weight of the finished gum, the amount of isomalt may be from about 40% to about 60% in addition to an amount of sorbitol from about

0 up to about 10%, more specifically, an amount of isomalt may be from about 45% to about 55% in combination with sorbitol from about 5% to about 10% based on the weight of the finished gum.

[0049] The polyol composition which may include one or more different polyols which may be derived from a genetically modified organism ("GMO") or GMO free source. For example, the maltitol may be GMO free maltitol or provided by a hydrogenated starch hydrolysate. The term "GMO-free" should be defined as referring to a composition that has been derived from process in which genetically modified organisms are not utilized.

[0050] The sweetening agents which may be included in some chewing gum manufactured using the below systems and methods may be any of a variety of sweeteners known in the art and may be used in many distinct physical forms well-known in the art to provide an initial burst of sweetness and/or a prolonged sensation of sweetness. Without being limited thereto, such physical forms include free forms, such as spray dried, powdered, beaded forms, encapsulated forms, and mixtures thereof.

[0051] Desirably, the sweetener is a high intensity sweetener such as aspartame, neotame, sucralose, monatin, and acesulfame potassium (Ace-K). The high intensity sweetener can be in an encapsulated form, a free form, or both.

[0052] In general, an effective amount of sweetener may be utilized to provide the level of sweetness desired, and this amount may vary with the sweetener selected. In some embodiments the amount of sweetener may be present in amounts from about 0.001% to about 3%, by weight of the finished gum, depending upon the sweetener or combination of sweeteners used. The exact range of amounts for each type of sweetener may be selected by those skilled in the art.

[0053] The sweeteners involved may be selected from a wide range of materials including water-soluble sweeteners, water-soluble artificial sweeteners, water-soluble sweeteners derived from naturally occurring water-soluble sweeteners, dipeptide based sweeteners, and protein based sweeteners, including mixtures thereof. Without being limited to particular sweeteners, representative categories and examples include:

(a) water-soluble sweetening agents such as dihydrochalcones, monellin, steviosides, lo han quo, lo han quo derivatives, glycyrrhizin, dihydroflavenol, and sugar alcohols such as sorbitol, mannitol, maltitol, xylitol, erythritol, and L-aminodicarboxylic acid aminoalkenoic acid ester amides, such as those disclosed in U.S. Pat. No. 4,619,834, which disclosure is incorporated herein by reference, and mixtures thereof,

(b) water-soluble artificial sweeteners such as soluble saccharin salts, i.e., sodium or calcium saccharin salts, cyclamate salts, the sodium, ammonium or calcium salt of 3,4-dihydro-6-methyl-1,2,3-oxathiazine-4-one-2,2-dioxide, the potassium salt of 3,4-dihydro-6-methyl-1,2,3-oxathiazine-4-one-2,2-dioxide (Acesulfame-K), the free acid form of saccharin, and mixtures thereof,

(c) dipeptide based sweeteners, such as L-aspartic acid derived sweeteners, such as L-aspartyl-L-phenylalanine methyl ester (Aspartame), N-[N-(3,3-dimethylbutyl)-L-α-aspartyl]-L-phenylalanine 1-methyl ester (Neotame), and materials described in U.S. Pat. No. 3,492,131, L-alphaaspartyl-N-(2,2,4,4-tetramethyl-3-thietanyl)-D-alaninamide hydrate (Alitame), methyl esters of L-aspartyl-L-phenylglycerine and L-aspartyl-L-2,5-dihydrophenyl-glycine, L-aspartyl-2,5-dihydro-L-phenylalanine; L-aspartyl-L-(1-cyclohexen)-alanine, and mixtures thereof;

(d) water-soluble sweeteners derived from naturally occurring water-soluble sweeteners, such as chlorinated derivatives of ordinary sugar (sucrose), e.g., chlorodeoxysugar derivatives such as derivatives of chlorodeoxysucrose or chlorodeoxygalactosucrose, known, for example, under the product designation of Sucralose; examples of chlorodeoxysucrose and chlorodeoxygalactosucrose derivatives include but are not limited to: 1-chloro-1′-deoxysucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-alpha-D-fructofuranoside, or 4-chloro-4-deoxygalactosucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-1-chloro-1-deoxy-beta-D-fructo-furanos ide, or 4,1′-dichloro-4,1′-dideoxygalactosucrose; 1′,6′-dichloro 1′,6′-dideoxysucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-1,6-dichloro-1,6-dideoxy-beta-D-fructo furanoside, or 4,1′,6′-trichloro-4,1′,6′-trideoxygalactosucrose; 4,6-dichloro-4,6-dideoxy-alpha-D-galactopyranosyl-6-chloro-6-deoxy-beta-D-fructo furanoside, or 4,6,6′-trichloro-4,6,6′-trideoxygalactosucrose; 6,1′,6′-trichloro-6,1′,6′-trideoxysucrose; 4,6-dichloro-4,6-dideoxy-alpha-D-galacto-pyranosyl-1,6-dichloro-1,6-dideoxy-beta -D-fructofuranoside, or 4,6,1′,6′-tetrachloro4,6,1′,6′-tetradeoxygalacto-sucrose ; and 4,6,1′,6′-tetradeoxy-sucrose, and mixtures thereof;

(e) protein based sweeteners such as thaumaoccous danielli (Thaumatin I and II) and talin; and

(f) the sweetener monatin (2-hydroxy-2-(indol-3-ylmethyl)-4-aminoglutaric acid) and its derivatives.

[0054] The intense sweetening agents may be used in many distinct physical forms well-known in the art to provide an initial burst of sweetness and/or a prolonged sensation of sweetness. Without being limited thereto, such physical forms include free forms, spray dried

forms, powdered forms, beaded forms, encapsulated forms, and mixtures thereof. In one embodiment, the sweetener is a high intensity sweetener such as aspartame, sucralose, and acesulfame potassium (e.g., Ace-K or acesulfame-K). Several representative forms of encapsulated sweeteners and methods of encapsulating sweeteners are illustrated in U.S. Pat. Nos. 7,244,454; 7,022,352; 6,759,066; 5,217,735; 5,192,561; 5,164,210; 4,997,659 and 4,981,698 as well as U.S. Patent Application Publication Nos. 2007/0231424; 2004/0096544; 2005/0112236; and 2005/0220867, the teachings and disclosure of which are hereby incorporated in their entireties by reference thereto.

[0055] The active component (e.g., sweetener), which is part of the delivery system, may be used in amounts necessary to impart the desired effect associated with use of the active component (e.g., sweetness). In general, an effective amount of intense sweetener may be utilized to provide the level of sweetness desired, and this amount may vary with the sweetener selected. The intense sweetener may be present in amounts from about 0.001% to about 3%, by weight of the composition, depending upon the sweetener or combination of sweeteners used. The exact range of amounts for each type of sweetener may be selected by those skilled in the art.

[0056] Anhydrous glycerin may also be employed as a softening agent, such as the commercially available United States Pharmacopeia (USP) grade. Glycerin is a syrupy liquid with a sweet warm taste and has a sweetness of about 60% of that of cane sugar. Because glycerin is hygroscopic, the anhydrous glycerin may be maintained under anhydrous conditions throughout the preparation of the gum structure. Other syrups may include corn syrup and maltitol syrup.

[0057] In some embodiments, flavorants may include those flavors known to the skilled artisan, such as natural and artificial flavors. These flavorings may be chosen from synthetic flavor oils and flavoring aromatics and/or oils, oleoresins and extracts derived from plants, leaves, flowers, fruits, and so forth, and combinations thereof Nonlimiting representative flavor oils include spearmint oil, cinnamon oil, oil of wintergreen (methyl salicylate), peppermint oil, Japanese mint oil, clove oil, bay oil, anise oil, eucalyptus oil, thyme oil, cedar leaf oil, oil of nutmeg, allspice, oil of sage, mace, oil of bitter almonds, and cassia oil. Also useful flavorings are artificial, natural and synthetic fruit flavors such as vanilla, and citrus oils including lemon, orange, lime, grapefruit, yazu, sudachi, and fruit essences including apple, pear, peach, grape, blueberry, strawberry, raspberry, cherry, plum, pineapple, apricot, banana, melon, apricot, ume, cherry, raspberry, blackberry, tropical fruit, mango, mangosteen, pomegranate, papaya and so forth. Other potential flavors whose release

profiles can be managed include a milk flavor, a butter flavor, a cheese flavor, a cream flavor, and a yogurt flavor; a vanilla flavor; tea or coffee flavors, such as a green tea flavor, a oolong tea flavor, a tea flavor, a cocoa flavor, a chocolate flavor, and a coffee flavor; mint flavors, such as a peppermint flavor, a spearmint flavor, and a Japanese mint flavor; spicy flavors, such as an asafetida flavor, an ajowan flavor, an anise flavor, an angelica flavor, a fennel flavor, an allspice flavor, a cinnamon flavor, a camomile flavor, a mustard flavor, a cardamom flavor, a caraway flavor, a cumin flavor, a clove flavor, a pepper flavor, a coriander flavor, a sassafras flavor, a savory flavor, a Zanthoxyli Fructus flavor, a perilla flavor, a juniper berry flavor, a ginger flavor, a star anise flavor, a horseradish flavor, a thyme flavor, a tarragon flavor, a dill flavor, a capsicum flavor, a nutmeg flavor, a basil flavor, a marjoram flavor, a rosemary flavor, a bayleaf flavor, and a wasabi (Japanese horseradish) flavor; alcoholic flavors, such as a wine flavor, a whisky flavor, a brandy flavor, a rum flavor, a gin flavor, and a liqueur flavor; floral flavors; and vegetable flavors, such as an onion flavor, a garlic flavor, a cabbage flavor, a carrot flavor, a celery flavor, mushroom flavor, and a tomato flavor. These flavoring agents may be used in liquid or solid form and may be used individually or in admixture. Commonly used flavors include mints such as peppermint, menthol, spearmint, artificial vanilla, cinnamon derivatives, and various fruit flavors, whether employed individually or in admixture. Flavors may also provide breath freshening properties, particularly the mint flavors when used in combination with the cooling agents, described herein below. In some embodiments, flavorants may choose from geraniol, linalool, nerol, nerolidal, citronellol, heliotropine, methyl cyclopentelone, ethyl vanillin, maltol, ethyl maltol, furaneol, alliaceous compounds, rose type compounds such as phenethanol, phenylacetic acid, nerol, linalyl esters, jasmine, sandlewood, patchouli, and/or cedarwood.

[0058] In some embodiments, other flavorings include aldehydes and esters such as cinnamyl acetate, cinnamaldehyde, citral diethylacetal, dihydrocarvyl acetate, eugenyl formate, p-methylamisol, and so forth may be used. Generally any flavoring or food additive such as those described in Chemicals Used in Food Processing, publication 1274, pages 63-258, by the National Academy of Sciences, may be used. This publication is incorporated herein by reference. These may include natural as well as synthetic flavors.

[0059] Further examples of aldehyde flavorings include but are not limited to acetaldehyde (apple), benzaldehyde (cherry, almond), anisic aldehyde (licorice, anise), cinnamic aldehyde (cinnamon), citral, i.e., alpha-citral (lemon, lime), neral, i.e., beta-citral (lemon, lime), decanal (orange, lemon), ethyl vanillin (vanilla, cream), heliotrope, i.e.,

piperonal (vanilla, cream), vanillin (vanilla, cream), alpha-amyl cinnamaldehyde (spicy fruity flavors), butyraldehyde (butter, cheese), valeraldehyde (butter, cheese), citronellal (modifies, many types), decanal (citrus fruits), aldehyde C-8 (citrus fruits), aldehyde C-9 (citrus fruits), aldehyde C-12 (citrus fruits), 2-ethyl butyraldehyde (berry fruits), hexenal, i.e., trans-2 (berry fruits), tolyl aldehyde (cherry, almond), veratraldehyde (vanilla), 2,6-dimethyl-5-heptenal, .e., melonal (melon), 2,6-dimethyloctanal (green fruit), and 2-dodecenal (citrus, mandarin), cherry, grape, blueberry, blackberry, strawberry shortcake, and mixtures thereof.

[0060] In some embodiments, flavoring agents are used at levels that provide a perceptible sensory experience i.e. at or above their threshold levels. In other embodiments, flavoring agents are used at levels below their threshold levels such that they do not provide an independent perceptible sensory experience. At subthreshold levels, the flavoring agents may provide an ancillary benefit such as flavor enhancement or potentiation.

[0061] In some embodiments, a flavoring agent may be employed in either liquid form and/or dried form. When employed in the latter form, suitable drying means such as spray drying the liquid may be used. Alternatively, the flavoring agent may be absorbed onto water soluble materials, such as cellulose, starch, sugar, maltodextrin, gum arabic and so forth or may be encapsulated. In still other embodiments, the flavoring agent may be adsorbed onto silicas, zeolites, and the like.

[0062] In some embodiments, the flavoring agents may be used in many distinct physical forms. Without being limited thereto, such physical forms include free forms, such as spray dried, powdered, beaded forms, encapsulated forms, and mixtures thereof.

[0063] Sensate compounds can include cooling agents, warming agents, tingling agents, effervescent agents, and combinations thereof. A variety of well known cooling agents may be employed. For example, among the useful cooling agents are included xylitol, erythritol, dextrose, sorbitol, menthane, menthone, ketals, menthone ketals, menthone glycerol ketals, substituted p-menthanes, acyclic carboxamides, mono menthyl glutarate, substituted cyclohexanamides, substituted cyclohexane carboxamides, substituted ureas and sulfonamides, substituted menthanols, hydroxymethyl and hydroxymethyl derivatives of p-menthane, 2-mercapto-cyclo-decanone, hydroxycarboxylic acids with 2-6 carbon atoms, cyclohexanamides, menthyl acetate, menthyl salicylate, N,2,3-trimethyl-2-isopropyl butanamide (WS-23), N-ethyl-p-menthane-3-carboxamide (WS-3), isopulegol, 3-(1-menthoxy)propane-1,2-diol, 3-(1-menthoxy)-2-methylpropane-1,2-diol, p-menthane-2,3-diol, p-menthane-3,8-diol, 6-isopropyl-9-methyl-1,4-dioxaspiro[4,5]decane-2-methanol, menthyl succinate and its alkaline earth metal salts, trimethylcyclohexanol, N-ethyl-2-isopropyl-5-

methylcyclohexanecarboxamide, Japanese mint oil, peppermint oil, 3-(1-menthoxy)ethan-1-ol, 3-(1-menthoxy)propan-1-ol, 3-(1-menthoxy)butan-1-ol, 1-menthylacetic acid N-ethylamide, 1-menthyl-4-hydroxypentanoate, 1-menthyl-3-hydroxybutyrate, N,2,3-trimethyl-2-(1-methylethyl)-butanamide, n-ethyl-t-2-c-6 nonadienamide, N,N-dimethyl menthyl succinamide, substituted p-menthanes, substituted p-menthane-carboxamides, 2-isopropanyl-5-methylcyclohexanol (from Hisamitsu Pharmaceuticals, hereinafter "isopregol"); menthone glycerol ketals (FEMA 3807, tradename FRESCOLAT® type MGA); 3-1-menthoxypropane-1,2-diol (from Takasago, FEMA 3784); and menthyl lactate; (from Haarman & Reimer, FEMA 3748, tradename FRESCOLAT® type ML), WS-30, WS-14, Eucalyptus extract (p-Mehtha-3,8-Diol), Menthol (its natural or synthetic derivatives), Menthol PG carbonate, Menthol EG carbonate, Menthol glyceryl ether, N-tertbutyl-p-menthane-3-carboxamide, P-menthane-3-carboxylic acid glycerol ester, Methyl-2-isopryl-bicyclo (2.2.1), Heptane-2-carboxamide; and Menthol methyl ether, and menthyl pyrrolidone carboxylate among others. These and other suitable cooling agents are further described in the following U.S. patents, all of which are incorporated in their entirety by reference hereto: U.S. Pat. Nos. 4,230,688; 4,032,661; 4,459,425; 4,136,163; 5,266,592; 6,627,233.

