

HYDROTHERMALLY TREATED POLYSACCHARIDE MIXTURES AND A METHOD OF PREPARING THEREOF

TECHNICAL FIELD

The present disclosure generally relates to hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures prepared by hydrothermal treatment of polysaccharide mixtures comprising at least one starch-containing material and at least one non-starch polysaccharide. The present disclosure also relates to a method of preparing the hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures. The present disclosure further relates to the application or uses of the hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures.

BACKGROUND

Currently, hydrocolloids and starches are commonly used as food ingredients to improve different aspects of the formulation and production of many types of food products. Chemically modified starches are often used in food formulation as chemically modified starches tend to have better functionality compared with their native counterpart. Although physically modified starches are also used in the food industry, the functionality of physically modified starches tends to be somewhat inferior in comparison to that of chemically modified starches.

There is a need for physically modified starches that have a superior performance compared to chemically modified starches and/or known physically modified starches.

Also, there is a need for food ingredients that have not been chemically modified and that have a superior performance compared to known food ingredients comprising hydrocolloids and chemically modified starches and/or food ingredients comprising hydrocolloids and known physically modified starches.

SUMMARY

The present disclosure generally relates to hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures prepared by hydrothermal treatment of polysaccharide mixtures comprising at least one starch-containing material and at least one non-starch polysaccharide. The present disclosure also relates to a method of preparing the hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures. The present disclosure further relates to the application or uses of the hydrothermally treated polysaccharide compounds and/or hydrothermally treated polysaccharide mixtures.

The hydrothermally treated polysaccharide mixtures can be prepared by combining or mixing at least one starch-containing material and at least one non-starch polysaccharide to form a polysaccharide mixture, wherein the combining step or mixing step is performed prior to and/or during hydrothermal treatment of the polysaccharide mixture. The hydrothermal treatment conditions allow the starch-containing material to be at least partially gelatinized. A drying process can be incorporated to dry the hydrothermally treated polysaccharide mixtures to form concentrated solutions, pastes and/or powders.

The hydrothermally treated polysaccharide mixtures can be used as food ingredients that improve the processing of food products (e.g., gluten-free food products or food products low in gluten content) and/or the quality of food products (e.g., gluten-free food products or food products low in gluten content) with respect to texture, taste, etc.

The present disclosure demonstrates that the functionality of a physically (e.g., hydrothermally) modified starch or physically modified starches can be improved by incorporating a non-starch polysaccharide or non-starch polysaccharides before and/or during the physical (e.g., hydrothermal) treatment and/or modification process of the starch, starch-containing material or starch-containing particles. As a result, a physically modified starch or physically modified starches of a better quality or an improved quality can be produced.

A first aspect of the present disclosure provides a compound comprising: a hydrothermally treated polysaccharide mixture, wherein the hydrothermally treated polysaccharide mixture comprises: at least one hydrothermally treated starch-containing material; and at least one hydrothermally treated non-starch polysaccharide.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise about 99.99 wt. % to about 0.5 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 99.5 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, the hydrothermally treated polysaccharide mixture can comprise about 99.99 wt. % to about 50.0 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 50.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, the hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.5 wt. % to about 90.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 10.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, the hydrothermally treated polysaccharide mixture can comprise about 99.5 wt. % to about 95.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 5.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis.

In some embodiments, the at least one starch-containing material can comprise a starch, starch-containing particles, pure starch, potato starch, wheat starch, maize starch, corn starch, rice starch, cassava starch, acorn starch, arrowroot starch, arracacha starch, banana starch, barley starch, breadfruit starch, buckwheat starch, canna starch, colacasia starch, katakuri starch, kudzu starch, malanga starch, millet starch, oat starch, oca starch, polynesian arrowroot starch, sago starch, sorghum starch, sweet potato starch, rye starch, taro starch, chestnut starch, water chestnut starch, yam starch, bean starch, favas starch, lentil starch, chickpea starch, mung bean starch, tapioca starch, soy starch, potatoes, wheat, maize, corn, rice, cassava, acorns, arrowroots, arracacha, bananas, barley, breadfruit, buckwheat, canna, colacasia, katakuri, kudzu, malanga, millet, oats, oca, polynesian arrowroots, sago, sorghum, sweet potatoes, rye, taro, beans, favas, lentils, peas, chickpeas, mung beans, tapioca, starch granules, flour granules, dough made from flour, a slurry made

from flour, starch-containing grains, a starch-containing food, a derivative thereof or a combination of one or more thereof.

In some embodiments, the non-starch polysaccharide can comprise a hydrocolloid, cellulose, a hemicellulose, a gum, a pectin, a xylan, a mannan, a glucan, a mucilage, an alginate, an arabinoxylan, a beta-glucan, a chitin, carrageenan, gellan, guar gum, inulin, lignin, xanthan gum, chitosan, a derivative thereof or a combination of one or more thereof.

In some embodiments, the at least one non-starch polysaccharide can comprise at least one gelling non-starch polysaccharide, wherein the at least one gelling non-starch polysaccharide can comprise an alginate, carrageenan, pectin, a derivative thereof or a combination of one or more thereof.

In some embodiments, the at least one non-starch polysaccharide can comprise at least one non-gelling non-starch polysaccharide, wherein the at least one non-gelling non-starch polysaccharide can comprise xanthan gum, guar gum, chitosan, a derivative thereof or a combination of one or more thereof.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise cross-linking ions comprising calcium cations, magnesium cations, sodium cations, potassium cations or a combination of one or more thereof.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise cross-linking ions in an amount of about 0.01 wt. % to about 5 wt. % on a dry weight basis.

In some embodiments, the at least one hydrothermally treated starch-containing material can be at least partially gelatinized.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise a peak viscosity and/or final viscosity that is higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch

polysaccharide by at least about 5% to at least about 170% with respect to peak viscosity and by at least about 5% to at least about 60% with respect to final viscosity when tested using a standard Rapid Visco Analyzer (RVA) test profile for starch and/or pre-gelatinised starch.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise a peak viscosity and/or final viscosity that is higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least about 5% to at least about 150% with respect to peak viscosity and by at least about 5% to at least about 120% with respect to final viscosity when tested using an RVA at a constant testing temperature between the range of 20-40°C (e.g., 30°C) for starch and/or pre-gelatinised starch.

In some embodiments, the hydrothermally treated polysaccharide mixture can comprise a pasting temperature that is lower than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least 1°C when tested using a standard RVA test profile for starch and/or pre-gelatinised starch.

In some embodiments, the hydrothermally treated polysaccharide mixture can be a food ingredient, thickener, gelling material, stabilizer, emulsifier or a combination of one or more thereof.

A second aspect of the present disclosure provides a method of preparing a hydrothermally treated polysaccharide mixture, comprising: providing an amount of at least one starch-containing material; providing an amount of at least one non-starch polysaccharide; mixing the at least one starch-containing material and the at least one non-starch polysaccharide to form a polysaccharide mixture, wherein the mixing step is performed prior to or during hydrothermal treatment of the polysaccharide mixture.

In some embodiments, the mixing step is performed prior to hydrothermal treatment of the polysaccharide mixture. In some embodiments, the mixing step is performed during hydrothermal treatment of the polysaccharide mixture.

In some embodiments, the method described above can comprise adding an amount of water to the polysaccharide mixture to form a polysaccharide mixture slurry; and heating the polysaccharide mixture slurry to form the hydrothermally treated polysaccharide mixture.

In some embodiments, the method described above can comprise adding an amount of water to the polysaccharide mixture to form a polysaccharide mixture slurry; and heating the polysaccharide mixture slurry to form the hydrothermally treated polysaccharide mixture; wherein the adding of the water and the heating are performed concurrently.

In some embodiments, the at least one starch-containing material can be dry/non-hydrated and the at least one non-starch polysaccharide can be dry/non-hydrated before the mixing step.

In some embodiments, the polysaccharide slurry can comprise water in an amount of about 10 wt. % to about 95 wt.%, about 50 wt. % to about 90 wt. %, or about 60 wt. % to about 80 wt. %.

In some embodiments, the hydrothermal treatment and in particular the heating step can comprise heating the polysaccharide mixture slurry to a temperature above the gelatinization temperature of the at least one starch-containing material, and wherein the polysaccharide mixture slurry is held at the temperature above the gelatinization temperature. In some embodiments, the temperature above the gelatinization temperature of the at least one starch-containing material is about 40°C to about 400°C. In some embodiments, the temperature above the gelatinization temperature of the at least one starch-containing material is about 50°C to about 95°C.

In some embodiments, the method described above can further comprise at least partially gelatinizing the at least one starch-containing material during the hydrothermal treatment. In some embodiments, the at least one starch-containing material can be about 1% to about 99% gelatinized during the hydrothermal treatment.

In some embodiments, the method described above can comprise adding the at least one non-starch polysaccharide to the at least one starch-containing material after the water has been added to the at least one starch-containing material and before the heating step or during the heating step.

In some embodiments, the method described above can comprise adding the at least one starch-containing material to the at least one non-starch polysaccharide after the water has been added to the at least one non-starch polysaccharide and before the heating step or during the heating step.

In some embodiments, no chemical modification steps are used and the hydrothermally treated polysaccharide mixture is physically functionalized.

In some embodiments, the heating step can comprise heating the polysaccharide mixture slurry using a heating apparatus, wherein the heating apparatus can comprise a jacketed vessel, Stephan mixer, extruder, jet steamer, high pressure processor or a combination of one or more thereof.

In some embodiments, the method described above can further comprise drying the hydrothermally treated polysaccharide mixture to form a concentrated solution, paste or powder. In some embodiments, the drying step can comprise spray drying, microwave drying, tray drying, drum drying or a combination of one or more thereof.

In some embodiments, the dried hydrothermally treated polysaccharide mixture can comprise about 0.1 wt. % to about 50 wt. % of water, about 1 wt. % to about 30 wt. % of water, about 10 wt. % to about 25 wt. % of water, or about 3 wt. % to about 10 wt. % of water.

In some embodiments, the heating step and drying step can be combined as a single step.

A third aspect of the present disclosure provides a hydrothermally treated polysaccharide mixture prepared by the method described above.

A fourth aspect provides a food ingredient comprising the hydrothermally treated polysaccharide mixture described above.

A fifth aspect provides a food product comprising the hydrothermally treated polysaccharide mixture described above.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present disclosure are described herein with reference to the drawings in which:

Figure 1 is a schematic diagram illustrating a method of preparing a hydrothermally treated polysaccharide mixture (HTT-PSM) in accordance with an embodiment of the present disclosure.

Figure 2 is a plot of viscosity (cP) against time (min) for Example 1 (HTT-PSM) and Comparative Examples 1-5 (NGRF, HTT-GRF, HTT-PSM-DM, NGRF-PSM-DM, and XG) tested using a standard temperature profile.

Figure 3 is a plot of viscosity (cP) against time (min) for Example 1 (HTT-PSM) and the Comparative Examples (NGRF, HTT-GRF, HTT-PSM-DM, NGRF-PSM-DM, and XG) tested using a constant temperature profile.

Figure 4 shows photos of three different types of gluten-free dough made using: (a) rice flour; (b) glutinous rice flour; and (c) 20 wt. % HTT-PSM with 80 wt. % rice flour. The top row of photos shows the three different types of dough before pressing. The bottom row of photos shows the three different types of dough after pressing.

Figure 5 shows a photo of a gluten-free rice cracker made from (a) rice flour (top photo) and a gluten-free rice cracker made from (b) rice flour substituted with 20 wt. % HTT-PSM (bottom photo).

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments can be utilized, and other changes can be made, without departing from the spirit or scope of the subject matter presented herein.

Unless specified otherwise, the terms "comprising" and "comprise" as used herein, and grammatical variants thereof, are intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, un-recited elements.

As used herein, the term "about", in the context of concentrations of components, conditions, other measurement values, etc., means $\pm 5\%$ of the stated value, or $\pm 4\%$ of the stated value, or $\pm 3\%$ of the stated value, or $\pm 2\%$ of the stated value, or $\pm 1\%$ of the stated value, or $\pm 0.5\%$ of the stated value, or $\pm 0\%$ of the stated value.

Throughout this disclosure, certain embodiments may be disclosed in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically

disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5 and 6. This applies regardless of the breadth of the range.

As used herein, the term “compound” and the term “mixture” are used interchangeably.

The present disclosure relates to hydrothermally treated polysaccharide mixtures, the physical properties of the hydrothermally treated polysaccharide mixtures, the method of preparing the hydrothermally treated polysaccharide mixtures, and the application of the hydrothermally treated polysaccharide mixtures.

The hydrothermally treated polysaccharide mixtures of the present disclosure can comprise at least one hydrothermally treated starch-containing material and at least one hydrothermally treated non-starch polysaccharide. As such, the term “polysaccharide” in the term “hydrothermally treated polysaccharide mixtures” can refer to the starch-containing material and/or the non-starch polysaccharide. In embodiments, the hydrothermally treated polysaccharide mixtures can be used as food ingredients.

The hydrothermally treated polysaccharide mixtures of the present disclosure can comprise physically functionalized polysaccharides (e.g., a physically functionalized starch-containing material(s) and/or a physically functionalized non-starch polysaccharide(s)). In embodiments, only physical processes are used to treat and/or modify the starch-containing material(s) and the non-starch polysaccharide(s). In embodiments, no chemical modification processes are employed or used.

The hydrothermally treated polysaccharide mixtures of the present disclosure can be prepared by combining or mixing at least one starch-containing material and at least one non-starch polysaccharide to form a polysaccharide mixture, wherein the combining step or mixing step is performed prior to and/or during hydrothermal

treatment of the polysaccharide mixture, wherein hydrothermal treatment of the polysaccharide mixture results in the hydrothermally treated polysaccharide mixture. The hydrothermal treatment of the polysaccharide mixture can be carried out under treatment conditions that allow the starch-containing material to be at least partially gelatinized. In some embodiments, a further drying process can be incorporated to dry the hydrothermally treated polysaccharide mixture to form a concentrated solution, paste or powder. In some embodiments, the combining step or mixing step is performed prior to hydrothermal treatment of the polysaccharide mixture.

Importantly, the present disclosure demonstrates that the functionality of a physically (e.g., hydrothermally) modified starch or physically modified starches can be improved by incorporating a non-starch polysaccharide or non-starch polysaccharides before or during the physical (e.g., hydrothermal) treatment and/or modification process of the starch, starch-containing material or starch-containing particles. As a result, a physically modified starch or physically modified starches of a better quality, superior quality or improved quality can be produced.

The incorporation of the non-starch polysaccharide or non-starch polysaccharides prior to and/or during the physical (e.g., hydrothermal) treatment and/or modification of the starch, starch-containing material, or starch-containing particles results in a product having greatly improved characteristics in comparison with: a modified starch that was processed under the same hydrothermal treatment conditions but without the addition of the non-starch polysaccharide(s); and a previously or already hydrothermally modified starch blended with a non-starch polysaccharide.

The present disclosure relates to hydrothermally treated polysaccharide mixtures that have an improved functionality over known physically modified starches and/or hydrocolloids. The present disclosure also relates to a method for improving the functionality of starches and/or hydrocolloids.

The hydrothermally treated polysaccharide mixtures of the present disclosure are applicable to, but not limited to, the food industry. In some embodiments, the

hydrothermally treated polysaccharide mixtures can be used to replace or substitute food ingredients, such as, chemically modified starches, physically modified starches and/or hydrocolloids while maintaining or improving the quality, texture and/or processing of the food products. In some embodiments, the hydrothermally treated polysaccharide mixtures can be used in lower amounts or lower dosages to replace or substitute food ingredients, such as, chemically modified starches, physically modified starches and/or hydrocolloids while maintaining or improving the quality, texture and/or processing of the food products.

In some embodiments, the hydrothermally treated polysaccharide mixtures of the present disclosure can be used to replace or substitute more expensive food ingredients, such as, chemically modified starches, physically modified starches and/or hydrocolloids while maintaining or improving the quality, texture and/or processing of the food products. In some embodiments, the hydrothermally treated polysaccharide mixtures can be used in lower amounts or lower dosages to replace or substitute more expensive food ingredients, such as, chemically modified starches, physically modified starches and/or hydrocolloids while maintaining or improving the quality, texture and/or processing of the food products.

In some embodiments, the hydrothermally treated polysaccharide mixtures can be used to improve the texture of food products (e.g., gluten-free food products and/or food products low in gluten content) and/or improve dough handling (e.g., gluten-free dough and/or dough low in gluten content). In some embodiments, the hydrothermal treated polysaccharide mixtures can be used to improve the processing of the food products.

In some embodiments, the use of the hydrothermally treated polysaccharide mixtures of the present disclosure can lead to a better, improved or superior quality of the final food products when replacing an ingredient in a similar amount or similar dosage to the replaced ingredient.