[0064] In some embodiments, warming components may be selected from a wide variety of compounds known to provide the sensory signal of warming to the user. These compounds offer the perceived sensation of warmth, particularly in the oral cavity, and often enhance the perception of flavors, sweeteners and other organoleptic components. In some embodiments, useful warming compounds can include vanillyl alcohol n-butylether (TK-1000) supplied by Takasago Perfumary Company Limited, Tokyo, Japan, vanillyl alcohol n-propylether, vanillyl alcohol isopropylether, vanillyl alcohol isobutylether, vanillyl alcohol n-aminoether, vanillyl alcohol isoamyleather, vanillyl alcohol n-hexyleather, vanillyl alcohol methylether, vanillyl alcohol ethylether, gingerol, shogaol, paradol, zingerone, capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin, homodihydrocapsaicin, ethanol, isopropyl alcohol, iso-amylalcohol, benzyl alcohol, glycerine, and combinations thereof.

[0065] In some embodiments, a tingling sensation can be provided. One such tingling sensation is provided by adding jambu, oleoresin, or spilanthol to some examples. In some embodiments, alkylamides extracted from materials such as jambu or sanshool can be included. Additionally, in some embodiments, a sensation is created due to effervescence. Such effervescence is created by combining an alkaline material with an acidic material. In some embodiments, an alkaline material can include alkali metal carbonates, alkali metal bicarbonates, alkaline earth metal carbonates, alkaline earth metal bicarbonates and mixtures

thereof. In some embodiments, an acidic material can include acetic acid, adipic acid, ascorbic acid, butyric acid, citric acid, formic acid, fumaric acid, glyconic acid, lactic acid, phosphoric acid, malic acid, oxalic acid, succinic acid, tartaric acid and combinations thereof. Examples of "tingling" type sensates can be found in U.S. Pat. No. 6,780,443, the entire contents of which are incorporated herein by reference for all purposes.

[0066] Sensate components may also be referred to as "trigeminal stimulants" such as those disclosed in U.S. Patent Application No. 205/0202118, which is incorporated herein by reference. Trigeminal stimulants are defined as an orally consumed product or agent that stimulates the trigeminal nerve. Examples of cooling agents which are trigeminal stimulants include menthol, WS-3, N-substituted p-menthane carboxamide, acyclic carboxamides including WS-23, methyl succinate, menthone glycerol ketals, bulk sweeteners such as xylitol, erythritol, dextrose, and sorbitol, and combinations thereof. Trigeminal stimulants can also include flavors, tingling agents, Jambu extract, vanillyl alkyl ethers, such as vanillyl n-butyl ether, spilanthol, Echinacea extract, Northern Prickly Ash extract, capsaicin, capsicum oleoresin, red pepper oleoresin, black pepper oleoresin, piperine, ginger oleoresin, gingerol, shoagol, cinnamon oleoresin, cassia oleoresin, cinnamic aldehyde, eugenol, cyclic acetal of vanillin and menthol glycerin ether, unsaturated amides, and combinations thereof.

[0067] In some embodiments, sensate components are used at levels that provide a perceptible sensory experience i.e. at or above their threshold levels. In other embodiments, sensate components are used at levels below their threshold levels such that they do not provide an independent perceptible sensory experience. At subthreshold levels, the sensates may provide an ancillary benefit such as flavor or sweetness enhancement or potentiation.

[0068] Potentiators can include of materials that may intensify, supplement, modify or enhance the taste and/or aroma perception of an original material without introducing a characteristic taste and/or aroma perception of their own. In some embodiments, potentiators designed to intensify, supplement, modify, or enhance the perception of flavor, sweetness, tartness, umami, kokumi, saltiness and combinations thereof can be included.

[0069] In some embodiments, examples of suitable potentiators, also known as taste potentiators include, but are not limited to, neohesperidin dihydrochalcone, chlorogenic acid, alapyridaine, cynarin, miraculin, glupyridaine, pyridinium-betain compounds, glutamates, such as monosodium glutamate and monopotassium glutamate, neotame, thaumatin, tagatose, trehalose, salts, such as sodium chloride, monoammonium glycyrrhizinate, vanilla extract (in ethyl alcohol), sugar acids, potassium chloride, sodium acid sulfate, hydrolyzed vegetable proteins, hydrolyzed animal proteins, yeast extracts, adenosine monophosphate (AMP),

glutathione, nucleotides, such as inosine monophosphate, disodium inosinate, xanthosine monophosphate, guanylate monophosphate, alapyridaine (N-(1-carboxyethyl)-6-(hydroxymethyl)pyridinium-3-ol inner salt, sugar beet extract (alcoholic extract), sugarcane leaf essence (alcoholic extract), curculin, strogin, mabinlin, gymnemic acid, hydroxybenzoic acids, 3-hydrobenzoic acid, 2,4-dihydrobenzoic acid, citrus aurantium, vanilla oleoresin, sugarcane leaf essence, maltol, ethyl maltol, vanillin, licorice glycyrrhizinates, compounds that respond to G-protein coupled receptors (T2Rs and T1Rs) and taste potentiator compositions that impart kokumi, as disclosed in U.S. Pat. No. 5,679,397 to Kuroda et al., which is incorporated in its entirety herein by reference. "Kokumi" refers to materials that impart "mouthfulness" and "good body".

[0070] Sweetener potentiators, which are a type of taste potentiator, enhance the taste of sweetness. In some embodiments, exemplary sweetener potentiators include, but are not limited to, monoammonium glycyrrhizinate, licorice glycyrrhizinates, citrus aurantium, alapyridaine, alapyridaine (N-(1-carboxyethyl)-6-(hydroxymethyl)pyridinium-3-ol) inner salt, miraculin, curculin, strogin, mabinlin, gymnemic acid, cynarin, glupyridaine, pyridinium-betain compounds, sugar beet extract, neotame, thaumatin, neohesperidin dihydrochalcone, hydroxybenzoic acids, tagatose, trehalose, maltol, ethyl maltol, vanilla extract, vanilla oleoresin, vanillin, sugar beet extract (alcoholic extract), sugarcane leaf essence (alcoholic extract), compounds that respond to G-protein coupled receptors (T2Rs and T1Rs) and combinations thereof.

[0071] Additional examples of potentiators for the enhancement of salt taste include acidic peptides, such as those disclosed in U.S. Pat. No. 6,974,597, herein incorporated by reference. Acidic peptides include peptides having a larger number of acidic amino acids, such as aspartic acid and glutamic acid, than basic amino acids, such as lysine, arginine and histidine. The acidic peptides are obtained by peptide synthesis or by subjecting proteins to hydrolysis using endopeptidase, and if necessary, to deamidation. Suitable proteins for use in the production of the acidic peptides or the peptides obtained by subjecting a protein to hydrolysis and deamidation include plant proteins, (e.g. wheat gluten, corn protein (e.g., zein and gluten meal), soybean protein isolate), animal proteins (e.g., milk proteins such as milk casein and milk whey protein, muscle proteins such as meat protein and fish meat protein, egg white protein and collagen), and microbial proteins (e.g., microbial cell protein and polypeptides produced by microorganisms).

[0072] The sensation of warming or cooling effects may also be prolonged with the use of a hydrophobic sweetener as described in U.S. Patent Application Publication 2003/0072842 A1 which is incorporated in its entirety herein by reference.

[0073] Acids can include, but are not limited to acetic acid, adipic acid, ascorbic acid, butyric acid, citric acid, formic acid, fumaric acid, glyconic acid, lactic acid, phosphoric acid, malic acid, oxalic acid, succinic acid, tartaric acid, aspartic acid, benzoic acid, caffeotannic acid, iso-citric acid, citramalic acid, galacturonic acid, glucuronic acid, glyceric acid, glycolic acid, ketoglutaric acid, a-ketoglutaric acid, lactoisocitric acid, oxalacetic acid, pyruvic acid, quinic acid, shikimic acid, succinic acid, tannic acid, hydroxyacetic acid, suberic acid, sebacic acid, azelaic acid, pimelic acid, capric acid and combinations thereof.

[0074] Chewing gum may also include emulsifiers which aid in dispersing the immiscible components into a single stable system. The emulsifiers useful in this invention include glyceryl monostearate, lecithin, fatty acid monoglycerides, diglycerides, propylene glycol monostearate, methyl cellulose, alginates, carrageenan, xanthan gum, gelatin, carob, tragacanth, locust bean gum, pectin, alginates, galactomannans such as guar gum, carob bean gum, glucomannan, gelatin, starch, starch derivatives, dextrins and cellulose derivatives such as carboxy methyl cellulose, acidulants such as malic acid, adipic acid, citric acid, tartaric acid, fumaric acid, and the like, used alone and mixtures thereof. The emulsifier may be employed in amounts from about 2% to about 15%, and more specifically, from about 7% to about 11%, by weight of the gum structure.

[0075] Coloring agents may be used in amounts effective to produce the desired color. The coloring agents may include pigments which may be incorporated in amounts up to about 6%, by weight of the finished gum. For example, titanium dioxide may be incorporated in amounts up to about 2%, and preferably less than about 1%, by weight of the gum structure. The colorants may also include natural food colors and dyes suitable for food, drug and cosmetic applications. These colorants are known as F.D.& C. dyes and lakes. The materials acceptable for the foregoing uses are preferably water-soluble. Illustrative nonlimiting examples include the indigoid dye known as F.D.& C. Blue No.2, which is the disodium salt of 5,5-indigotindisulfonic acid. Similarly, the dye known as F.D.& C. Green No. 1 comprises a triphenylmethane dye and is the monosodium salt of 4-[4-(N-ethyl-p-sulfoniumbenzylamino)diphenylmethylene]-[1-(N-ethyl -N-p-sulfoniumbenzyl)-delta-2,5-cyclohexadieneimine]. A full recitation of all F.D.& C. colorants and their corresponding chemical structures may be found in the Kirk-Othmer Encyclopedia of Chemical Technology, 3rd Edition, in volume 5 at pages 857-884, which text is incorporated herein by reference.

[0076] As classified by the United States Food, Drug, and Cosmetic Act (21 C.F.R. 73), colors can include exempt from certification colors (sometimes referred to as natural even though they can be synthetically manufactured) and certified colors (sometimes referred to as artificial), or combinations thereof. In some embodiments, exempt from certification or natural colors can include, but are not limited to annatto extract, (E160b), bixin, norbixin, astaxanthin, dehydrated beets (beet powder), beetroot red/betanin (E162), ultramarine blue, canthaxanthin (E161g), cryptoxanthin (E161c), rubixanthin (E161d), violanxanthin (E161e), rhodoxanthin (E161f), caramel (E150(a-d)), β-apo-8′-carotenal (E160e), β-carotene (E160a), alpha carotene, gamma carotene, ethyl ester of beta-apo-8 carotenal (E160f), flavoxanthin (E161a), lutein (E161b), cochineal extract (E120); carmine (E132), carmoisine/azorubine (E122), sodium copper chlorophyllin (E141), chlorophyll (E140), toasted partially defatted cooked cottonseed flour, ferrous gluconate, ferrous lactate, grape color extract, grape skin extract (enocianina), anthocyanins (E163), haematococcus algae meal, synthetic iron oxide, iron oxides and hydroxides (E172), fruit juice, vegetable juice, dried algae meal, tagetes (Aztec marigold) meal and extract, carrot oil, corn endosperm oil, paprika, paprika oleoresin, phaffia yeast, riboflavin (E101), saffron, titanium dioxide, turmeric (E100), turmeric oleoresin, amaranth (E123), capsanthin/capsorbin (E160c), lycopene (E160d), and combinations thereof.

[0077] In some embodiments, certified colors can include, but are not limited to, FD&C blue #1, FD&C blue #2, FD&C green #3, FD&C red #3, FD&C red #40, FD&C yellow #5 and FD&C yellow #6, tartrazine (E102), quinoline yellow (E104), sunset yellow (E110), ponceau (E124), erythrosine (E127), patent blue V (E131), titanium dioxide (E171), aluminium (E173), silver (E174), gold (E175), pigment rubine/lithol rubine BK (E180), calcium carbonate (E170), carbon black (E153), black PN/brilliant black BN (E151), green S/acid brilliant green BS (E142), and combinations thereof. In some embodiments, certified colors can include FD&C aluminum lakes. These include of the aluminum salts of FD&C dyes extended on an insoluble substrate of alumina hydrate. Additionally, in some embodiments, certified colors can be included as calcium salts.

[0078] Additional additives including functional ingredients include physiological cooling agents, throat-soothing agents, spices, warming agents, tooth-whitening agents or other dental care ingredients, breath-freshening agents, vitamins, nutraceuticals, phytochemicals, polyphenols, antioxidants, active ingredients, minerals, caffeine, drugs and other actives may also be included in the composition of the chewing gum. Such components

may be used in amounts sufficient to achieve their intended effects and will be more fully discussed below.

[0079] Breath fresheners can include essential oils as well as various aldehydes, alcohols, and similar materials. In some embodiments, essential oils can include oils of spearmint, peppermint, wintergreen, sassafras, chlorophyll, citral, geraniol, cardamom, clove, sage, carvacrol, eucalyptus, cardamom, magnolia bark extract, marjoram, cinnamon, lemon, lime, grapefruit, and orange. In some embodiments, aldehydes such as cinnamic aldehyde and salicylaldehyde can be used. Additionally, chemicals such as menthol, carvone, iso-garrigol, and anethole can function as breath fresheners. Of these, the most commonly employed are oils of peppermint, spearmint and chlorophyll.

[0080] In addition to essential oils and chemicals derived from them, in some embodiments breath fresheners can include but are not limited to zinc citrate, zinc acetate, zinc fluoride, zinc ammonium sulfate, zinc bromide, zinc iodide, zinc chloride, zinc nitrate, zinc flurosilicate, zinc gluconate, zinc tartarate, zinc succinate, zinc formate, zinc chromate, zinc phenol sulfonate, zinc dithionate, zinc sulfate, silver nitrate, zinc salicylate, zinc glycerophosphate, copper nitrate, chlorophyll, copper chlorophyll, chlorophyllin, hydrogenated cottonseed oil, chlorine dioxide, beta cyclodextrin, zeolite, silica-based materials, carbon-based materials, enzymes such as laccase, and combinations thereof.