In some embodiments, the use of the hydrothermally treated polysaccharide mixtures of the present disclosure can lead to a reduction in costs of food ingredients when replacing an ingredient in a lower amount or lower dosage than the replaced ingredient while at the same time maintaining or improving the quality of the food product.

In some embodiments, the hydrothermally treated polysaccharide mixtures can be used as thickeners, gelling materials, stabilizers and/or emulsifiers.

Figure 1 is a schematic diagram illustrating a method of preparing a hydrothermally treated polysaccharide mixture (HTT-PSM) in accordance with an embodiment of the present disclosure. As illustrated in **Figure 1**, in an embodiment, at least one dry/non-hydrated starch-containing material and at least one dry/non-hydrated non-starch polysaccharide can be mixed to form a non-hydrated or dry polysaccharide mixture. A certain or specific amount of water can be added to the non-hydrated or dry polysaccharide mixture to hydrate the non-hydrated or dry polysaccharide mixture and thereby form a polysaccharide mixture slurry. Alternatively, the non-hydrated or dry polysaccharide mixture can be added to a certain or specific amount of water to form a polysaccharide mixture slurry. The polysaccharide mixture slurry can subsequently be subjected to a hydrothermal treatment process to form the hydrothermally treated polysaccharide mixture. Upon completion of the hydrothermal treatment process, the hydrothermally treated polysaccharide mixture can be subjected to a drying or concentration process. The resulting hydrothermally treated polysaccharide mixture can be in the form of a concentrated solution, paste or powder.

The hydrothermally treated polysaccharide compound(s) and/or hydrothermally treated polysaccharide mixture(s) of the present disclosure can be prepared by physically treating the starch-containing material(s) and physically treating the non-starch polysaccharide(s).

The hydrothermally treated polysaccharide compound(s) and/or hydrothermally treated polysaccharide mixture(s) of the present disclosure can be prepared by hydrothermally treating the starch-containing material(s) and hydrothermally treating the non-starch polysaccharide(s).

In some embodiments, the starch-containing material can be starch, starch-containing particles, pure starch, potato starch, wheat starch, maize starch, corn starch, rice starch, cassava starch, acorn starch, arrowroot starch, arracacha starch, banana starch, barley starch, breadfruit starch, buckwheat starch, canna starch, colacasia starch, katakuri starch, kudzu starch, malanga starch, millet starch, oat starch, oca starch, polynesian arrowroot starch, sago starch, sorghum starch, sweet potato starch, rye starch, taro starch, chestnut starch, water chestnut starch, yam starch, bean starch, favas starch, lentil starch, chickpea starch, mung bean starch, tapioca starch, soy starch, potatoes, wheat, maize, corn, rice, cassava, acorns, arrowroots, arracacha, bananas, barley, breadfruit, buckwheat, canna, colacasia, katakuri, kudzu, malanga, millet, oats, oca, polynesian arrowroots, sago, sorghum, sweet potatoes, rye, taro, beans, favas, lentils, peas, chickpeas, mung beans, tapioca or a combination of one or more thereof. In embodiments, the starch-containing material can be gluten-free.

In some embodiments, the starch-containing material can be a starch granule, starch granules, a flour granule, flour granules, dough, dough made from flour, a slurry, a slurry made from flour, slurries made from flour, starch-containing grains, a starch-containing food, starch-containing food, starch-containing foods, or a combination of one or more thereof.

In some embodiments, the non-starch polysaccharide can be a hydrocolloid, cellulose, a hemicellulose, a gum, a pectin, a xylan, a mannan, a glucan, a mucilage, an alginate, an arabinoxylan, a beta-glucan, a chitin, carrageenan, gellan, guar gum, inulin, lignin, xanthan gum, chitosan, a derivative thereof, or a combination thereof. In some embodiments, the non-starch polysaccharide can be xanthan gum, guar gum, chitosan, a derivative thereof, or a combination of one or more thereof. In some

embodiments, the non-starch polysaccharide can be an alginate, carrageenan, pectin, a derivative thereof, or a combination of one or more thereof.

In some embodiments, the non-starch polysaccharide can be a gelling non-starch polysaccharide, gelling non-starch polysaccharides, non-gelling non-starch polysaccharide, non-gelling non-starch polysaccharides, or a combination thereof. In some embodiments, the gelling non-starch polysaccharide(s) can be an alginate, carrageenan, pectin, a derivative thereof, or a combination thereof. In some embodiments, the non-gelling non-starch polysaccharide(s) can be xanthan gum, guar gum, chitosan, a derivative thereof, or a combination of one or more thereof.

In some embodiments, a gelling polysaccharide(s) can be added during the preparation of the hydrothermally treated polysaccharide mixture of the present disclosure. In some embodiments, a gelling crosslinking ion(s) can be added during the preparation of the hydrothermally treated polysaccharide mixture.

In some embodiments, cross-linking ions can be added during the preparation of the hydrothermally treated polysaccharide mixture of the present disclosure. In some embodiments, the cross-linking ions can be calcium cations, magnesium cations, sodium cations, potassium cations, or a combination thereof. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise cross-linking cations in an amount of about 0.01 weight percent (wt. %) to about 5 wt. % on a dry weight basis. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise cross-linking cations in an amount of about 0.1 weight percent (wt. %) to about 2 wt. % on a dry weight basis.

In some embodiments, the hydrothermally treated polysaccharide compound(s) and/or hydrothermally treated polysaccharide mixture(s) can comprise at least one starch-containing material and at least one non-starch polysaccharide.

In some embodiments, the at least one starch containing material and the at least one non-starch polysaccharide can be mixed to form a polysaccharide mixture. In some

embodiments, the at least one starch containing material and the at least one non-starch polysaccharide can be mixed to form a polysaccharide mixture prior to and/or during the hydrothermal treatment of the polysaccharide mixture. In some embodiments, the at least one starch containing material and the at least one non-starch polysaccharide can be mixed to form a polysaccharide mixture prior to the hydrothermal treatment of the polysaccharide mixture.

In some embodiments, the at least one starch-containing material and the at least one non-starch polysaccharide can be present in a hydrothermally treated polysaccharide mixture of the present disclosure in a ratio of about 99:1 to about 95:5, about 99:1 to about 90:10, about 99:1 to about 85:15, about 99:1 to about 80:10, about 99:1 to about 75:25, about 99:1 to about 70:30, about 99:1 to about 65:35, about 99:1 to about 60:40, about 99:1 to about 55:45, about 99:1 to about 51:49, or about 99:1 to about 50:50. In some embodiments, the starch-containing material and the non-starch polysaccharide can be present in a hydrothermally treated polysaccharide mixture of the present disclosure in a ratio of about 99:1 to about 95:5.

In some embodiments, the starch-containing material and the non-starch polysaccharide can be present in a hydrothermally treated polysaccharide mixture of the present disclosure in a ratio of about 99.99:0.01 to about 0.01:99.9.

In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.99 weight percent (wt. %) to about 0.5 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 99.5 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.99 wt. % to about 50.0 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 50.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.99 wt. % to about 51.0 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 49.0 wt. % of the at least one non-starch

polysaccharide on a dry weight basis. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.5 weight percent (wt. %) to about 90.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 10.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis. In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can comprise about 99.5 weight percent (wt. %) to about 95.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 5.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis.

In accordance with some embodiments of the present disclosure, a method of preparing a hydrothermally treated polysaccharide mixture can comprise: providing an amount of at least one starch-containing material; providing an amount of at least one non-starch polysaccharide; mixing the at least one starch-containing material and the at least one non-starch polysaccharide to form a polysaccharide mixture, wherein the mixing step is performed prior to and/or during physical or hydrothermal treatment of the polysaccharide mixture; adding water to the polysaccharide mixture to form a polysaccharide mixture slurry; and heating the polysaccharide mixture slurry to form the hydrothermally treated polysaccharide mixture. In some embodiments, the adding of the water and the heating can be performed sequentially. In some embodiments, the adding of the water and heating can be done concurrently. In some embodiments, the hydrothermal treatment conditions allow or cause the at least one starch containing material to be at least partially gelatinized. In some embodiments, a further drying or concentration step can be used to dry the hydrothermally treated polysaccharide mixture to form a concentrated solution, paste or powder. In some embodiments, the mixing step is performed prior to physical or hydrothermal treatment of the polysaccharide mixture.

In some embodiments, the at least one starch-containing material is dry/non-hydrated and the at least one non-starch polysaccharide is dry/non-hydrated before mixing.