[0081] In some embodiments, the release profiles of probiotics can be managed for a gum structure including, but not limited to lactic acid producing microorganisms such as Bacillus coagulans, Bacillus subtilis, Bacillus laterosporus, Bacillus laevolacticus, Sporolactobacillus inulinus, Lactobacillus acidophilus, Lactobacillus curvatus, Lactobacillus plantarum, Lactobacillus jenseni, Lactobacillus casei, Lactobacillus fermentum, Lactococcus lactis, Pedioccocus acidilacti, Pedioccocus pentosaceus, Pedioccocus urinae, Leuconostoc mesenteroides, Bacillus coagulans, Bacillus subtilis, Bacillus laterosporus, Bacillus laevolacticus, Sporolactobacillus inulinus and mixtures thereof. Breath fresheners are also known by the following trade names: Retsyn,™ Actizol,™ and Nutrazin.™ Examples of malodor-controlling compositions are also included in U.S. Pat. No. 5,300,305 to Stapler et al. and in U.S. Patent Application Publication Nos. 2003/0215417 and 2004/0081713 which are incorporated in their entirety herein by reference for all purposes.

[0082] Dental care ingredients (also known as oral care ingredients) may include but are not limited to tooth whiteners, stain removers, oral cleaning, bleaching agents, desensitizing agents, dental remineralization agents, antibacterial agents, anticaries agents, plaque acid buffering agents, surfactants and anticalculus agents. Non-limiting examples of

such ingredients can include, hydrolytic agents including proteolytic enzymes, abrasives such as hydrated silica, calcium carbonate, sodium bicarbonate and alumina, other active stain-removing components such as surface-active agents, including, but not limited to anionic surfactants such as sodium stearate, sodium palminate, sulfated butyl oleate, sodium oleate, salts of fumaric acid, glycerol, hydroxylated lecithin, sodium lauryl sulfate and chelators such as polyphosphates, which are typically employed as tartar control ingredients. In some embodiments, dental care ingredients can also include tetrasodium pyrophosphate and sodium tri-polyphosphate, sodium bicarbonate, sodium acid pyrophosphate, sodium tripolyphosphate, xylitol, sodium hexametaphosphate.

[0083] In some embodiments, peroxides such as carbamide peroxide, calcium peroxide, magnesium peroxide, sodium peroxide, hydrogen peroxide, and peroxydiphospate are included. In some embodiments, potassium nitrate and potassium citrate are included. Other examples can include casein glycomacropeptide, calcium casein peptone-calcium phosphate, casein phosphopeptides, casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), and amorphous calcium phosphate. Still other examples can include papaine, krillase, pepsin, trypsin, lysozyme, dextranase, mutanase, glycoamylase, amylase, glucose oxidase, and combinations thereof.

[0084] Further examples can include surfactants such as sodium stearate, sodium ricinoleate, and sodium lauryl sulfate surfactants for use in some embodiments to achieve increased prophylactic action and to render the dental care ingredients more cosmetically acceptable. Surfactants can preferably be detersive materials which impart to the composition detersive and foaming properties. Suitable examples of surfactants are water-soluble salts of higher fatty acid monoglyceride monosulfates, such as the sodium salt of the monosulfated monoglyceride of hydgrogenated coconut oil fatty acids, higher alkyl sulfates such as sodium lauryl sulfate, alkyl aryl sulfonates such as sodium dodecyl benzene sulfonate, higher alkyl sulfoacetates, sodium lauryl sulfoacetate, higher fatty acid esters of 1,2-dihydroxy propane sulfonate, and the substantially saturated higher aliphatic acyl amides of lower aliphatic amino carboxylic acid compounds, such as those having 12 to 16 carbons in the fatty acid, alkyl or acyl radicals, and the like. Examples of the last mentioned amides are N-lauroyl sarcosine, and the sodium, potassium, and ethanolamine salts of N-lauroyl, N-myristoyl, or N-palmitoyl sarcosine.

[0085] In addition to surfactants, dental care ingredients can include antibacterial agents such as, but not limited to, triclosan, chlorhexidine, zinc citrate, silver nitrate, copper, limonene, and cetyl pyridinium chloride. In some embodiments, additional anticaries agents

can include fluoride ions or fluorine-providing components such as inorganic fluoride salts. In some embodiments, soluble alkali metal salts, for example, sodium fluoride, potassium fluoride, sodium fluorosilicate, ammonium fluorosilicate, sodium monofluorophosphate, as well as tin fluorides, such as stannous fluoride and stannous chloride can be included. In some embodiments, a fluorine-containing compound having a beneficial effect on the care and hygiene of the oral cavity, e.g., diminution of enamel solubility in acid and protection of the teeth against decay may also be included as an ingredient. Examples thereof include sodium fluoride, stannous fluoride, potassium fluoride, potassium stannous fluoride (SnF.sub.2-KF), sodium hexafluorostannate, stannous chlorofluoride, sodium fluorozirconate, and sodium monofluorophosphate. In some embodiments, urea is included.

[0086] Further examples are included in the following U.S. patents and U.S. published patent applications, the contents of all of which are incorporated in their entirety herein by reference for all purposes: U.S. Pat. No. 5,227,154 to Reynolds, U.S. Pat. No. 5,378,131 to Greenberg, U.S. Pat. No. 6,846,500 to Luo et al., U.S. Pat. No. 6,733,818 to Luo et al., U.S. Pat. No. 6,696,044 to Luo et al., U.S. Pat. No. 6,685,916 to Holme et al., U.S. Pat. No. 6,485,739 to Luo et al., U.S. Pat. No. 6,479,071 to Holme et al., U.S. Pat. No. 6,471,945 to Luo et al., U.S. Patent Publication Nos. 20050025721 to Holme et al., 2005008732 to Gebreselassie et al., and 20040136928 to Holme et al.

[0087] Actives generally refer to those ingredients that are included in a delivery system and/or gum for the desired end benefit they provide to the user. In some embodiments, actives can include medicaments, nutrients, nutraceuticals, herbals, nutritional supplements, pharmaceuticals, drugs, and the like and combinations thereof.

[0088] Examples of useful drugs include ace-inhibitors, antianginal drugs, anti-arrhythmias, anti-asthmatics, anti-cholesterolemics, analgesics, anesthetics, anti-convulsants, anti-depressants, anti-diabetic agents, anti-diarrhea preparations, antidotes, anti-histamines, anti-hypertensive drugs, anti-inflammatory agents, anti-lipid agents, anti-manics, anti-nauseants, anti-stroke agents, anti-thyroid preparations, anti-tumor drugs, anti-viral agents, acne drugs, alkaloids, amino acid preparations, anti-tussives, anti-uricemic drugs, anti-viral drugs, anabolic preparations, systemic and non-systemic anti-infective agents, anti-neoplastics, anti-parkinsonian agents, anti-rheumatic agents, appetite stimulants, biological response modifiers, blood modifiers, bone metabolism regulators, cardiovascular agents, central nervous system stimulates, cholinesterase inhibitors, contraceptives, decongestants, dietary supplements, dopamine receptor agonists, endometriosis management agents, enzymes, erectile dysfunction therapies such as sildenafil citrate, which is currently marketed

as Viagra™, fertility agents, gastrointestinal agents, homeopathic remedies, hormones, hypercalcemia and hypocalcemia management agents, immunomodulators, immunosuppressives, migraine preparations, motion sickness treatments, muscle relaxants, obesity management agents, osteoporosis preparations, oxytocics, parasympatholytics, parasympathomimetics, prostaglandins, psychotherapeutic agents, respiratory agents, sedatives, smoking cessation aids such as bromocryptine or nicotine, sympatholytics, tremor preparations, urinary tract agents, vasodilators, laxatives, antacids, ion exchange resins, anti-pyretics, appetite suppressants, expectorants, anti-anxiety agents, anti-ulcer agents, anti-inflammatory substances, coronary dilators, cerebral dilators, peripheral vasodilators, psycho-tropics, stimulants, anti-hypertensive drugs, vasoconstrictors, migraine treatments, antibiotics, tranquilizers, anti-psychotics, anti-tumor drugs, anti-coagulants, anti-thrombotic drugs, hypnotics, anti-emetics, anti-nauseants, anti-convulsants, neuromuscular drugs, hyper- and hypo-glycemic agents, thyroid and anti-thyroid preparations, diuretics, anti-spasmodics, terine relaxants, anti-obesity drugs, erythropoietic drugs, anti-asthmatics, cough suppressants, mucolytics, DNA and genetic modifying drugs, and combinations thereof.

[0089] Examples of active ingredients contemplated for use in some embodiments can include antacids, H2-antagonists, and analgesics. For example, antacid dosages can be prepared using the ingredients calcium carbonate alone or in combination with magnesium hydroxide, and/or aluminum hydroxide. Moreover, antacids can be used in combination with H2-antagonists.

[0090] Analgesics include opiates and opiate derivatives, such as Oxycontin™, ibuprofen, aspirin, acetaminophen, and combinations thereof that may optionally include caffeine.

[0091] Other drug active ingredients for use in embodiments can include anti-diarrheals such as Immodium™ AD, anti-histamines, anti-tussives, decongestants, vitamins, and breath fresheners. Also contemplated for use herein are anxiolytics such as Xanax™; anti-psychotics such as Clozaril™ and Haldol™; non-steroidal anti-inflammatories (NSAID's) such as ibuprofen, naproxen sodium, Voltaren™ and Lodine™, anti-histamines such as Claritin™, Hismanal™, Relafen™, and Tavist™; anti-emetics such as Kytril™ and Cesamet™; bronchodilators such as Bentolin™, Proventil™; anti-depressants such as Prozac™, Zolof™, and Paxil™; anti-migraines such as Imigra™, ACE-inhibitors such as Vasotec™, Capoten™ and Zestril™: anti-Alzheimer's agents, such as Nicergoline™: and CaH-antagonists such as Procardia™, Adalat™, and Calan™.

[0092] The popular H2-antagonists which are contemplated for use in the present invention include cimetidine, ranitidine hydrochloride, famotidine, nizatidien, ebrotidine, mifentidine, roxatidine, pisatidine and aceroxatidine.

[0093] Active antacid ingredients can include, but are not limited to, the following: aluminum hydroxide, dihydroxyaluminum aminoacetate, aminoacetic acid, aluminum phosphate, dihydroxyaluminum sodium carbonate, bicarbonate, bismuth aluminate, bismuth carbonate, bismuth subcarbonate, bismuth subgallate, bismuth subnitrate, bismuth subsilysilate, calcium carbonate, calcium phosphate, citrate ion (acid or salt), amino acetic acid, hydrate magnesium aluminate sulfate, magaldrate, magnesium aluminosilicate, magnesium carbonate, magnesium glycinate, magnesium hydroxide, magnesium oxide, magnesium trisilicate, milk solids, aluminum mono-ordibasic calcium phosphate, tricalcium phosphate, potassium bicarbonate, sodium tartrate, sodium bicarbonate, magnesium aluminosilicates, tartaric acids and salts.

[0094] A variety of nutritional supplements may also be used as active ingredients including virtually any vitamin or mineral. For example, vitamin A, vitamin C, vitamin D, vitamin E, vitamin K, vitamin B6, vitamin B12, thiamine, riboflavin, biotin, folic acid, niacin, pantothenic acid, sodium, potassium, calcium, magnesium, phosphorus, sulfur, chlorine, iron, copper, iodine, zinc, selenium, manganese, choline, chromium, molybdenum, fluorine, cobalt and combinations thereof, may be used.

[0095] Examples of nutritional supplements that can be used as active ingredients are set forth in U.S. Patent Application Publication Nos. 2003/0157213 A1, 2003/0206993 and 2003/0099741 A1 which are incorporated in their entirety herein by reference for all purposes.

[0096] Various herbals may also be used as active ingredients such as those with various medicinal or dietary supplement properties. Herbals are generally aromatic plants or plant parts and or extracts thereof that can be used medicinally or for flavoring. Suitable herbals can be used singly or in various mixtures. Commonly used herbs include Echinacea, Goldenseal, Calendula, Rosemary, Thyme, Kava Kava, Aloe, Blood Root, Grapefruit Seed Extract, Black Cohosh, Ginseng, Guarana, Cranberry, Gingko Biloba, St. John's Wort, Evening Primrose Oil, Yohimbe Bark, Green Tea, Ma Huang, Maca, Bilberry, Lutein, and combinations thereof.

[0097] An effervescent system may include one or more edible acids and one or more edible alkaline materials. The edible acid(s) and the edible alkaline material(s) may react together to generate effervescence.

[0098] In some embodiments, the alkaline material(s) may be selected from, but is not limited to, alkali metal carbonates, alkali metal bicarbonates, alkaline earth metal carbonates, alkaline earth metal bicarbonates, and combinations thereof. The edible acid(s) may be selected from, but is not limited to, citric acid, phosphoric acid, tartaric acid, malic acid, ascorbic acid, and combinations thereof. In some embodiments, an effervescing system may include one or more other ingredients such as, for example, carbon dioxide, oral care ingredients, flavorants, etc.

[0099] For examples of use of an effervescing system in a gum, refer to U.S. Provisional Patent No. 60/618,222 filed Oct. 13, 2004, and entitled "Effervescent Pressed Confectionery Tablet Compositions," the contents of which are incorporated herein by reference for all purposes. Other examples can be found in U.S. Pat. No. 6,235,318, the contents of which are incorporated herein by reference for all purposes.

[0100] Appetite suppressors can be ingredients such as fiber and protein that function to depress the desire to consume food. Appetite suppressors can also include benzphetamine, diethylpropion, mazindol, phendimetrazine, phentermine, hoodia (P57), Olibra,™ ephedra, caffeine and combinations thereof. Appetite suppressors are also known by the following trade names: Adipex,™ Adipost,™ Bontril™ PDM, Bontril™ Slow Release, Didrex,™ Fastin,™ Ionamin,™ Mazanor,™ Melfiat,™ Obenix,™ Phendiet,™ Phendiet-105,™ Phentercot,™ Phentride,™ Plegine,™ Prelu-2,TM Pro-Fast,™ PT 105,™ Sanorex,™ Tenuate,™ Sanorex,™ Tenuate,™ Tenuate Dospan,™ Tepanil Ten-Tab,™ Teramine,™ and Zantryl.™ These and other suitable appetite suppressors are further described in the following U.S. patents, all of which are incorporated in their entirety by reference hereto: U.S. Pat. No. 6,838,431 to Portman, U.S. Pat. No. 6,716,815 to Portman, U.S. Pat. No. 6,558,690 to Portman, U.S. Pat. No. 6,468,962 to Portman, U.S. Pat. No. 6,436,899 to Portman.

[0101] Micronutrients can include materials that have an impact on the nutritional well being of an organism even though the quantity required by the organism to have the desired effect is small relative to macronutrients such as protein, carbohydrate, and fat. Micronutrients can include, but are not limited to vitamins, minerals, enzymes, phytochemicals, antioxidants, and combinations thereof.