In some embodiments, the at least one starch-containing material is dispersed in water and the at least one non-starch polysaccharide is non-hydrated before mixing.

In some embodiments, the at least one starch-containing material is non-hydrated and the at least one non-starch polysaccharide is hydrated before mixing.

In some embodiments, the at least one starch-containing material is dispersed in water and the at least one non-starch polysaccharide is hydrated before mixing.

In some embodiments, the hydrothermal treatment can be performed after the mixing of the at least one-starch containing material and the at least one non-starch polysaccharide. In some embodiments, the hydrothermal treatment can be performed during the mixing of the at least one-starch containing material and the at least one non-starch containing material.

In some embodiments, more than one starch-containing material can be added. In some embodiments, more than one non-starch polysaccharide can be added.

In some embodiments, water can be added to the polysaccharide mixture to form a polysaccharide mixture slurry comprising about 10 wt. % to about 95 wt. % of water, 50 wt. % to about 90 wt.%, or about 60 wt. % to about 80 wt. % of water. In some embodiments, water can be added to the polysaccharide mixture to form a polysaccharide mixture slurry comprising about 60 wt. % to about 80 wt. % of water.

In some embodiments, the polysaccharide mixture slurry can be heated to and held at a temperature above the gelatinization temperature of the at least one starch-containing material. In some embodiments, the temperature above the gelatinization temperature can range from about 40°C to about 400°C. In some embodiments, the temperature above the gelatinization temperature can range from about 50°C to about 95°C.

In some embodiments, the physical or hydrothermal treatment allows or causes the starch-containing material to be at least partially gelatinized. In some embodiments, the physical or hydrothermal treatment allows or causes the starch-containing material to be about 1% to about 99% gelatinized.

In some embodiments, the heating step can comprise heating the polysaccharide mixture slurry in a jacketed vessel, Stephan mixer, extruder, jet steamer, high pressure processor or a combination thereof. Other means for heating the polysaccharide mixture slurry are also contemplated.

In some embodiments, the drying or concentration step can comprise spray drying, microwave drying, tray drying, drum drying or a combination thereof. Other means for drying the hydrothermally treated polysaccharide mixture are also contemplated.

In some embodiments, the hydrothermal treated polysaccharide mixture can be dried or concentrated to form a dried or concentrated hydrothermally treated polysaccharide mixture comprising about 0.1 wt. % to about 50 wt. % of water, about 1 wt. % to about 30 wt. % of water, about 10 wt. % to about 25 wt. % of water, or about 3 wt. % to about 10 wt. % of water.

In some embodiments, the heating step and drying or concentration step can be combined as a single step.

In some embodiments, the at least one non-starch polysaccharide can be added to the at least one starch-containing material after water has been added to the starch-containing material and before the heating step or during the heating step.

In some embodiments, the at least one starch-containing material can be added to the at least one non-starch polysaccharide after water has been added to the non-starch polysaccharide and before the heating step or during the heating step.

In some embodiments, the peak viscosity of a hydrothermally treated polysaccharide mixture of the present disclosure when tested using a standard Rapid Visco Analyzer (RVA) test is higher than that of the at least one starch-containing material that has been prepared or treated in the same manner but without the addition of the at least one non-starch polysaccharide by at least about 5% to at least about 170%, at least about 5% to at least about 163%, at least about 15% to at least about 163%, at least about 30% to at least about 163% with respect to peak viscosity.

In some embodiments, the final viscosity of a hydrothermally treated polysaccharide mixture of the present disclosure when tested using a standard Rapid Visco Analyzer (RVA) test is higher than that of the at least one starch-containing material that has been prepared or treated in the same manner but without the addition of the at least one non-starch polysaccharide by at least about 5% to at least about 60%, at least about 5% to at least about 58%, at least about 15% to at least about 58%, or at least about 30% to at least about 58% with respect to final viscosity.

In embodiments, the peak viscosity of a hydrothermally treated polysaccharide mixture of the present disclosure when tested using a Rapid Visco Analyzer (RVA) at a constant testing temperature between the range of about 20°C to about 40°C (e.g., about 30°C) is higher than that of the at least one starch-containing material that has been prepared or treated in the same manner but without the addition of the at least one non-starch polysaccharide by at least about 5% to at least about 150%, at least about 5% to at least about 137%, at least about 15% to at least about 137%, or at least about 30% to at least about 137% with respect to peak viscosity.

In embodiments, the final viscosity of a hydrothermally treated polysaccharide mixture of the present disclosure when tested using a Rapid Visco Analyzer (RVA) at a constant testing temperature between the range of about 20°C to about 40°C (e.g., about 30°C) is higher than that of the at least one starch-containing material that has been prepared or treated in the same manner but without the addition of the at least one non-starch polysaccharide by at least about 5% to at least about 120%, at least

about 5% to at least about 116%, at least about 15% to at least about 116%, or at least about 30% to at least about 116% with respect to final viscosity.

In some embodiments, the pasting temperature of a hydrothermally treated polysaccharide mixture of the present disclosure when tested using a standard RVA test is lower than that of the at least one starch-containing material that has been prepared or treated in the same manner but without the addition of the at least one non-starch polysaccharide by at least about 0.5°C, at least about 1°C, at least about 1.5°C or at least about 5°C.

In some embodiments, a hydrothermally treated polysaccharide mixture of the present disclosure can be used to make a food product. In some embodiments, the food product can be but is not limited to a bun, steam bun, bakery product, cake, cookie, biscuit, bread, brownie, noodles, snack, cracker, pretzel, beverage and/or dessert. In some embodiments, the food product can comprise about 0.01 wt. % to about 50 wt. % of the hydrothermally treated polysaccharide mixture, about 0.1 wt. % to about 30 wt. % of the hydrothermally treated polysaccharide mixture, or about 5 wt. % to about 20 wt. % of the hydrothermally treated polysaccharide mixture

In some embodiments, the method of preparing a hydrothermally treated polysaccharide mixture can be performed on a small scale and/or large industrial size scale.

EXAMPLES

Example 1

A hydrothermally treated polysaccharide mixture (referred to as “HTT-PSM”) was prepared in accordance with an embodiment of the present disclosure. Glutinous rice flour packaged under the brand “White Elephant” was obtained from Thai Flour Industry Co. Ltd., the country of origin being Thailand. Xanthan Gum (Versagum 200) was obtained from a local distributor of Cargill Specialty Asia, the country of origin

being China. A Stephan mixer (Stephan Universal Machine Type UMSK5, U.S.A.) was used for the preparation of the HTT-PSM.

2 kilograms of the HTT-PSM was prepared by first weighing out 1400 grams of water in the Stephan mixing bowl and heating the water to 90°C (as shown on the data logger) using indirect steam injection. A thermocouple was attached to the Stephan mixing bowl and the temperature of the components inside the Stephan mixer bowl was monitored using PicoLog recorder software.

570 grams of dry/non-hydrated glutinous rice flour (referred to as “GRF”) and 30 grams of a dry/non-hydrated non-starch polysaccharide (referred to as “NSP” and is Xanthan Gum in this case) were weighed out in a container and dry mixed using a mixer (KitchenAid, 5KSM150, U.S.A.) at speed 1 for 1 minute to form a non-hydrated or dry polysaccharide mixture. Once the temperature of the water reached 90°C, the non-hydrated or dry polysaccharide mixture was slowly added into the Stephan mixing bowl to form a polysaccharide mixture slurry. The Stephan mixing bowl was then covered with a lid and the motor of the rotating shaft was set at 510 rpm. The polysaccharide mixture slurry was then heated up to 90°C and held at 90°C for 30 minutes to form the hydrothermally treated polysaccharide mixture (HTT-PSM). The HTT-PSM comprised 1.5% by weight of the non-starch polysaccharide (NSP), 28.5% by weight of glutinous rice flour (GRF) and 70% by weight of water.

The HTT-PSM was subsequently thinly spread onto a plastic liner and dried in a tray dehydrator set at 60°C for approximately 24 hours to form a dried HTT-PSM. The dried HTT-PSM was then broken down into smaller pieces and grinded into a powder before storage and characterization.

The dried HTT-PSM was comprised of the non-starch polysaccharide (NSP) and the glutinous rice flour (GRF) at a ratio of 5 : 95. The moisture content of the dried HTT-PSM ranged from 10 wt. % to 14 wt. %.

For RVA testing, the amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and the sample mass basis used was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added.

Comparative Example 1

A non-hydrated native glutinous rice flour (referred to as “NGRF”) was used as Comparative Example 1. The glutinous rice flour packaged under the brand “White Elephant” and obtained from Thai Flour Industry Co. Ltd. was used as the NGRF. The moisture content of the NGRF was about 13.35 wt. %. The NGRF was provided and/or prepared in powder form for characterization purposes.

For RVA testing, the amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and the sample mass basis used was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added.

Comparative Example 2

A hydrothermally treated glutinous rice flour (referred to as “HTT-GRF”) was prepared as Comparative Example 2. Glutinous rice flour packaged under the brand “White Elephant” was obtained from Thai Flour Industry Co. Ltd. A Stephan mixer (Stephan Universal Machine Type UMSK5, U.S.A.) was used for the preparation of the HTT-GRF.

2 kilograms of the HTT-GRF was prepared by first weighing out 1400 grams of water in the Stephan mixing bowl and heating the water to 90°C (as shown on the data logger) using indirect steam injection. A thermocouple was attached to the Stephan mixing bowl and the temperature of the components inside the Stephan mixer bowl was monitored using PicoLog recorder software.

600 grams of dry/non-hydrated glutinous rice flour (referred to as “GRF”) was weighed out in a container and once the temperature of the water reached 90°C, the dry/non-hydrated GRF was slowly added into the Stephan mixing bowl to form a glutinous rice flour slurry. The Stephan mixing bowl was then covered with a lid and the motor of the rotating shaft was set at 510 rpm. The glutinous rice flour slurry was then heated up to 90°C and held at 90°C for 30 minutes to form the hydrothermally treated glutinous rice flour (HTT-GRF). The HTT-GRF comprised 30% by weight of glutinous rice flour (GRF) and 70% by weight of water. The HTT-GRF did not comprise a non-starch polysaccharide (NSP).

The HTT-GRF was subsequently thinly spread onto a plastic liner and dried in a tray dehydrator set at 60°C for approximately 24 hours to form a dried HTT-GRF. The dried HTT-GRF was then broken down into smaller pieces and grinded into a powder before storage and characterization.

The dried HTT-GRF comprised of the non-starch polysaccharide (NSP) and the glutinous rice flour (GRF) at a ratio of 0 : 100. The moisture content of dried HTT-GRF ranged from 10 wt. % to 14 wt. %.

For RVA testing, the amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and the sample mass basis used was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added.

Comparative Example 3

A Comparative Example 3 comprising the dried HTT-GRF of Comparative Example 2 dry mixed with a non-hydrated, non-treated non-starch polysaccharide (referred to as “non-treated NSP” and is non-treated Xanthan Gum in this case) was prepared and referred to as “HTT-PSM-DM”. Xanthan Gum (Versagum 200) was used as the non-treated Xanthan gum.

The HTT-PSM-DM Comparative Example 3 was prepared in a bulk amount of 100 grams by dry mixing 5 grams of the non-hydrated, non-treated NSP with 95 grams of the dried HTT-GRF using a mixer (KitchenAid, 5KSM150, U.S.A.) at speed 1 for 1 minute. The HTT-PSM-DM comprised of the non-hydrated, non-treated NSP and the dried HTT-GRF at a ratio of 5 : 95. The HTT-PSM-DM had a moisture content of 10 wt. % to 14 wt. %. The HTT-PSM-DM was prepared in powder form for storage and characterization purposes.

For RVA testing, the amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and sample mass basis was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added. For example, 3 grams of HTT-PSM-DM with a moisture content of 14 wt. % was weighed out in a canister before addition of 25ml of water for RVA testing.

Comparative Example 4

A Comparative Example 4 comprising the NGRF of Comparative Example 1 dry mixed with a non-hydrated, non-treated non-starch polysaccharide (referred to as “non-treated NSP” and is non-treated Xanthan Gum in this case) was prepared and referred to as “NGRF-PSM-DM”. The NGRF-PSM-DM sample was prepared in a bulk amount of 100 grams by dry mixing 5 grams of the non-hydrated, non-treated NSP with 95 grams of the NGRF using a mixer (KitchenAid, 5KSM150, U.S.A.) at speed 1 for 1 minute. The NGRF-PSM-DM comprised of the non-hydrated, non-treated NSP and the NGRF at a ratio of 5 : 95. The NGRF-PSM-DM was prepared in powder form for storage and characterization purposes.

For RVA testing, the amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and sample mass basis was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added. For example, 3 grams of NGRF-PSM-DM with a moisture

basis of 14 wt. % was weighed out in a canister before addition of 25ml of water for RVA testing.

Comparative Example 5

A 0.5% Xanthan Gum solution (referred to as “XG”) was used as Comparative Example 5. Xanthan Gum (Versagum 200) was used to prepare the 0.5% Xanthan Gum solution). The concentration of Xanthan Gum in the 0.5% Xanthan Gum solution is equivalent to the concentration of Xanthan Gum present in the HTT-PSM, HTT-PSM-DM and NGRF-PSM-DM upon addition of water when prepared for RVA analysis. 0.14 grams of XG was weighed in a RVA canister and hydrated in 27.86 grams of water for RVA analysis. The XG was characterized in solution form.

The sample of HTT-PSM of Example 1, the sample of HTT-PSM-DM of Comparative Example 3, and the sample of NGRF-PSM-DM of Comparative Example 4 to be used for characterization purposes each contained the same amount of non-starch polysaccharide (NSP) or Xanthan Gum (e.g., 5% by weight of NSP or Xanthan Gum on a dry weight basis).

CHARACTERIZATION OF THE EXAMPLES

The viscosity profiles and pasting properties of Example 1 and Comparative Examples 1-5 were tested using a Rapid Visco Analyzer (RVA) (Newport Scientific Pte. Ltd., model no. RVA-4, Australia). As illustrated in **Table 1**, Example 1 and Comparative Examples 1-5 were tested using a standard temperature profile and a constant temperature profile.

Table 1. Standard temperature profile and constant temperature profile details

Time (Hr:Min:Sec)	Type	Standard Temperature Profile	Constant Temperature Profile
		Value	
00:00:00	Temperature	15°C	30°C
00:00:00	Speed	960 rpm	960 rpm
00:00:10	Speed	160rpm	160 rpm
00:02:00	Temperature	15°C	30°C
00:07:43	Temperature	95°C	30°C
00:10:00	Temperature	95°C	30°C
00:13:56	Temperature	45°C	30°C

Standard temperature profile testing

The viscosity profiles and pasting properties of Example 1 and Comparative Examples 1-5 tested under the standard Rapid Visco Analyzer (RVA) test protocol are shown in **Figure 2** and **Table 2**, respectively. The amount of sample and water added were corrected for the sample moisture content to give a constant dry weight. The moisture basis used was 14 wt. % and the sample mass basis used was 3 grams. Based on a 14 wt. % moisture basis, 25 ml of water was added.

Correction formula for 14 wt. % moisture content:

$$M_2 = (100 - 14) \times M_1 / (100 - W_1)$$

$$W_2 = 25.0 + (M_1 - M_2)$$

Where M_1 = sample mass for the material (3g basis was used)

M_2 = corrected sample mass (g)

W_1 = actual moisture content of sample (wt. %)

W_2 = corrected water volume (ml)

The examples tested using a standard temperature profile included the following:

<u>Abbreviated Title</u>	<u>Description</u>
1. NGRF:	Native glutinous rice flour (Comparative Example 1);
2. HTT-GRF:	Hydrothermally treated glutinous rice flour (Comparative Example 2);
3. HTT-PSM:	Hydrothermally treated glutinous rice four in the presence of 5 % (dry wt.) NSP (Example 1);
4. HTT-PSM-DM:	Dry mix of 5 % (dry wt.) of non-treated NSP with 95 % (dry wt.) of HTT-GRF (Comparative Example 3);
5. NGRF-PSM-DM :	Dry mix of 5 wt. % of non-treated NSP with 95 wt. % of NGRF (Comparative Example 4); and
6. XG:	0.5% Xanthan gum solution (Comparative Example 5)

Pasting Properties

The pasting properties of NGRF (Comparative Example 1), HTT-GRF (Comparative Example 2), HTT-PSM (Example 1), HTT-PSM-DM (Comparative Example 3), NGRF-PSM-DM (Comparative Example 4), and XG (Comparative Example 5) tested under the standard RVA test protocol are shown in **Table 2**.