[0102] In some embodiments, vitamins can include fat soluble vitamins such as vitamin A, vitamin D, vitamin E, and vitamin K and combinations thereof. In some embodiments, vitamins can include water soluble vitamins such as vitamin C (ascorbic acid),

the B vitamins (thiamine or B1, riboflavoin or B2, niacin or B3, pyridoxine or B6, folic acid or B9, cyanocobalimin or B12, pantothenic acid, biotin), and combinations thereof.

[0103] In some embodiments minerals can include but are not limited to sodium, magnesium, chromium, iodine, iron, manganese, calcium, copper, fluoride, potassium, phosphorous, molybdenum, selenium, zinc, and combinations thereof.

[0104] In some embodiments micronutrients can include but are not limited to L-carnitine, choline, coenzyme Q10, alpha-lipoic acid, omega-3-fatty acids, pepsin, phytase, trypsin, lipases, proteases, cellulases, and combinations thereof.

[0105] In some embodiments phytochemicals can include but are not limited to cartotenoids, chlorophyll, chlorophyllin, fiber, flavanoids, anthocyanins, cyaniding, delphinidin, malvidin, pelargonidin, peonidin, petunidin, flavanols, catechin, epicatechin, epigallocatechin, epigallocatechingallate (EGCG), theaflavins, thearubigins, proanthocyanins, flavonols, quercetin, kaempferol, myricetin, isorhamnetin, flavononeshesperetin, naringenin, eriodictyol, tangeretin, flavones, apigenin, luteolin, lignans, phytoestrogens, resveratrol, isoflavones, daidzein, genistein, glycitein, soy isoflavones, and combinations thereof

[0106] Mouth moisteners can include, but are not limited to, saliva stimulators such as acids and salts and combinations thereof In some embodiments, acids can include acetic acid, adipic acid, ascorbic acid, butyric acid, citric acid, formic acid, fumaric acid, glyconic acid, lactic acid, phosphoric acid, malic acid, oxalic acid, succinic acid, tartaric acid and combinations thereof. In some embodiments, salts can include sodium chloride, calcium chloride, potassium chloride, magnesium chloride, sea salt, sodium citrate, and combinations thereof

[0107] Mouth moisteners can also include hydrocolloid materials that hydrate and may adhere to oral surface to provide a sensation of mouth moistening. Hydrocolloid materials can include naturally occurring materials such as plant exudates, seed confectionerys, and seaweed extracts or they can be chemically modified materials such as cellulose, starch, or natural confectionery derivatives. In some embodiments, hydrocolloid materials can include pectin, gum arabic, acacia gum, alginates, agar, carageenans, guar gum, xanthan gum, locust bean gum, gelatin, gellan gum, galactomannans, tragacanth gum, karaya gum, curdlan, konjac, chitosan, xyloglucan, beta glucan, furcellaran, gum ghatti, tamarin, bacterial gums, and combinations thereof. Additionally, in some embodiments, modified natural gums such as propylene glycol alginate, carboxymethyl locust bean gum, low methoxyl pectin, and their combinations can be included. In some embodiments, modified celluloses can be included such as microcrystalline cellulose, carboxymethlcellulose (CMC),

methylcellulose (MC), hydroxypropylmethylcellulose (HPCM), and hydroxypropylcellulose (MPC), and combinations thereof.

[0108] Similarly, humectants which can provide a perception of mouth hydration can be included. Such humectants can include, but are not limited to glycerol, sorbitol, polyethylene glycol, erythritol, and xylitol. Additionally, in some embodiments, fats can provide a perception of mouth moistening. Such fats can include medium chain triglycerides, vegetable oils, fish oils, mineral oils, and combinations thereof.

[0109] Throat soothing ingredients can include analgesics, anesthetics, demulcents, antiseptic, and combinations thereof. In some embodiments, analgesics/anesthetics can include menthol, phenol, hexylresorcinol, benzocaine, dyclonine hydrochloride, benzyl alcohol, salicyl alcohol, and combinations thereof. In some embodiments, demulcents can include but are not limited to slippery elm bark, pectin, gelatin, and combinations thereof In some embodiments, antiseptic ingredients can include cetylpyridinium chloride, domiphen bromide, dequalinium chloride, and combinations thereof

[0110] In some embodiments, antitussive ingredients such as chlophedianol hydrochloride, codeine, codeine phosphate, codeine sulfate, dextromethorphan, dextromethorphan hydrobromide, diphenhydramine citrate, and diphenhydramine hydrochloride, and combinations thereof can be included.

[0111] In some embodiments, throat soothing agents such as honey, propolis, aloe vera, glycerine, menthol and combinations thereof can be included. In still other embodiments, cough suppressants can be included. Such cough suppressants can fall into two groups: those that alter the consistency or production of phlegm such as mucolytics and expectorants; and those that suppress the coughing reflex such as codeine (narcotic cough suppressants), antihistamines, dextromethorphan and isoproterenol (non-narcotic cough suppressants). In some embodiments, ingredients from either or both groups can be included.

[0112] In still other embodiments, antitussives can include, but are not limited to, the group consisting of codeine, dextromethorphan, dextrorphan, diphenhydramine, hydrocodone, noscapine, oxycodone, pentoxyverine and combinations thereof. In some embodiments, antihistamines can include, but are not limited to, acrivastine, azatadine, brompheniramine, chlorpheniramine, clemastine, cyproheptadine, dexbrompheniramine, dimenhydrinate, diphenhydramine, doxylamine, hydroxyzine, meclizine, phenindamine, phenyltoloxamine, promethazine, pyrilamine, tripelennamine, triprolidine and combinations thereof. In some embodiments, non-sedating antihistamines can include, but are not limited

to, astemizole, cetirizine, ebastine, fexofenadine, loratidine, terfenadine, and combinations thereof.

[0113] In some embodiments, expectorants can include, but are not limited to, ammonium chloride, guaifenesin, ipecac fluid extract, potassium iodide and combinations thereof. In some embodiments, mucolytics can include, but are not limited to, acetylcycsteine, ambroxol, bromhexine and combinations thereof. In some embodiments, analgesic, antipyretic and anti-inflammatory agents can include, but are not limited to, acetaminophen, aspirin, diclofenac, diflunisal, etodolac, fenoprofen, flurbiprofen, ibuprofen, ketoprofen, ketorolac, nabumetone, naproxen, piroxicam, caffeine and mixtures thereof. In some embodiments, local anesthetics can include, but are not limited to, lidocaine, benzocaine, phenol, dyclonine, benzonotate and mixtures thereof.

[0114] In some embodiments nasal decongestants and ingredients that provide the perception of nasal clearing can be included. In some embodiments, nasal decongestants can include but are not limited to phenylpropanolamine, pseudoephedrine, ephedrine, phenylephrine, oxymetazoline, and combinations thereof. In some embodiments ingredients that provide a perception of nasal clearing can include but are not limited to menthol, camphor, borneol, ephedrine, eucalyptus oil, peppermint oil, methyl salicylate, bornyl acetate, lavender oil, wasabi extracts, horseradish extracts, and combinations thereof. In some embodiments, a perception of nasal clearing can be provided by odoriferous essential oils, extracts from woods, confectionerys, flowers and other botanicals, resins, animal secretions, and synthetic aromatic materials.

[0115] In some embodiments, optional or functional ingredients can include breath fresheners, dental care components, actives, herbals, effervescing systems, appetite suppressors, vitamins, micronutrients, mouth moistening components, throat care components, energy boosting agents, concentration boosting agents, and combinations thereof.

[0116] In some embodiments, the modified release component includes at least one ingredient selected from the group comprising flavors, sweeteners, sensates, breath fresheners, dental care components, actives, herbals, effervescing systems, appetite suppressors, potentiators, food acids, micronutrients, mouth moistening components, throat care components, and combinations thereof. These ingredients can be in encapsulated form, in free form, or both.

[0117] Now that a review of representative ingredients has been provided, further detail regarding the extruder to be used for manufacturing encapsulate compositions will be

discussed. Reference is now made to the drawings, wherein like reference numerals are used to refer to like elements throughout the disclosure.

[0118] Referring first to Figures 1-3, a planetary roller extruder 10 for use in the below discussed systems and methods is illustrated. The planetary roller extruder 10 is a type of continuous extruder, and may be a single continuous extrusion body or a sectioned body that includes multiple barrels or barrel sections 12 (the term "barrel section" referring to a single barrel, multiple grouped barrels, or a chosen section of a single barrel). For ease of description, a single barrel is shown in detail in Figures 1 and 2 as a barrel section 12. Embodiments including multiple barrel sections are shown schematically in Figures 5 and 6. These sections 12 and the mixing that occurs therein will be discussed later in the disclosure.

[0119] As shown in Figures 1-3, the planetary roller extruder 10 includes a cylinder 14 and a rotatable center shaft 16 that runs from a feed end to an extrusion end of the planetary roller extruder 10. As different areas of the planetary roller extruder 10 may include different functions, the center shaft 16 may include different diameters or configurations at different positions of the planetary roller extruder 10. For example, in Figure 1 the center shaft 16 includes a larger diameter in feed section 17 than in barrel section 12. For ease of description, the portion of the center shaft located in the feed section 17 will be referred to as center shaft 16a, and the portion(s) of the center shaft located in the barrel sections 12 will be referred to as center shaft 16b.

[0120] One reason for the discrepancy in diameter that may occur between a diameter of the shaft 16a in the feed section 17 and the diameter of the shaft 16b in the barrel sections 12 is the presence of a plurality of rotatable planetary screws 18 in the barrel sections 12. These screws 18 facilitate mixing of encapsulate flow within the barrel sections 12, and are disposed around the center shaft 16b in the barrel sections 12. The planetary screws 18 are rotatable about an axis of the center shaft 16b in the same direction of rotation as center shaft 16b, and rotatable about their own axes in a direction opposite rotation of the center shaft 16b. In some embodiments (such as that shown in Figures 1 and 3), these planetary screws 18 terminate at the ends of each barrel section 12.

[0121] The number of screws 18 used in the planetary roller extruder 10 depends on the particulars of the encapsulate composition to be manufactured, with at least two screws 18, and more likely three or more screws 18 to be used in each barrel 12 in any gum application. Planetary screws 18 may be disposed about the shaft 16b in the barrel sections 12 in numbers such as but not limited to a general range of 2-18 screws, or more particularly numbers including 3, 6, 9, 12, 15, and 18 screws.

[0122] As is best shown in Figures 2 and 3, an inner wall of the cylinder 14 and an outer surface of the central shaft 16b combine to form a mixing annulus 20, in which the screws 18 are disposed, and encapsulate composition will flow and be mixed. Within this annulus 20, each of the screws 18, center shaft 16b, and cylinder 14 include corresponding or mate-able grooving or toothing 22, 24, 26. This toothing 22, 24, 26 assists in efficiently mixing the encapsulate composition flowing through the planetary roller extruder 10, with space (such as space 27 in Figure 3) remaining for encapsulate flow between the teeth/ridges of the screws 18 and the corresponding teeth/ridges of the central shaft 16b and cylinder 14. The screws 18 may have any desirable tooth configuration (i.e. variance in the gaps between the teeth, tooth shape, tooth length, etc.), which will therefore create variation in the corresponding toothing of the center shaft 16b and cylinder 14.

[0123] Referring back to Figure 1, it is noted that the planetary roller extruder 10 may include one or more points of entry for ingredients entering the planetary roller extruder, such as point of entry 28 located in a feed zone 32 of the feed section 17, and such as downstream points of entry 30 (please see Figure 6) located in the barrels 12. These inlets 28, 30 are variously selectable for use depending on the chosen encapsulate application and ingredient to be added. In fact, the feed section 17 and any desirable barrel section 12 may be configured with one or multiple feed inlets 28, 30 if so desired, provided the inlet area is configured for ingredient entry. Such areas may be disposed at zero pressure areas (particularly for solids) or extrusion pressure areas (particularly for liquids) along the planetary roller extruder 10, such as but not limited to areas without planetary screws 18. These areas may be located in the feed section 17, in junction areas 33 (please see Figure 6) between barrel sections 12, and/or in other areas of barrel sections 12 wherein screws 18 or portions of screws 18 may be present or absent.

[0124] There are two types of feed inlets that may be used in some exemplary embodiments of the planetary roller extruder 10. The first type of feed inlet (represented as inlet 28 as shown in Figure 1) may be used for addition of ingredients in the feeding zone 32 of the feed section 17 (though it may be used for any ingredient in any portion of the planetary roller extruder 10 that includes a zero pressure as discussed).

[0125] The second type of feed inlet (represented as inlet 30 in Figure 6) that may be used in some embodiments of the planetary roller extruder 10 is a side feed inlet (which, for purposes of this disclosure, may be disposed anywhere around the periphery of the planetary roller extruder 10, between or at the junctions 33), which is shown schematically in Figure 6. Such side feed inlets 30 may be used downstream of the feeding zone 32 (though it may also

be used in the feeding zone 32 and anywhere else within feed section 17), and may enter the planetary roller extruder 10 laterally (i.e. from the side) as opposed to via a hopper.

[0126] As shown in Figure 1, the planetary roller extruder 10 may also include an extrusion portion 34 at an output end of thereof. In the exemplary embodiment shown in Figure 1, the barrel 12 includes this portion 34. The extrusion portion 34 is the section from which chewing gum flowing through the planetary roller extruder 10 will ultimately be extruded. It is notable that a downstream extent 35 of the screws 18 and/or a downstream extent of the central shaft 16b are located in proximity to an extrusion or termination point 37 of the planetary roller extruder 10. Indeed, the downstream extent 35 of the screws 18 and/or a downstream extent of the central shaft 16b may terminate such that the ends thereof are flush with the extrusion point 37 (e.g. the end of the planetary roller extruder 10).

[0127] Further, while the exemplary embodiment of Figure 1 shows the barrel 12 to include extrusion portion 34, downstream extent 35, and extrusion point 37, the barrel 12 will not necessarily be the downstream extent (i.e. far left) of the planetary roller extruder 10. Indeed, the barrel 12 is also configured for association with one or more additional barrel sections, wherein the downstream extent of those one or more additional barrel sections 12 would include the extrusion portion 34, downstream extent 35, and extrusion point 37. The planetary roller extruder may also be associated with a melt pump or other pumping mechanism configured to assist in extrusion of product and located downstream of (and perhaps connected to) the extrusion portion 34.

[0128] Additionally, the planetary roller extruder 10 includes efficient temperature control for the encapsulate mixed therein and extruded therefrom. As shown in Figures 1 and 2, each of the cylinder 14 and central shaft 16 includes a temperature control system, such as but not limited to fluid channels 36,38 running longitudinally and/or circumferentially therethrough. For at least the below discussed two reasons, these cooling systems each offer an advantage over the prior art.

[0129] The first reason relates to configuration of the screws 18 with the central shaft 16b and inner surface of the cylinder 14. Presence of the rotating screws 18 creates a relatively small gap between mating surfaces within the mixing annulus 20 (i.e. respective mating surfaces of the screws 18, inner wall, and shaft 16b). This relatively small gap (as small as ¼ mm or less in some embodiments) creates a reduced thickness in the encapsulate flowing through the planetary roller extruder 10, thereby exposing product flow to a relatively large cooling surface area at the inner wall of the cylinder 14 and outer surface of the shaft 16b. In addition, contact between the gum flow and the cooling surfaces are

constantly renewed via rotation of the screws 18 in the mixing annulus 20. The net result of the surface area exposure and consistent renewal (both the exposure and renewal being caused by the screws 18) is a more efficient cooling of the encapsulate flow relative to traditional screw extruders.

[0130] The second reason relates to the relative low pressure created in the mixing annulus 20 of the planetary roller extruder 10. This low pressure 10 allows the cylinder 14 to include a thinner cylinder wall in comparison with the more pressure tolerant walls (i.e. thicker walls) found in traditional extruders. The relative thinness of the planetary roller extruder walls allows for better heat transfer from the fluid contained in the channels 36,38 to the encapsulate flow within the annulus 20, since heat from the channels 36,38 obviously has to be transferred through less wall material in order to reach the flow. As with the first reason, the result of this better temperature transfer is a more efficient cooling of the encapsulate flow relative to traditional screw extruders.

[0131] It should also be noted that temperature control or cooling can be achieved in the planetary roller extruder 10 via mere addition of ingredients that are cooler than the encapsulate flow currently within the annulus 20.

[0132] Length to diameter (L/D) ratio analysis of traditional twin and single screw extruders typically allows one to compare extruders with respect to energy input and capability relative to length of an extruder screw and diameter of an extruder screw or barrel. However, such an analysis is not customarily applied to planetary roller extruders, since one of ordinary skill in the art would view the barrels and internal elements of a planetary roller extruder and the mechanisms and flow patterns existing within the planetary roller extruder differently from conventional screw extruders.

[0133] If, however, one were to attempt to apply the principles of L/D analysis to planetary roller extruders, one of ordinary skill could select the planetary screws (i.e. spindles that rotates about the central shaft) as the elements of a planetary roller extruder that most resemble an extruder screw of a traditional screw extruder. In selecting the planetary screws in an exemplary planetary roller extruder for L/D analysis, each screw in the extruder would be lined up end to end to calculate the total "L" in the L/D ratio. Thus, if a single planetary screw typically includes an L/D of around 18/1, the L/D in a typical planetary roller extruder would be at least 54/1 per barrel, as typical planetary roller extruder barrel include at least three planetary screws that rotate about the central shaft and more likely at least 7 planetary rollers with an L/D of at least 126/1 per barrel.

[0134] Further, since planetary roller extruder 10 allows for more effective temperature control and mixing, less additional process steps may be required in the production process. Accordingly, it should be noted that a planetary roller extruder 10 used in a manufacturing system may result in a smaller overall system footprint on the production floor and allow for more production equipment to be utilized compared to systems utilizing conventional extruders.

[0135] Now that a description of the planetary roller extruder 10 has been provided above, further detail regarding the methods and systems using the planetary roller extruder for ingredient encapsulation will be discussed. This discussion will begin with a general description of the encapsulate materials to be mixed.

[0136] An encapsulated ingredient typically includes an "active" ingredient that is relatively sensitive to high energy mixing environments (such as heat and shearing forces that can be associated with some types of mixing) and an encapsulating ingredient. Any active ingredients that may typically be used in chewing gum, such as but not limited to high intensity sweeteners (including natural sweeteners and synthetic sweeteners), food acids, and miscellaneous ingredients (including texture modifiers, coloring agents, salts, oral care ingredients, and other ingredients), are contemplated for use with the planetary roller extruder discussed above and below. Any encapsulating ingredients that may typically be used in chewing gum, such as but not limited to polymer or resin, are contemplated for use with the planetary roller extruder discussed above and below.

[0137] Active ingredients may include, but are not limited to sweeteners and food acids. Sweeteners used may be selected from a wide range of materials including water-soluble sweeteners, water-soluble artificial sweeteners, water-soluble sweeteners derived from naturally occurring water-soluble sweeteners, dipeptide based sweeteners, and protein based sweeteners, including mixtures thereof. Without being limited to particular sweeteners, representative categories and examples include: (a) water-soluble sweetening agents such as dihydrochalcones, monellin, steviosides, glycyrrhizin, saccharin salts, i.e., sodium or calcium saccharin salts, cyclamate salts, acesulfame salts, such as the sodium, ammonium or calcium salt of 3,4-dihydro-6-methyl-1,2,3-oxathiazine-4-one-2,2-dioxide, the potassium salt of 3,4-dihydro-6-methyl-1,2,3-oxathiazine-4-one-2,2-dioxide (Acesulfame-K), the free acid form of saccharin and monatin; (b) dipeptide based sweeteners, such as L-aspartic acid derived sweeteners, such as L-aspartyl-L-phenylalanine methyl ester (Aspartame) and L-alphaaspartyl-N-(2,2,4,4-tetramethyl-3-thietanyl)-D-alaninamide hydrate (Alitame), methyl esters of L-aspartyl-L-phenylglycerine and L-aspartyl-L-2,5-dihydrophenyl-glycine, L-

aspartyl-2,5-dihydro-L-phenylalanine; L-aspartyl-L-(l-cyclohexen)-alanine, neotame and advantame; (c) water-soluble sweeteners derived from naturally occurring water-soluble sweeteners, such as Reb-A, chlorinated derivatives of ordinary sugar (sucrose), e.g., chlorodeoxysugar derivatives such as derivatives of chlorodeoxysucrose or chlorodeoxygalactosucrose, known, for example, under the product designation of Sucralose; examples of chlorodeoxy.sucrose and chlorodeoxygalactosucrose derivatives include but are not limited to: 1-chloro-1'-deoxysucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-alpha-D-fructofuranoside, or 4-chloro-4-deoxygalactosucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-1-chloro-l-deoxy-beta-D-fructo-furanoside, or 4,1'-dichloro-4,1'-dideoxygalactosucrose; 1',6'-dichloro 1',6'-dideoxysucrose; 4-chloro-4-deoxy-alpha-D-galactopyranosyl-1,6-dichloro-l,6-dideoxy-beta-D- fructofuranoside, or 4,1',6'-trichloro-4,1',6'-trideoxygalactosucrose; 4,6-dichloro-4,6-dideoxy-alpha-D-galactopyranosyl-6-chloro-6-deoxy-beta-D-fructofuranoside, or 4,6,6'-trichloro-4,6,6'-trideoxygalactosucrose; 6,1',6'-trichloro-6,1',6'-trideoxysucrose; 4,6-dichloro-4,6-dideoxy-alpha-D-galacto-pyranosyl-1,6-dichloro-l,6-dideox y-beta-D-fructofuranoside, or 4,6,1',6'-tetrachloro 4,6,1',6'-tetradeoxygalacto-sucrose; and 4,6,1',6'-tetradeoxy-sucrose, and mixtures thereof; or (d) Other protein based sweeteners such as thaumaoccous danielli (Thaumatin I and II) and talin. Food acids may include citric acid, malic acid, fumaric acid, tartaric acid, lactic acid and adipic acid.

[0138] Typically, encapsulation of an active ingredient will result in a delay in the release of the predominant amount of the active ingredient during consumption of a gum structure that includes the encapsulated active ingredient (e.g., as part of a delivery system added as an ingredient to the gum). In some embodiments, the release profile of the ingredient (e.g., the flavor, sweetener, etc.) can be managed by managing various characteristics of the ingredient, delivery system containing the ingredient, and/or the gum structure containing the delivery system and/or how the delivery system is made. For example, characteristics might include one or more of the following: tensile strength of the delivery system, water solubility of the ingredient, water solubility of the encapsulating material, water solubility of the delivery system, ratio of ingredient to encapsulating material in the delivery system, average or maximum particle size of ingredient, average or maximum particle size of delivery system, the amount of the ingredient or the delivery system in the gum, ratio of different polymers used to encapsulate one or more ingredients, hydrophobicity of one or more polymers used to encapsulate one or more ingredients, hydrophobicity of the

delivery system, the type or amount of coating on the delivery system, the type or amount of coating on an ingredient prior to the ingredient being encapsulated, etc.

[0139] Additionally, encapsulation of a component will result in the protection of the component during the remainder of the production process. As components of the gum to be encapsulated may be sensitive to temperature, mixing, extruding, or other factors, the encapsulation allows for efficient handling and protection of these sensitive components during production. Protection of the active ingredient as referenced above is achieved via a mixing of the active ingredient(s) with an encapsulating ingredient(s). Indeed, an encapsulate as defined herein is an active ingredient(s) mixed for production or extrusion with an encapsulating ingredient(s)

[0140] As mentioned above, the encapsulating material may be a polymer or resin ingredient, wherein the characteristics of the polymer or resin ingredient control the release profile and the protection of the active ingredient to be encapsulated. In some embodiments, the encapsulating material may be polyvinyl acetate, polyethylene, crosslinked polyvinyl pyrrolidone, polymethylmethacrylate, polylactidacid, polyhydroxyalkanoates, ethylcellulose, polyvinyl acetatephthalate, polyethylene glycol esters, methacrylicacid-co-methylmethacrylate, polyvinylacetate-viynyl alcohol copolymer or any other ingredient suitable for polymer matrix type encapsulation.

[0141] With reference now to Figures 4-6, an exemplary embodiment of a process 102 for manufacturing or extruding encapsulates using the above discussed planetary roller extruder, and an exemplary embodiment of a system 200 for manufacturing or extruding encapsulates, will now be described in detail. As discussed above, it may be desirable to encapsulate certain ingredients or components used in chewing gum. Encapsulates as used herein include at least one or more active ingredient or component to be protected and released in a certain release profile, and an additional encapsulating ingredients such as, but not limited to a resin or polymer. After encapsulation, the encapsulated ingredients may be mixed with other gum ingredients to form a finished gum product.

[0142] A first step 104 in the process involves feeding one or more active ingredients/components and/or an encapsulating ingredient into the planetary roller extruder 10. The active ingredient(s) and encapsulate ingredients may be added in pellet, molten, or raw ingredient form, such as but not limited to powder, liquid, or flake materials.

[0143] In the exemplary embodiment of Figure 5, the system 200 includes a feed section 17 and two downstream mixing barrel sections 12a and 12b. Of course any number of barrels or barrel sections 12 greater or lesser than two may be used to manufacture or

extrude an encapsulate as described herein. Indeed, the planetary roller extruder 10 offers flexibility over traditional extruders (such as a twin screw) via this ability to select and interchange the number of barrels to be used in light of the active ingredient(s) to be encapsulated and the acceptable temperature ranges associated therewith. For ease of description however, the system 200 will be discussed with reference to the feed section 17 and two barrel sections 12a and 12b as shown in Figure 5.

[0144] Active ingredients and encapsulating ingredients enter the planetary roller extruder 10 from active ingredient source 201a and encapsulating ingredient source 201b, respectively. Alternatively, active and encapsulating ingredients/components may enter the planetary roller extruder 10 from a common encapsulate ingredient source 201. The active ingredients and encapsulating ingredients may enter the planetary roller extruder 10 at an active ingredient inlet 28a, and an encapsulating ingredient inlet 28b, respectively. It should be noted that inlets 28a and 28b may be disposed at different entry points of planetary roller extruder 10, allowing the active ingredients and encapsulating ingredients to include varying durations of mixing. In at least one exemplary embodiment, encapsulating ingredient inlet 28b allows entry of encapsulating ingredient before the introduction of active ingredients via active ingredient inlet 28a.

[0145] Upon entry of the planetary roller extruder 10 rotation of at least the center shaft 16 in the feed section 17 creates a directional flow 202 of the active and encapsulating ingredient through the planetary roller extruder 10 and towards the downstream extent 35 of the screws 18 (step 106). In the exemplary embodiment of Figure 5, this downstream extent 35 of the screws 18 is located in proximity to the outlet or extrusion point 37 of the planetary roller extruder 10. As the flow 202 exits the feed section 17, the flow 202 enters barrel section 12a, which includes the beginning portion of the mixing annulus 20 that contains the plurality of screws 18. Within this annulus 20, rotating screws 18 mix the active and encapsulating ingredients in the flow 202 via movement of the flow 202 through the space 27 (as shown best in Figure 3) between the screws 18 and between the teeth of the rotating screws, rotating center shaft 16, and the cylinder 14 (step 108).

[0146] As the ingredients are conveyed and mixed the ingredients form an encapsulate as previously discussed.

[0147] While in the barrel section 12a, the one or more ingredients/components in the encapsulate ingredients flow 202 are conveyed via mixing achieved by the rotating center shaft 16 and rotating screws 18 within the mixing annulus 20. It should be noted that the mixing may occur within a temperature range of 80-120 degrees Celsius. Of course, the

planetary roller extruder 10 is capable of mixing at higher temperatures, however higher temperatures may not be desirable as ingredient degradation may occur. As will be discussed in greater detail below, this offers an important advantage over standard continuous extruders, through which material can reach temperatures such as 130 degrees Celsius or higher.

[0148] As may be appreciated, the use of a planetary roller extruder 10 may allow for significantly better dispersive action within the extruder, and further allow for more effective mixing of the flow 202 compared to conventional extruders. The resulting better dispersive action and more effective mixing may allow for a reduction (or elimination) of lumps in the flow 202, while promoting uniform particle size within flow 202, particle adhesion, and better encapsulate coverage.

[0149] In addition, because of the more efficient mixing provided by the planetary roller extruder 10 elements (including the spindles, shaft, and walls as previously contemplated) relative to a twin screw extruder, encapsulates can be sufficiently mixed using less energy than is necessary using a twin screw extruder. Specifically, the use of a planetary roller extruder 10 allows for lower polymer melt temperatures at a given Specific Mechanical Energy input. This allows the flow 202 to be sufficiently mixed within the planetary roller extruder 10 at a temperature of less than 120 degrees Celsius, or perhaps 100 degrees Celsius, 90 degrees Celsius, 80 degrees Celsius or lower over an entire duration of the mixing process within the planetary roller extruder 10. Indeed, the flow may reach a downstream extent of the planetary roller extruder 10 at a temperature less than 90 degrees Celsius and be extruded therefrom at this relatively low temperature.

[0150] In certain embodiments, during flow through at least portions of barrels 12a and 12b, the temperature control channels 36 and 38 (through the cylinder 14 and center shaft 16b as discussed above and with reference to Figures 1-3) may supplement achievement of extrusion at this relatively low temperature by providing active cooling to the flow 202 of encapsulate ingredients as it is being mixed. This active cooling occurs via contact of the flow 202 with the outer surface of the central shaft 16b and the inner wall of the cylinder 14.