Table 2. Pasting properties of NGRF, HTT-GRF, HTT-PSM, HTT-PSM-DM, NGRF-PSM-DM, and XG tested using a standard temperature profile

Sample Name	Peak viscosity (cP)	Final Viscosity (cP)	Peak Time (min)	Pasting Temp (°C)	Peak Temp (°C)
NGRF	5091 ± 16	3392 ± 8	6.9 ± 0.0	67.4 ± 0.0	83.2 ± 0.0
HTT-GRF	2731 ± 175	880 ± 5	4.3 ± 0.1	16.4 ± 1.3	46.9 ± 1.4
HTT-PSM	7197 ± 286	1396 ± 23	4.5 ± 0.4	15.3 ± 0.0	49.6 ± 6.0
HTT-PSM-DM	1240 ± 192	1976 ± 174	6.7 ± 0.0	15.5 ± 0.1	81.3 ± 0.0
NGRF-PSM-DM	4587 ± 356	3733 ± 231	7.9 ± 0.0	79.9 ± 0.7	94.8 ± 0.3
XG	193 ± 6	158 ± 8	2.77 ± 0.1	---	---

Figure 2 illustrates a plot of viscosity (cP) against time (min) for NGRF (Comparative Example 1), HTT-GRF (Comparative Example 2), HTT-PSM (Example 1), HTT-PSM-DM (Comparative Example 3), NGRF-PSM-DM (Comparative Example 4), and XG (Comparative Example 5) tested using a standard temperature profile.

As shown in **Figure 2** and **Table 2**, NGRF (Comparative Example 1) exhibited a delayed pasting characteristic that occurred only at about 83.2°C and with a peak viscosity of about 5091 cP. At such a high temperature of 83.2°C, NGRF was undergoing a cooking process where the starch was just starting to gelatinize under the conditions of excess water and a temperature above the gelatinization temperature.

As shown in **Figure 2** and **Table 2**, HTT-GRF (Comparative Example 2) exhibited a reduced pasting temperature of 16.4°C as compared to NGRF with a pasting temperature of 67.4°C.

2 kilograms of the HTT-PSM (Example 1) was prepared by first weighing out 1400 grams of water in the Stephan mixing bowl and heating the water to 90°C. 570 grams of dry/non-hydrated GRF and 30 grams of a dry/non-hydrated NSP (Xanthan Gum in this case) were dry mixed to form a non-hydrated or dry polysaccharide mixture. The non-hydrated or dry polysaccharide mixture was slowly added into the Stephan mixing bowl to form a polysaccharide mixture slurry, which was then heated up to 90°C and held at 90°C for 30 minutes to form the HTT-PSM. The HTT-PSM comprised 1.5% by weight of the Xanthan Gum, 28.5% by weight of GRF and 70% by weight of water. The dried HTT-PSM comprised of the Xanthan Gum and the GRF at a ratio of 5 : 95. The moisture content of the dried HTT-PSM ranged from 10 wt. % to 14 wt. %.

The pasting curves from **Figure 2** and pasting properties from **Table 2** illustrate that when the NSP was hydrated and hydrothermally treated with the GRF, the peak viscosity of the resulting HTT-PSM product was further increased by 41 % (as compared to NGRF) to 7197 cP and the pasting temperature was reduced to 15.3°C. The hydrophilic nature of hydrocolloids or non-starch polysaccharides (NPS) increases

water retention and consequently has a significant influence on starch swelling thus resulting in a higher viscosity.

In current food applications known in the art, dry/non-hydrated non-starch polysaccharides (NSP) in an amount of up to about 5% by weight (on a dry weight basis) are commonly incorporated into solid starch food systems. As explained above under Comparative Example 3, 5.0 wt. % of a non-treated NSP (in this case non-treated Xanthan Gum) was dry mixed with 95 wt. % of dried HTT-GRF of Comparative Example 2 on a dry weight basis to prepare the HTT-PSM-DM. As shown in **Figure 2** and **Table 2**, the pasting property of the HTT-PSM-DM comprising 95 wt. % of HTT-GRF dry mixed with 5 wt. % of non-treated NSP was determined. The peak viscosity of HTT-PSM-DM was lower than that of HTT-GRF with a value of about 1240 cP. The peak time of 6.7 minutes was also longer than HTT-GRF and HTT-PSM. The delay in viscosity pick-up was thought to be hindered by the non-treated NSP component, which is more hydrophilic than the HTT-GRF component of the HTT-PSM-DM. The non-treated NSP having a more hydrophilic nature took up the majority of the water thus resulting in the postponement of the HTT-GRF component of the HTT-PSM-DM in displaying its cold-swelling properties.

In Comparative Example 4, 5.0 wt. % of a non-treated NSP (in this case Xanthan Gum) was dry mixed with 95 wt. % of NGRF of Comparative Example 1 on a dry weight basis to prepare the NGRF-PSM-DM, which was subsequently put through RVA testing. This sample was prepared to simulate current food applications where a NSP is added to native flours in dried forms. The concentration of the NSP in the NGRF-PSM-DM was the same as the concentration of the NSP in the HTT-PSM and HTT-PSM-DM.

As shown in **Figure 2** and **Table 2**, the pasting curve of NGRF-PSM-DM was similar to that of NGRF but with a higher viscosity at temperature before pasting. The higher viscosity was contributed by the presence of XG. As compared to NGRF, the NGRF-PSM-DM sample had a lower peak viscosity of 4587 cP, higher peak time of 7.9 minutes, higher pasting and peak temperature of 79.9°C and 94.8°C respectively. These results indicate that a NSP incorporated in a dry mix had no significant effect in

improving pasting properties. As demonstrated by the results of HTT-PSM testing, the synergistic effect of NSP was only observed when it was hydrothermally treated with GRF under certain processing conditions, in this case, a 70% water composition and heating at 90°C for 30 minutes.

A 0.5% Xanthan Gum solution was used as Comparative Example 5. The 0.5% Xanthan Gum solution calculated to comprise an equivalent amount of NSP (in this case Xanthan Gum) as that present in the HTT-PSM, HTT-PSM-DM, and NGRF-PSM-DM for RVA testing was also tested. As shown in **Figure 2** and **Table 2**, the viscosity of the 0.5% Xanthan Gum solution was very low throughout the entire standard temperature profile with the peak viscosity reaching only about 193 cP.

Constant temperature profile testing

Example 1 and Comparative Examples 1-5 were put through RVA testing at a constant temperature profile to simulate food preparation at room temperature. The viscosity profiles and pasting properties of Example 1 and Comparative Examples 1-5 tested under the RVA test protocol at a constant temperature are shown in **Figure 3** and **Table 3**, respectively.

The examples tested at a constant temperature profile include the following:

<u>Abbreviated Title</u>	<u>Description</u>
1. NGRF:	Native glutinous rice flour (Comparative Example 1);
2. HTT-GRF:	Hydrothermally treated glutinous rice flour (Comparative Example 2);
3. HTT-PSM:	Hydrothermally treated glutinous rice flour in the presence of 1.5 wt.% NSP (Example 1);
4. HTT-PSM-DM:	Dry mixing 1.5 wt.% of non-treated NSP with 98.5 wt.% of HTT-GRF (Comparative Example 3);
5. NGRF-PSM-DM :	Dry mix of 5 wt. % of non-treated NSP with 95 wt. % of

- NGRF (Comparative Example 4); and
6. XG: 0.5% Xanthan gum solution (Comparative Example 5)

Pasting Properties

The pasting properties of NGRF (Comparative Example 1), HTT-GRF (Comparative Example 2), HTT-PSM (Example 1), HTT-PSM-DM (Comparative Example 3), NGRF-PSM-DM (Comparative Example 4), and XG (Comparative Example 5) tested under the RVA test protocol using a constant temperature profile are shown in **Table 3**.

Table 3. Pasting properties of NGRF, HTT-GRF, HTT-PSM, HTT-PSM-DM, NGRF-PSM-DM, and XG tested at a constant temperature profile.

Sample Name	Peak viscosity (cP)	Final Viscosity (cP)	Peak Time (mins)
NGRF	41 ± 7.1	21 ± 1.4	3.6 ± 1.6
HTT-GRF	2905 ± 173	1178 ± 26.2	2.2 ± 0.2
HTT-PSM	6907 ± 153	2545 ± 2.1	3.0 ± 0.7
HTT-PSM-DM	2551 ^a	2500 ^a	10.9 ^a
NGRF-PSM-DM	857 ± 6.4	619 ± 16.3	2.4 ± 0.2
XG	191 ± 1.4	178 ± 1.4	6.44 ± 0.3

^a RVA analysis of HTT-PSM-DM was conducted with only 1 replicate.