[0151] Using a mixer such as the planetary roller extruder 10 that is capable of bringing the flow temperature down from 140 degrees Celsius (such as in a typical twin screw extrusion process) to 120 degrees Celsius, or perhaps 100 degrees Celsius, 90 degrees Celsius, 80 degrees Celsius or lower throughout and upon exiting the planetary roller extruder 10, is advantageous for various reasons. For example, this reduction in temperature allows the active ingredients to be fully or substantially fully encapsulated without reaching

temperatures that undesirably degrade the active ingredients. Indeed, as a result of the controlled temperature range and controlled temperature variation described, the encapsulate ingredients/components may experience less decomposition and degradation. Degradation and decomposition may manifest itself as a lack of whiteness, an undesired odor, taste in the encapsulate ingredients, or a decrease in the overall percentage of active ingredient in the encapsulate from input to extrusion. Degradation and decomposition may further manifest itself as a change in color or a darkening of color of the active ingredient encapsulated. Therefore, observing the color of an encapsulate and the active ingredient therein may be determinative of degradation or decomposition, wherein a uniform color through the encapsulation process may be indicative of no degradation or decomposition. In addition, the encapsulate ingredients could be mixed with other temperature sensitive, active ingredients without undesirable degradation of the other active ingredients when they enter the flow.

[0152] In addition, for most ingredients, only a single pass through the planetary roller extruder 10 is needed in order to achieve a desirable user experience and release profile for the encapsulate. Conventional extruders or mixing may require multiple passes of extrusion or mixing, resulting in ingredients that may be exposed to elevated temperatures for multiple passes, leading to more ingredient degradation for temperature sensitive ingredients and high process costs.

[0153] Another beneficial feature achieved by mixing within the planetary roller extruder is the relatively consistent temperature maintained during mixing of the flow 202. The ability of the planetary roller extruder to encapsulate and extrude active ingredients at a temperature low enough such that the product may be maintained within a 20 degree Celsius range from the first barrel (or at least onset of mixing) to the outlet of the planetary roller extruder 10 allows the encapsulate ingredients to be sufficiently mixed without undesirable degradation. This relatively uniform temperature distribution is attributable to the relatively low overall energy required for mixing in a planetary roller extruder 10 compared to conventional extruders, and cooling systems that may be optionally implemented.

[0154] Further, as a result of more effective mixing compared to conventional extruders, the use of planetary roller extruder 10 allows for less variation in viscosity in the flow 202. As previously discussed, significantly better dispersive action compared to conventional extruders allows for more complete mixing of ingredients and effective homogenization of flow 202, while uniform temperature distribution allows for the characteristics of the flow 202 to be more consistent. Accordingly, since the temperature

distribution is more consistent and the flow 202 is more homogenous, viscosity is more consistent as well.

[0155] It is noted that active ingredients that are more water soluble or absorptive require more effective and homogeneous mixing in order to provide a desirable user experience. This is because ineffective mixing may cause a non-uniform dispersion of the active ingredients, resulting in water accessing the ingredients too quickly and exhibiting a shorter and less desirable release profile while being chewed. In an effort to prevent a release profile of too short a duration, conventional encapsulation methods using conventional mixers may require use of active ingredients that are less water soluble, or require a passing of active ingredients that are more soluble to be passed through an additional secondary mixing or extruding step.

[0156] However, the more effective homogeneous mixing achieved in the planetary roller extruder 10 compared to conventional extruders (perhaps aided by the enhanced temperature control) allows for more water soluble or water absorbing variants of active ingredients to be encapsulated. In addition, some active ingredients may be encapsulated with a single pass while still allowing for a desirable release profile and user experience.

[0157] Similarly, as a result of the relatively low overall energy required for mixing in a planetary roller extruder 10 compared to conventional extruders (perhaps aided by the enhanced temperature control) , encapsulates may be produced with more active ingredient/component and less resin/polymer compared to conventional processes. Using the planetary roller extruder 10, allows the sensitive active ingredient to be added in greater quantities (relative to percent of the flow 202) without increasing the risk of degradation. This increase relative to percentage has the added benefit of reducing the amount of encapsulating ingredient (again by percentage of flow) needed to form the encapsulate. In at least one embodiment, the active ingredient may be between 30-40% of the total encapsulate. Similarly, the encapsulating ingredient may be between 60-70% of the total encapsulate. Compared to conventional processes, the use of the planetary roller extruder 10 may allow for a higher ratio of active ingredient/component to encapsulating resin/polymer.

[0158] Further, since the planetary roller extruder 10 allows for lower energy mixing and significantly better temperature control compared to conventional methods, it may be contemplated that multiple active ingredients with different temperature sensitivities may be mixed together in a single encapsulation. In certain embodiments, additional active ingredients may be added downstream of the first barrel of the planetary roller extruder 10. Additional active ingredients may be added downstream because temperatures within the

planetary roller extruder 10 downstream are uniformly low from the first barrel to the outlet. Additional active ingredients are less likely to experience degradation, as discussed above, compared to conventional methods wherein temperatures may elevate downstream. These additional active ingredients may be added in a downstream inlet 30 (as shown in Figure 6). Addition of these further active ingredients offers a wider variety of chewing formulations that may be achieved.

[0159] Furthermore, with the use of the planetary roller extruder 10, some of the more temperature sensitive encapsulating ingredients may be softened as the temperature within the planetary roller extruder 10 without degrading. Specifically, polyvinyl acetate may be softened at temperatures, preferably between 80 to 90 degrees Celsius but may begin to degrade at a temperature of 120 degrees Celsius, 130 degrees Celsius or higher.

[0160] As previously discussed, the planetary roller extruder 10 allows for more complete mixing. Accordingly, the encapsulate ingredients are mixed more effectively, while limiting degradation of the ingredients. As a result of the more effective mixing, the release profiles for the encapsulates are more desirable for users. It is noted that the release profiles of encapsulates made with planetary roller extruder 10 release at a slower rate, to allow for a longer lasting release profiles for the end user. Accordingly, the sensory experience of a user (perhaps via a longer lasting and more intense flavor) as compared to encapsulate created by conventional methods may be enhanced with longer lasting release profiles.

[0161] In order to quantify the release profiles of encapsulate, dissolution release rate of encapsulates may be tested and measured. Dissolution release rate measurement allows for a comparison of various encapsulates release profiles. The release rate of an encapsulate may be measured by measuring the percentage of active ingredient released over time into a dissolving solution. These measurements include the initial release rate of the active ingredient, as this relates to an end user's initial experience. Measurements pertaining to release rate over time and the derivatives of the release rate of time also provide relevant user experience information relating to the longevity of flavor release, or more generally the release of active ingredients or components. The average release rate over time is a further relevant measurement, as this measurement describes the overall release over time of active ingredients or components to the end user.

[0162] Referring to Figure 7, exemplary embodiments of encapsulates have been tested to measure the dissolution release of Acesulfame K (Ace-K) over time. It is noted that the characteristics of the encapsulate of Acesulfame K may be considered representative of encapsulates of other similar active ingredients contemplated herein. The solid line illustrates

Ace-K that has been encapsulated using a twin screw extruder, representative of conventional encapsulation methods. The dashed line illustrates Ace-K that has been encapsulated using a planetary roller extruder, using methods contemplated herein. The chart illustrates the percentage of Ace-K released over time. The test method utilized may relate a user's sensory experience as encapsulates interact with a user's mouth with empirical data to allow for comparisons between various methods and formulations.

[0163] The dissolution release of an encapsulate may be measured using ultraviolet-visible spectroscopy. A pre-weighed amount of milled encapsulate may be added to a stirred test container filled with water. An automated detector continuously measures the release of the active ingredient in the water. The release percentage may be plotted against time, as shown in Figure 7.

[0164] As shown in Figure 7, the encapsulate formed using the planetary roller extruder has a lower dissolution release over the same time as an encapsulate formed in a more conventional extruder. Specifically, the encapsulate formed using the planetary roller extruder releases 15-20% less Ace-K on initial dissolution (specifically 17.8%; 28.2% released with an encapsulate formed in a more conventional extruder compared to less than 20%, or specifically 10.4% released with an encapsulate formed using the planetary roller extruder). Initial dissolution may relate to a user's initial experience when first dissolving an encapsulate. As a result of the lower initial dissolution release, the encapsulate formed using the planetary roller extruder has a similar dissolution curve over time compared to the encapsulate formed in a more conventional extruder, but has released less Ace-K at any given time compared to the encapsulate formed in a more conventional extruder, as shown in Figure 7. For example, the encapsulate formed using the planetary roller extruder has released 10-15% less Ace-K after 3 minutes (180 seconds) of dissolution (specifically 12.2%; 46.1% released with an encapsulate formed in a more conventional extruder compared to less than 35% or specifically 33.9% released with an encapsulate formed using the planetary roller extruder). Additionally, the encapsulate formed using the planetary roller extruder has released 5-10% less Ace-K after 10 minutes of dissolution (specifically 6.4%; 54.9% released with an encapsulate formed in a more conventional extruder compared to 48.5% released with an encapsulate formed using the planetary roller extruder). As a result, the encapsulate formed using the planetary roller extruder will provide a longer lasting user experience because the encapsulate will have more Ace-K remaining to release.

[0165] Another benefit of the more efficient dispersive mixing action in the planetary roller extruder as compared to conventional extruders is the ability to better encapsulate

active ingredients that are more water soluble. Indeed, the more efficient dispersive mixing in the planetary roller extruder 10 allows for more complete mixing of ingredients and effective homogenization of flow 202 and a greater consistency in the resulting encapsulate. As a result, the dissolution release of more water soluble ingredients may be more predictable and consistent, allowing for a more consistent user experience.

[0166] It should be noted that the exemplary embodiment illustrated in Figure 5 includes use of at least two planetary screws 18, and more likely three or more or 3-18 screws 18 to achieve the mixing as discussed above and inclusive of both homogenization and mastication. In addition, the center shaft 16 desirably rotates at at least 50 RPM, or at least 100 RPM, with extrusion occurring at at least 50 Kg/hr with an input of less than .2 KWH/KG in order to achieve the extruding at at least 50 Kg/hr. Accordingly, more encapsulate may be mixed without extruding any faster.

[0167] It should be further noted that after the encapsulation process, the encapsulate flow 202 may exit the planetary roller extruder 10 as a viscous rope or strand. The resulting viscous rope or strand may be milled or ground after extrusion. In at least one embodiment, the resulting viscous rope or strand may be first ground into smaller fragments, and then milled into a powder. In at least one embodiment, the viscous rope or strand may be fed into a "dry" pelletizer before being ground and/or milled. During the milling or grinding process, undesirable small and thin particles ("fines") may shear and form, adhering to the process equipment, reducing efficiency. These fines may be defined as particles that have a diameter smaller than 150 microns, wherein the remainder of the particles have a diameter larger than 150 microns. Due to the enhanced mixing characteristics of the planetary roller extruder 10 (i.e. dispersive mixing that creates less lumps in the flow 202, while promoting uniform particle size within flow 202, particle adhesion, and better encapsulate coverage), the encapsulate flow 202 may exhibit more uniform particle size, stronger particles, and more cohesive particles compared to an encapsulate flow of a conventional process. As a result, compared to convention methods, when the encapsulate flow 202 of planetary roller extruder 10 is ground or milled, the resulting material may exhibit less than 5% fines and may exhibit more uniform particle size.

[0168] All references, including publications, patent applications, and patents cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0169] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0170] Exemplary embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

CLAIMS

What is claimed is:

1. A method for encapsulating an ingredient, the method comprising:

feeding at least one active ingredient into a planetary roller extruder;

feeding at least one additional ingredient into said planetary roller extruder;

creating a flow of said at least one active ingredient and said at least one additional ingredient through said planetary roller extruder towards a downstream extent of said planetary roller extruder;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and

extruding said encapsulate from said planetary roller extruder.

2. The method of claim 1, wherein said flow is substantially a same color during the method.

3. The method of claim 1, wherein said flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said flow reaches said downstream extent of said planetary roller extruder.

4. The method of claim 1, wherein once said flow reaches a molten state a temperature of said flow is substantially uniform across any cross-section of said flow taken perpendicular to a direction of said flow.

5. The method of claim 1, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

6. The method of claim 1, wherein said encapsulate releases less than 35% of said at least one active ingredient, wherein said at least one active ingredient is Acesulfame K, over 180 seconds.

7. The method of claim 1, wherein said encapsulate contains the range of 30-40% of said at least one active ingredient and 60-70% of said at least one additional ingredient.

8. The method of claim 1, wherein said at least one active ingredient is a plurality of active ingredients.

9. The method of claim 1, wherein said at least one active gum ingredient has a water solubility of at least 20%.

10. The method of claim 1, wherein said at least one additional ingredient is at least one encapsulating ingredient.

11. The method of claim 1, wherein said at least one additional ingredient is a resin or polymer.

12. The method of claim 1, further comprising milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

13. The method of claim 1, wherein a temperature of said flow is within a 20 degree Celsius range within said mixer.

14. A method for encapsulating an ingredient, the method comprising:

feeding a desirable amount at least one active ingredient into a mixer;

feeding at least one additional ingredient into said mixer;

creating a flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer;

maintaining said flow at a substantially constant color from said creating of said flow through arrival of said flow at said downstream extent of said mixer;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and

extruding said encapsulate from said mixer.

15. The method of claim 14, wherein said flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said flow reaches said downstream extent of said mixer.

16. The method of claim 14, wherein once said flow reaches a molten state a temperature of said flow is substantially uniform across any cross-section of said flow taken perpendicular to a direction of said flow.

17. The method of claim 14, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

18. The method of claim 14, wherein said encapsulate releases less than 35% of said at least one active ingredient, wherein said at least one active ingredient is Acesulfame K, over 180 seconds.

19. The method of claim 14, wherein said encapsulate contains the range of 30-40% of said at least one active ingredient and 60-70% of said at least one additional ingredient.

20. The method of claim 14, wherein said at least one active ingredient is a plurality of active ingredients.

21. The method of claim 14, wherein said at least one active gum ingredient has a water solubility of at least 20%.

22. The method of claim 14, wherein said at least one additional ingredient is at least one encapsulating ingredient.

23. The method of claim 14, wherein said at least one additional ingredient is a resin or polymer.

24. The method of claim 14, wherein said mixer is a planetary roller extruder.

25. The method of claim 14, further comprising milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

26. The method of claim 14, wherein a temperature of said flow is within a 20 degree Celsius range within said mixer.

27. A method for encapsulating an ingredient, the method comprising:

feeding at least one active ingredient into a mixer;

feeding at least one additional ingredient into said mixer;

creating a molten flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer, wherein a temperature of said molten flow is substantially uniform across any cross-section of said molten flow taken perpendicular to a direction of said molten flow;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and

extruding said encapsulate from said mixer.

28. The method of claim 27, wherein said molten flow is substantially a same color during the method.

29. The method of claim 27, wherein said molten flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said molten flow reaches said downstream extent of said mixer.

30. The method of claim 27, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

31. The method of claim 27, wherein said encapsulate releases less than 35% of said at least one active ingredient, wherein said at least one active ingredient is Acesulfame K, over 180 seconds.

32. The method of claim 27, wherein said encapsulate contains the range of 30-40% of said at least one active ingredient and 60-70% of said at least one additional ingredient.

33. The method of claim 27, wherein said at least one active ingredient is a plurality of active ingredient.

34. The method of claim 27, wherein said at least one active gum ingredient has a water solubility of at least 20%.

35. The method of claim 27, wherein said at least one additional ingredient is at least one encapsulating ingredient.

36. The method of claim 27, wherein said at least one additional ingredient is a resin or polymer.

37. The method of claim 27, wherein said mixer is a planetary roller extruder.

38. The method of claim 27, further comprising milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

39. The method of claim 27, wherein a temperature of said molten flow is within a 20 degree Celsius range within said mixer.

40. A method for encapsulating an ingredient, the method comprising:

feeding at least one active ingredient into a mixer;

feeding at least one additional ingredient into said mixer;

creating a flow of said at least one active ingredient and at least one additional ingredient through said mixer towards a downstream extent of said mixer;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and

extruding said encapsulate from said mixer, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

41. The method of claim 40, wherein said flow is substantially a same color during the method.

42. The method of claim 40, wherein said flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said flow reaches said downstream extent of said mixer.

43. The method of claim 40, wherein once said flow reaches a molten state a temperature of said flow is substantially uniform across any cross-section of said flow taken perpendicular to a direction of said flow.

44. The method of claim 40, wherein said encapsulate releases less than 35% of at least one of said plurality of active ingredients over 180 seconds.

45. The method of claim 40, wherein said encapsulate contains the range of 30-40% of said plurality of active ingredients and 60-70% of said at least one additional ingredient.

46. The method of claim 40, wherein said plurality of active ingredients have a water solubility of 20%

47. The method of claim 40, wherein said at least one additional ingredient is at least one encapsulating ingredient.

48. The method of claim 40, wherein said at least one additional ingredient is a resin or polymer.

49. The method of claim 40, wherein said mixer is a planetary roller extruder.

50. The method of claim 40, further comprising milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

51. The method of claim 40, wherein a temperature of said flow is within a 20 degree Celsius range within said mixer.

52. A method for encapsulating an ingredient, the method comprising:

feeding at least one active ingredient into a mixer;

feeding at least one additional ingredient into said mixer;

creating a flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate;

extruding said encapsulate from said mixer; and

milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

53. The method of claim 52, wherein said flow is substantially a same color during the method.

54. The method of claim 52, wherein said flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said flow reaches said downstream extent of said mixer.

55. The method of claim 52, wherein once said flow reaches a molten state a temperature of said flow is substantially uniform across any cross-section of said flow taken perpendicular to a direction of said flow.

56. The method of claim 52, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

57. The method of claim 52, wherein said encapsulate releases less than 35% of said at least one active ingredient, wherein said at least one active ingredient is Acesulfame K, over 180 seconds.

58. The method of claim 52, wherein said encapsulate contains the range of 30-40% of said at least one active ingredient and 60-70% of said at least one additional ingredient.

59. The method of claim 52, wherein said at least one active ingredient is a plurality of active ingredients.

60. The method of claim 52, wherein said at least one active gum ingredient has a water solubility of at least 20%.

61. The method of claim 52, wherein said at least one additional ingredient is at least one encapsulating ingredient.

62. The method of claim 52, wherein said at least one additional ingredient is a resin or polymer.

63. The method of claim 52, wherein said mixer is a planetary roller extruder.

64. The method of claim 52, wherein a temperature of said flow is within a 20 degree Celsius range within said mixer.

65. A method for encapsulating an ingredient, the method comprising:

feeding at least one active ingredient into a mixer;

feeding at least one additional ingredient into said mixer;

creating a molten flow of said at least one active ingredient and said at least one additional ingredient through said mixer towards a downstream extent of said mixer;

encapsulating said at least one active ingredient via a mixing of said at least one active ingredient and said at least one additional ingredient to produce an encapsulate; and

extruding said encapsulate from said mixer, wherein a temperature of said molten flow remains within a 20 degree Celsius range from said creating to said extruding.

66. The method of claim 65, wherein said molten flow is substantially a same color during the method.

67. The method of claim 65, wherein said molten flow of said encapsulate includes a temperature of less than 120 degrees Celsius when said molten flow reaches said downstream extent of said mixer.

68. The method of claim 65, wherein a temperature of said molten flow is substantially uniform across any cross-section of said molten flow taken perpendicular to a direction of said molten flow.

69. The method of claim 65, wherein said at least one active ingredient is Acesulfame K and said encapsulate has an initial dissolution rate that is less than or equal to 20%.

70. The method of claim 65, wherein said encapsulate releases less than 35% of said at least one active ingredient, wherein said at least one active ingredient is Acesulfame K, over 180 seconds.

71. The method of claim 65, wherein said encapsulate contains the range of 30-40% of said at least one active ingredient and 60-70% of said at least one additional ingredient.

72. The method of claim 65, wherein said at least one active ingredient is a plurality of active ingredient.

73. The method of claim 65, wherein said at least one active gum ingredient has a water solubility of at least 20%.

74. The method of claim 65, wherein said at least one additional ingredient is at least one encapsulating ingredient.

75. The method of claim 65, wherein said at least one additional ingredient is a resin or polymer.

76. The method of claim 65, wherein said mixer is a planetary roller extruder.

77. The method of claim 67, further comprising milling said encapsulate, wherein a milled encapsulate contains less than or equal to 5% of a particle size of less than 150 microns.

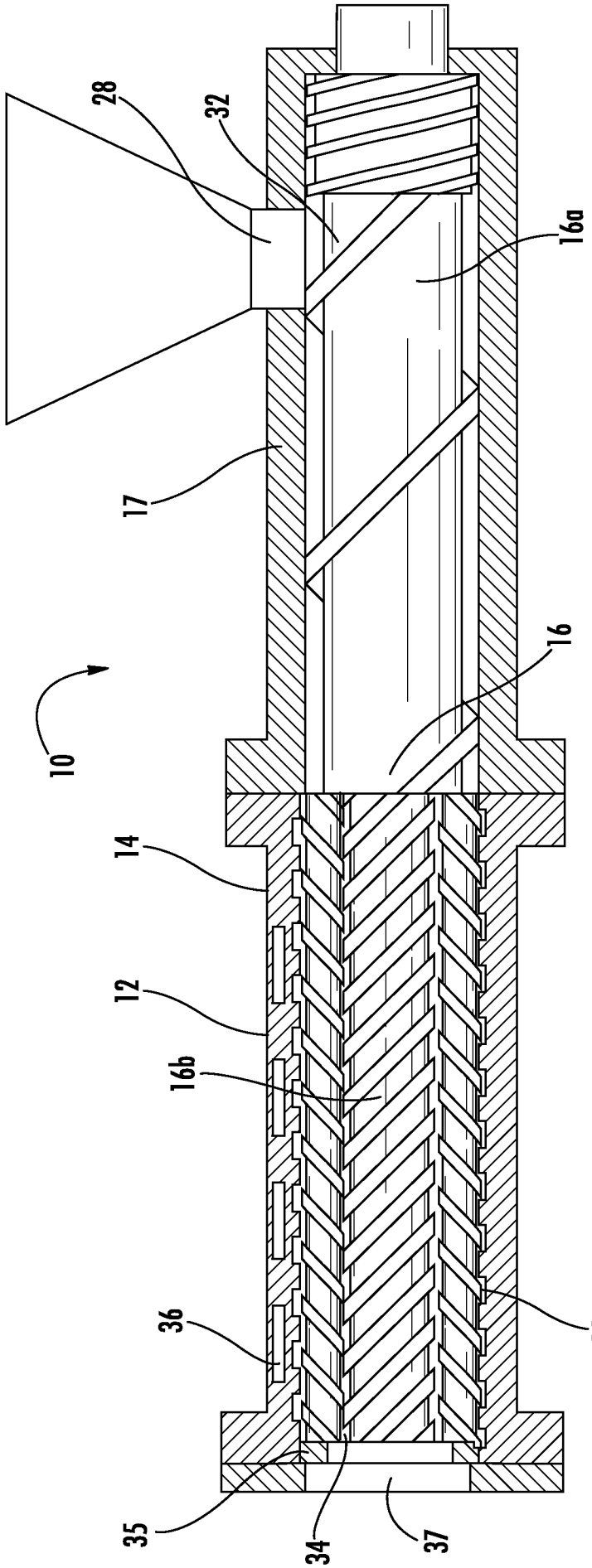

FIG. 1

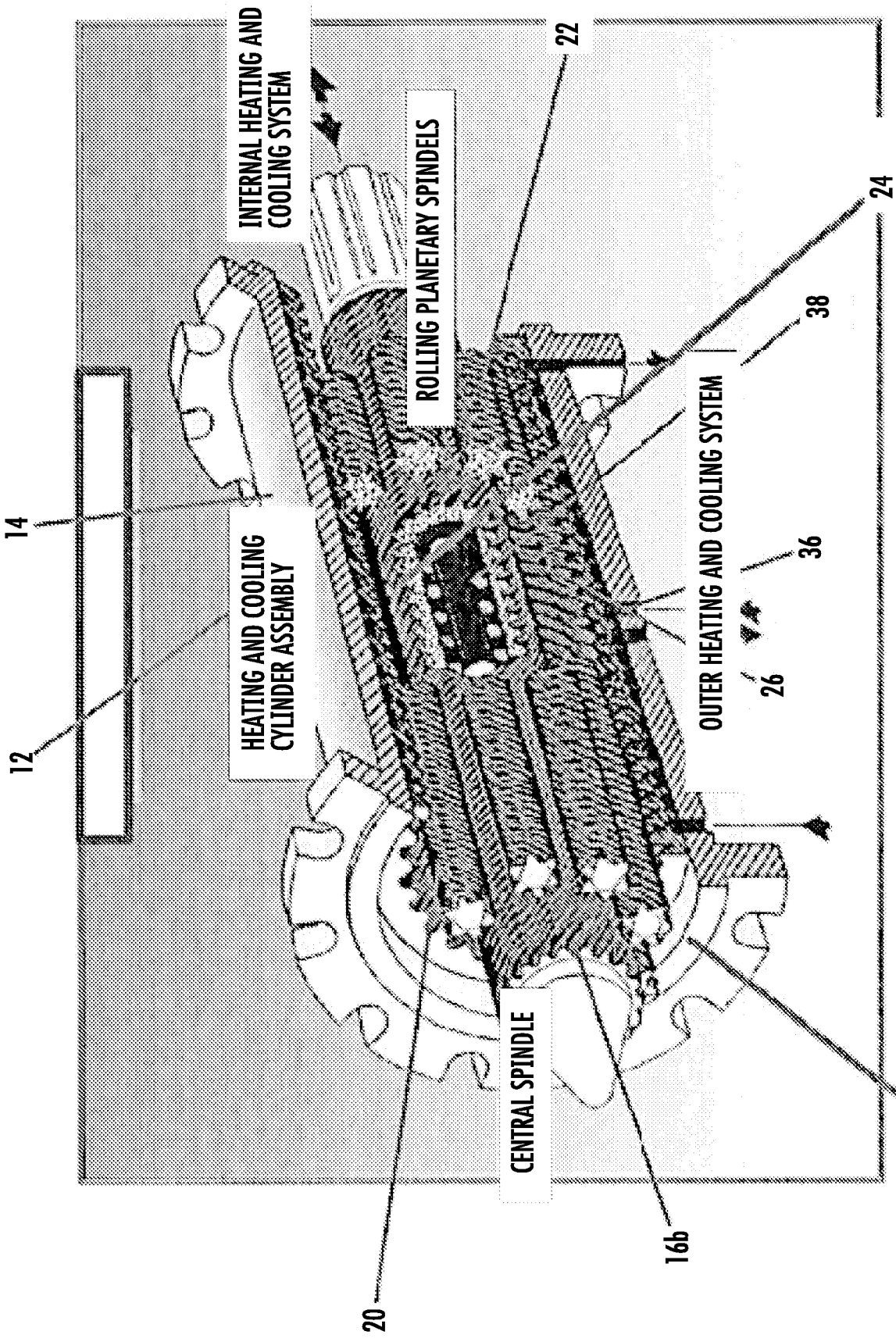
INTERNAL HEATING AND COOLING SYSTEM
ROLLING PLANETARY SPINDELS
22
24
38
14
HEATING AND COOLING CYLINDER ASSEMBLY
OUTER HEATING AND COOLING SYSTEM
36
26
12
CENTRAL SPINDLE
18
16b
20

FIG. 2

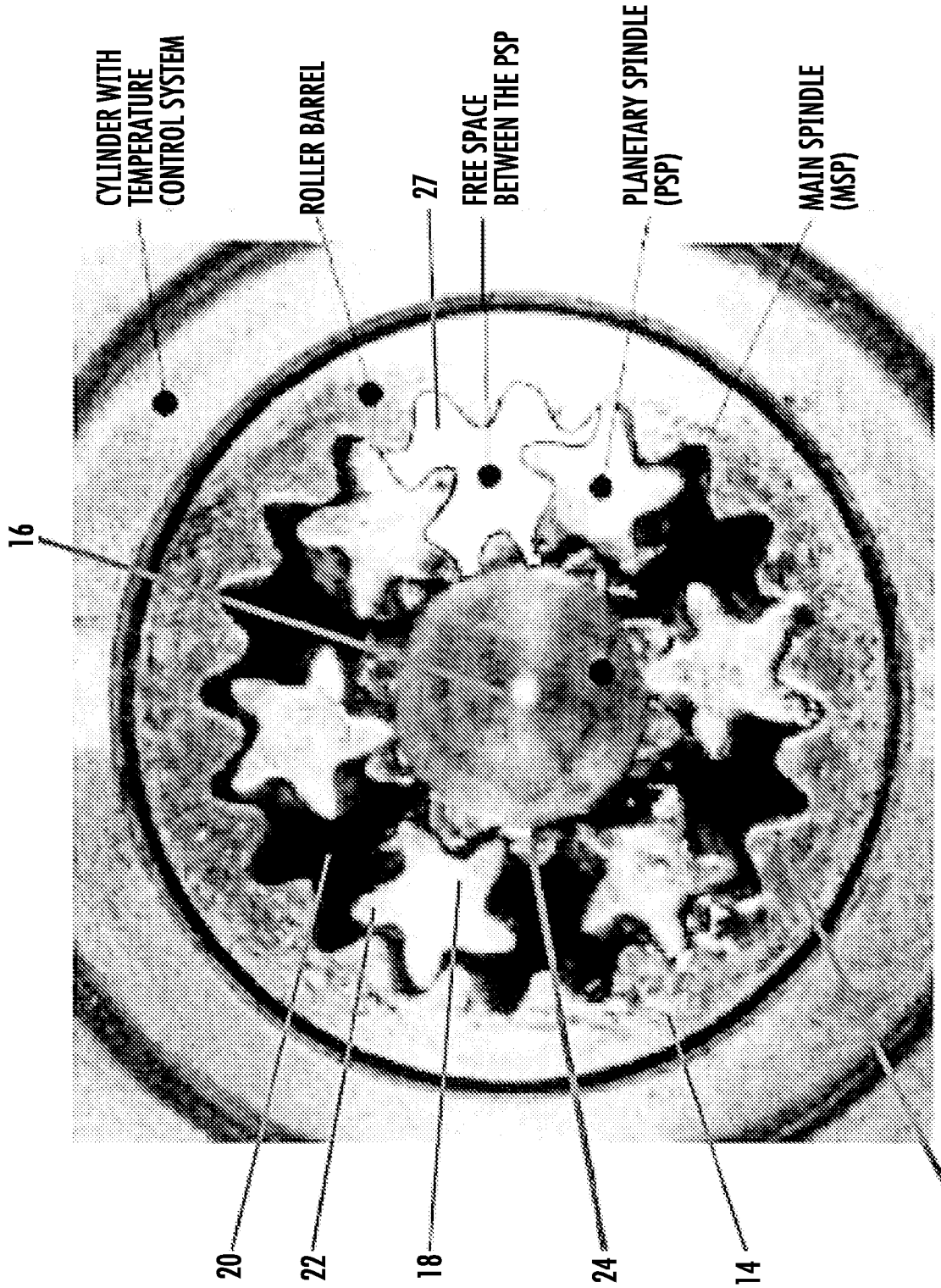
CYLINDER WITH TEMPERATURE CONTROL SYSTEM
ROLLER BARREL
27
FREE SPACE BETWEEN THE PSP
PLANETARY SPINDLE (PSP)
MAIN SPINDLE (MSP)
16
20
22
18
24
14
26