Figure 3 illustrates a plot of viscosity (cP) against time (min) for NGRF (Comparative Example 1), HTT-GRF (Comparative Example 2), HTT-PSM (Example 1), HTT-PSM-DM (Comparative Example 3), NGRF-PSM-DM (Comparative Example 4), and XG (Comparative Example 5) tested using a constant temperature profile.

Referring to **Figure 3** and **Table 3**, NGRF (Comparative Example 1) exhibited a very low and constant viscosity of about 41 cP and failed to exhibit cold-swelling properties; thus, NGRF is generally not useful for food application at room temperature. Similar to the standard temperature profile, HTT-PSM exhibited the highest peak viscosity of about 6907 cP followed by HTT-GRF, which exhibited a peak viscosity of about 2905 cP. With the ability to achieve such high viscosities (e.g., about 6907 cP and about

2905 cP) at a constant temperature of 30°C, the results indicated that HTT-PSM and HTT-GRF had cold-swelling properties and thus could serve as a potential ingredient to improve the viscosity of food products prepared at room temperature.

In contrast, as shown in **Figure 3** and **Table 3**, HTT-PSM-DM exhibited a steady incremental increase in viscosity over a long period of time while NGRF-PSM-DM exhibited a pasting curve similar to that of NGRF, except with a higher viscosity of 857 cP, as contributed by the presence of an NSP (in this case Xanthan Gum). The results for both HTT-PSM-DM and NGRF-PSM-DM showed that the incorporation of an NSP in a dry mix had no significant effect on pasting properties. Rather, as shown in **Figure 3** and **Table 3**, an improvement in pasting properties was only observed when an NSP was hydrothermally treated with GRF as was done to prepare the HTT-PSM.

As shown in **Figure 3** and **Table 3**, the 0.5% Xanthan Gum solution exhibited a low and constant viscosity similar to the viscosity observed for the standard temperature profile.

APPLICATION

The hydrothermally treated polysaccharide mixtures (HTT-PSMs) of the present disclosure can be used as replacements or substitutions for food ingredients such as chemically modified starches, physically modified starches and hydrocolloids to provide for improved or easier processing of food products and to provide for improved textural properties for food products.

The feasibility and effectiveness of using the hydrothermally treated polysaccharide mixtures (HTT-PSMs) of the present disclosure were tested with respect to the effect on processing of food products and the effect on the textural properties of food products. Gluten-free rice dough and gluten-free rice crackers were prepared to test the feasibility and effectiveness of using the hydrothermally treated polysaccharide mixtures (HTT-PSMs) of the present disclosure.

Improvement in the processing of gluten-free food products (e.g., gluten-free rice dough for application in making noodles)

Figure 4 shows three different types of gluten-free dough prepared from: (a) 100 wt. % rice flour on a dry weight basis; (b) 100 wt. % glutinous rice flour on a dry weight basis; and (c) 20 wt. % of HTT-PSM (Example 1) and 80 wt. % rice flour on a dry weight basis. Dough sample (a) was prepared by weighing 10 grams of rice flour out in a container and mixing in 6.5 grams of water to hydrate the rice flour. Dough sample (b) was prepared by weighing 10 grams of glutinous rice flour out in a container and mixing in 6.5 grams of water to hydrate the glutinous rice flour. Dough sample (c) was prepared by dry mixing 8 grams of rice flour with 2 grams of HTT-PSM (Example 1) and mixing in 6 grams of water to hydrate the rice flour and HTT-PSM dry mix. The three different types of dough were compared before pressing and after pressing to serve as a simulation for processes where dough is pressed and sheeted as in the case of noodles.

As shown in **Figure 4**, the dough made from rice flour and the dough made from glutinous rice were brittle and were not able to be sheeted as the dough structures fell apart upon pressing due to the lack of a gluten network. The absence of gluten in the dough resulted in the dough not being extensible. Thus, sheeting of the dough to make noodles was not noodle possible.

Further, as clearly shown in **Figure 4**, when rice flour was substituted with HTT-PSM at 20 wt. %, soft dough was formed. The soft dough was able to be pressed and kneaded without the dough structure falling apart. Moreover, sheeting of the gluten-free dough was also possible.

Improvement in the textural properties of gluten-free food products (e.g., rice crackers)

Rice Cracker	(a) without HTT-PSM	(b) with HTT-PSM
Ingredients	Weight (g)	Weight (g)
Rice Flour	27.07	21.65
HTT-PSM	-	5.41
Baking Powder	1.50	1.50
Water	18.05	18.05
Oil	2.26	2.26
Sesame Oil	0.75	0.75
Salt	0.38	0.38
Total	50.00	50.00

A first gluten-free rice dough was prepared using 100 wt. % rice flour on a dry weight basis. A second gluten-free rice dough was prepared using 20 wt. % of HTT-PSM (Example 1) and 80 wt. % rice flour on a dry weight basis (Bakers' percentage). The two different types of dough were used to make rice crackers.

Due to the absence of a gluten network, the first gluten-free rice dough made from 100 wt. % rice flour was not able to trap air bubbles; thus, the baked rice cracker was compact and hard. As a result, the baked rice cracker would need to show an improvement in terms of the appearance and hardness in order to gain consumer acceptance.

As mentioned above, for the second gluten-free dough, the rice flour was partially substituted with 20 wt. % of HTT-PSM (Baker's percentage). As a result, the processing and handling of the second gluten free rice dough was much easier in comparison to the first gluten free rice dough.

Figure 5 shows a photo of the gluten-free rice cracker made from (a) the rice flour (top photo) and a gluten-free rice cracker made from (b) the rice flour substituted with 20 wt. % HTT-PSM (bottom photo).

As shown in **Figure 5**, the baked rice crackers made from the rice flour substituted with 20 wt. % HTT-PSM had noticeable improvements in terms of appearance and textural properties. As shown in **Figure 5**, the rice crackers incorporated with HTT-PSM (see **Figure 5(b)**) appeared to be puffier and about 2 to 3 times larger in terms of height or thickness compared with rice crackers made from rice flour alone (see **Figure 5(a)**). The air cells present in the rice cracker incorporated with HTT-PSM made the rice cracker less compact and less hard when biting the rice cracker. Consumer acceptance was thus significantly improved by the partial substitution of rice flour with HTT-PSM.

In embodiments, the hydrothermally treated polysaccharide mixtures (HTT-PSMs) of the present disclosure can be used to solve or ameliorate problems or issues present in gluten-free products. In embodiments, the hydrothermally treated polysaccharide mixtures (HTT-PSMs) of the present disclosure can be used as a key ingredient in the gluten-free food product category and/or low gluten content food product category.

The hydrothermally treated polysaccharide mixtures of the present disclosure can be used in the food industry as food ingredients to provide for easier processing of food products. For example, the hydrothermally treated polysaccharide mixtures of the present disclosure can be used to provide for easier handling of dough in gluten-free products and/or easier handling of dough in products low in gluten content. The hydrothermally treated polysaccharide mixtures of the present disclosure can be used in the food industry as food ingredients to improve the textural properties of food products. The hydrothermally treated polysaccharide mixtures of the present disclosure can also be used as thickeners, gelling agents, stabilizers and/or emulsifiers. The hydrothermally treated polysaccharide mixtures of the present disclosure can be used in the food industry as a replacement or substitute food ingredient for native starches, modified starches and/or hydrocolloids.

The present disclosure is relates to the physical modification of starches. Hydrothermal treatment can modify the properties of a starch to generate a different functionality suitable for use in food products. The present disclosure relates to the

incorporation of a non-starch polysaccharide(s) during the hydrothermal treatment of the starch or starches. The incorporation of the non-starch polysaccharide(s) during the hydrothermal treatment of the starch or starches results in a novel and inventive physically modified starch (e.g., the HTT-PSM of Example 1) having improved functionality and/or a novel and inventive non-starch polysaccharide (e.g., the HTT-PSM of Example 1) having improved functionality.

While various aspects and embodiments have been disclosed herein, it will be apparent that various other modifications and adaptations of the invention will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the invention and it is intended that all such modifications and adaptations come within the scope of the appended claims. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit of the invention being indicated by the appended claims.