FIG. 3

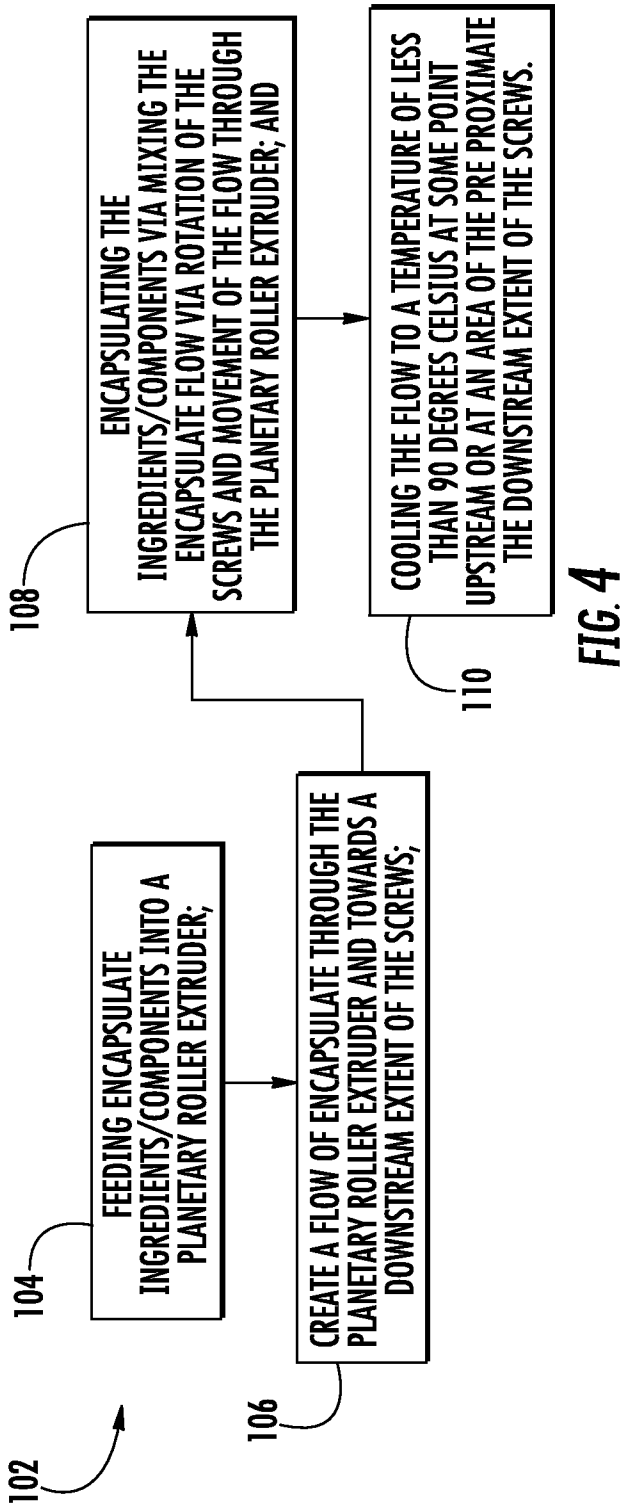
102
104
FEEDING ENCAPSULATE INGREDIENTS/COMPONENTS INTO A PLANETARY ROLLER EXTRUDER;
106
CREATE A FLOW OF ENCAPSULATE THROUGH THE PLANETARY ROLLER EXTRUDER AND TOWARDS A DOWNSTREAM EXTENT OF THE SCREWS;
108
ENCAPSULATING THE INGREDIENTS/COMPONENTS VIA MIXING THE ENCAPSULATE FLOW VIA ROTATION OF THE SCREWS AND MOVEMENT OF THE FLOW THROUGH THE PLANETARY ROLLER EXTRUDER; AND
110
COOLING THE FLOW TO A TEMPERATURE OF LESS THAN 90 DEGREES CELSIUS AT SOME POINT UPSTREAM OR AT AN AREA OF THE PRE PROXIMATE THE DOWNSTREAM EXTENT OF THE SCREWS.

FIG. 4

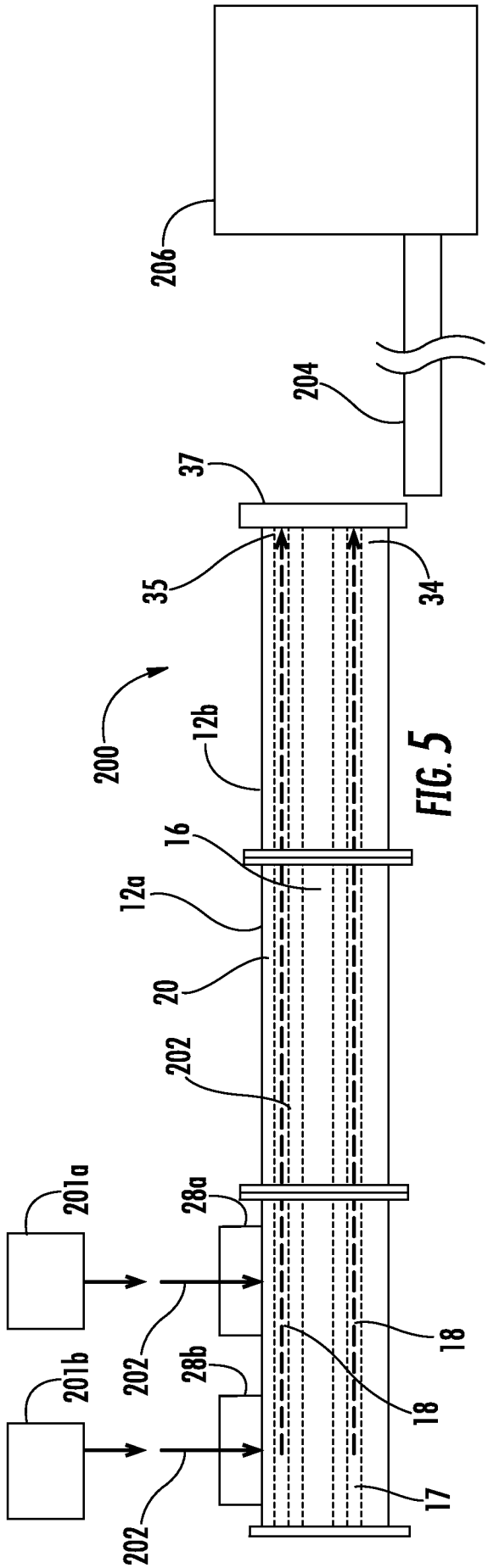
206
204
37
35
34
200
12b
16
12a
20
202
28a
201a
202
28b
201b
202
18
18
17

FIG. 5

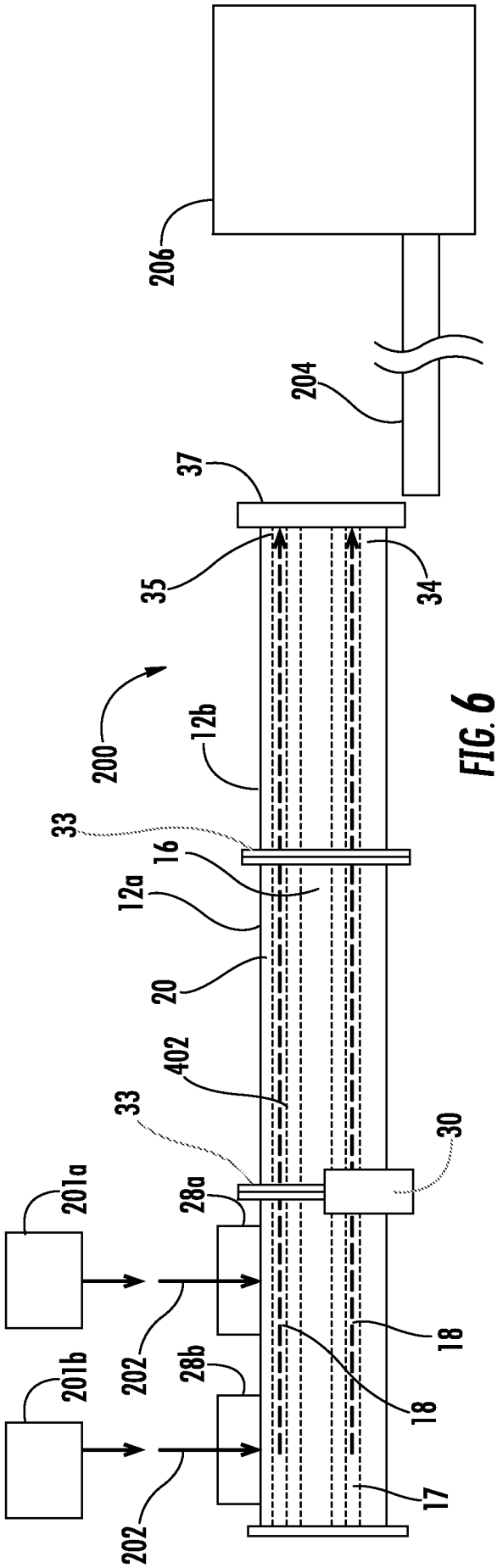
206
204
37
35
34
200
12b
33
16
12a
20
402
33
30
201a
28a
18
202
201b
28b
18
17
202

FIG. 6

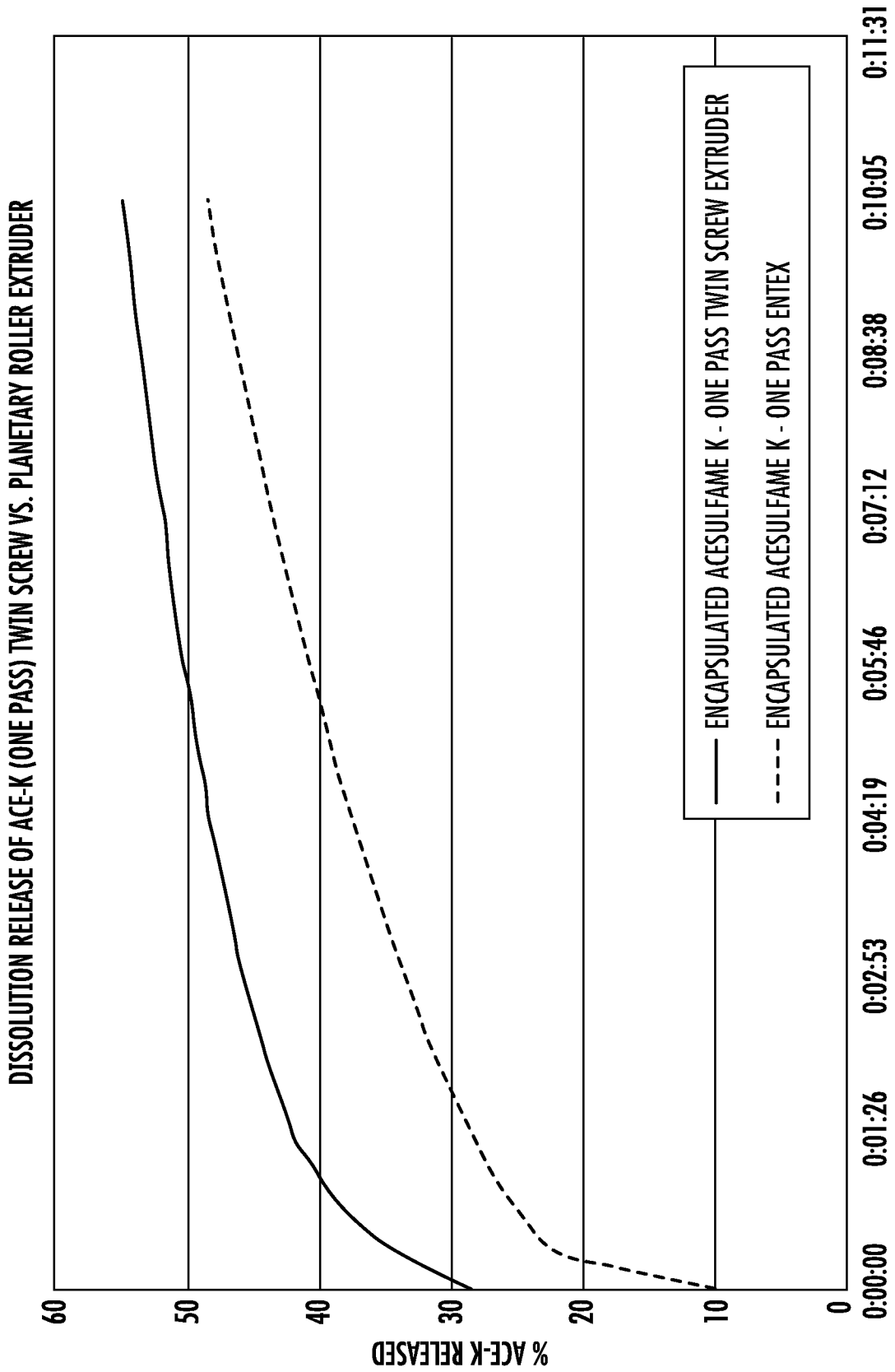
DISSOLUTION RELEASE OF ACE-K (ONE PASS) TWIN SCREW VS. PLANETARY ROLLER EXTRUDER
% ACE-K RELEASED
60
50
40
30
20
10
0
0:00:00
0:01:26
0:02:53
0:04:19
0:05:46
0:07:12
0:08:38
0:10:05
0:11:31
TIME (MIN)
ENCAPSULATED ACESULFAME K - ONE PASS TWIN SCREW EXTRUDER
ENCAPSULATED ACESULFAME K - ONE PASS ENTEX

FIG. 7