CLAIMS

We Claim:

1. A compound comprising:
 - a hydrothermally treated polysaccharide mixture, wherein the hydrothermally treated polysaccharide mixture comprises:
 - at least one hydrothermally treated starch-containing material; and
 - at least one hydrothermally treated non-starch polysaccharide.
2. The compound of claim 1, wherein the hydrothermally treated polysaccharide mixture comprises about 99.99 wt. % to about 0.5 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 99.5 wt. % of the at least one non-starch polysaccharide on a dry weight basis.
3. The compound of claim 1 or 2, wherein the hydrothermally treated polysaccharide mixture comprises about 99.99 wt. % to about 50.0 wt. % of the at least one starch-containing material and about 0.01 wt. % to about 50.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis.
4. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture of the present disclosure comprises about 99.5 wt. % to about 90.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 10.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis.
5. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises about 99.5 wt. % to about 95.0 wt. % of the at least one starch-containing material and about 0.5 wt. % to about 5.0 wt. % of the at least one non-starch polysaccharide on a dry weight basis.

6. The compound of any one of the preceding claims, wherein the at least one starch-containing material is selected from the group consisting of starch, starch-containing particles, pure starch, potato starch, wheat starch, maize starch, corn starch, rice starch, cassava starch, acorn starch, arrowroot starch, arracacha starch, banana starch, barley starch, breadfruit starch, buckwheat starch, canna starch, colacasia starch, katakuri starch, kudzu starch, malanga starch, millet starch, oat starch, oca starch, polynesian arrowroot starch, sago starch, sorghum starch, sweet potato starch, rye starch, taro starch, chestnut starch, water chestnut starch, yam starch, bean starch, favas starch, lentil starch, chickpea starch, mung bean starch, tapioca starch, soy starch, potatoes, wheat, maize, corn, rice, cassava, acorns, arrowroots, arracacha, bananas, barley, breadfruit, buckwheat, canna, colacasia, katakuri, kudzu, malanga, millet, oats, oca, polynesian arrowroots, sago, sorghum, sweet potatoes, rye, taro, beans, favas, lentils, peas, chickpeas, mung beans, tapioca, starch granules, flour granules, dough made from flour, a slurry made from flour, starch-containing grains, a starch-containing food, a derivative thereof and a combination thereof.

7. The compound of any one of the preceding claims, wherein the non-starch polysaccharide is selected from the group consisting of a hydrocolloid, cellulose, a hemicellulose, a gum, a pectin, a xylan, a mannan, a glucan, a mucilage, an alginate, an arabinoxylan, a beta-glucan, a chitin, carrageenan, gellan, guar, inulin, lignin, xanthan, chitosan, a derivative thereof and a combination thereof.

8. The compound of any one of the preceding claims, wherein the at least one non-starch polysaccharide comprises at least one gelling non-starch polysaccharide, wherein the at least one gelling non-starch polysaccharide is selected from the group consisting of an alginate, carrageenan, pectin, a derivative thereof and a combination thereof.

9. The compound of any one of the preceding claims, wherein the at least one non-starch polysaccharide comprises at least one non-gelling non-starch polysaccharide, wherein the at least one non-gelling non-starch polysaccharide is selected from the group consisting of xanthan gum, guar gum, chitosan, a derivative thereof and a combination thereof.

10. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises cross-linking ions selected from the group consisting of calcium cations, magnesium cations, sodium cations, potassium cations and a combination thereof.
11. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises cross-linking ions in an amount of about 0.01 wt. % to about 5 wt. % on a dry weight basis.
12. The compound of any one of the preceding claims, wherein the at least one hydrothermally treated starch-containing material is at least partially gelatinized.
13. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises a peak viscosity higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least about 5%, at least about 15%, or at least about 30% when tested using a standard Rapid Visco Analyzer (RVA) test.
14. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises a final viscosity higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least about 5%, at least about 15% or at least about 30% when tested using a standard Rapid Visco Analyzer (RVA) test.
15. The compound any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises a peak viscosity higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least about 5%, at least about 15% or at least about 30% when testing using RVA at a constant testing temperature between the range of 20-40°C.

16. The compound any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises a final viscosity higher than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least about 5%, at least about 15% or at least about 30% when testing using RVA at a constant testing temperature between the range of 20-40°C.
17. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture comprises a pasting temperature that is lower than that of the at least one starch-containing material that has been treated in the same manner as the hydrothermally treated polysaccharide mixture but without the addition of the at least one non-starch polysaccharide by at least 1°C when tested using RVA.
18. The compound of any one of the preceding claims, wherein the hydrothermally treated polysaccharide mixture is selected from the group consisting of a food ingredient, thickener, gelling material, stabilizer, emulsifier and a combination thereof.
19. A method of preparing a hydrothermally treated polysaccharide mixture, comprising:
providing an amount of at least one starch-containing material;
providing an amount of at least one non-starch polysaccharide; and
mixing the at least one starch-containing material and the at least one non-starch polysaccharide to form a polysaccharide mixture, wherein the mixing step is performed prior to or during hydrothermal treatment of the polysaccharide mixture.
20. The method of claim 19, wherein the method comprises:
adding an amount of water to the polysaccharide mixture to form a polysaccharide mixture slurry; and
heating the polysaccharide mixture slurry to form the hydrothermally treated polysaccharide mixture.

21. The method of claim 19, wherein the method comprises:
adding an amount of water to the polysaccharide mixture to form a polysaccharide mixture slurry; and
heating the polysaccharide mixture slurry to form the hydrothermally treated polysaccharide mixture;
wherein the adding of the water and the heating are performed concurrently.
22. The method of any one of claims 19-21, wherein the at least one starch-containing material and the at least one non-starch polysaccharide are non-hydrated before the mixing step.
23. The method of any one of claims 20-22, wherein the polysaccharide slurry comprises water in an amount selected from the group consisting of about 10 wt. % to about 95 wt.%, about 50 wt. % to about 90 wt. %, and about 60 wt. % to about 80 wt. %.
24. The method of any one of claims 20-23, wherein the heating step comprises heating the polysaccharide mixture slurry to a temperature above the gelatinization temperature of the at least one starch-containing material, and wherein the polysaccharide mixture slurry is held at the temperature above the gelatinization temperature.
25. The method of claim 24, wherein the temperature above the gelatinization temperature of the at least one starch-containing material is about 40°C to about 400°C.
26. The method of claim 24 or 25, wherein the temperature above the gelatinization temperature of the at least one starch-containing material is about 50°C to about 95°C.
27. The method of anyone of claims 24-26, further comprising: at least partially gelatinizing the at least one starch-containing material.
28. The method of claim 27, wherein the at least one starch-containing material is about 1% to about 99% gelatinized.

29. The method of any one of claims 19-28, wherein no chemical modification steps are used and wherein the hydrothermally treated polysaccharide mixture is physically functionalized.

30. The method of any one of claims 20-29, wherein the heating step comprises heating the polysaccharide mixture slurry using a heating apparatus selected from the group consisting of a jacketed vessel, Stephan mixer, extruder, jet steamer, high pressure processor and a combination thereof.

31. The method of any one of claims 19-30, further comprising drying the hydrothermally treated polysaccharide mixture to form a dried hydrothermally treated polysaccharide mixture selected from the group consisting of a concentrated solution, paste and powder.

32. The method of claim 31, wherein the drying step is performed using a drying method selected the group consisting of spray drying, microwave drying, tray drying, drum drying and a combination thereof.

33. The method of claim 31 or 32, wherein the dried hydrothermally treated polysaccharide mixture comprises an amount of water selected from the group consisting of about 0.1 wt. % to about 50 wt. % of water, about 1 wt. % to about 30 wt. % of water, about 10 wt. % to about 25 wt. % of water, and about 3 wt. % to about 10 wt. % of water.

34. The method of any one of claims 33, wherein the heating step and drying step can be combined as a single step.

35. The method of claim 19, wherein the method comprises adding the at least one non-starch polysaccharide to the at least one starch-containing material after an amount of water has been added to the starch-containing material and while performing a heating step.

36. The method of claim 19, wherein the method comprises adding the at least one starch-containing material to the at least one non-starch polysaccharide after an amount of water has been added to the non-starch polysaccharide and while performing a heating step.

37. A hydrothermally treated polysaccharide mixture prepared by the method of any one of claims 19-36.

38. A food ingredient comprising: the hydrothermally treated polysaccharide mixture of any one of claims 1-18.

39. A food ingredient comprising: the hydrothermally treated polysaccharide mixture of any one of claims 19-36.

40. A food product comprising the hydrothermally treated polysaccharide mixture of any one of claims 1-18.

41. A food product comprising the hydrothermally treated polysaccharide mixture of any one of claims 19-36.