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(57) Abstract: The present invention relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising providing a plant protein suspension; optionally adding oil to the suspension and mixing to form an emulsion; ensuring the pH of the suspension or emulsion is between pH 5 to 10, preferably between 7 to 9; adding a firming agent and mixing; optionally performing a cold set gelation at between 0 to 30°C; and performing a freezing step.



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Hard-boiled egg analogue product

Introduction

Demand for plant-based alternatives to animal products has grown significantly across many food categories and applications. Just as plant-based alternatives for meat and dairy products are becoming mainstream, consumers are also becoming more interested in egg-like substitutes.

The trend for these products has been driven by many factors including allergenicity, sustainability, animal welfare, and a consumer shift towards more “flexitarian” diets.

Over the last decade, several companies have developed commercial versions of egg replacers. These kinds of products are typically sold as powders to be reconstituted in water and subsequently cooked, or in liquid format for cooking applications.

The offer for ready to eat egg analogs is highly undeveloped. The products are characterized by a poor nutritional value compared to the animal counterpart they intend to replace, for example lower in protein content, higher in carbohydrate, and higher in sodium. They also have a long ingredient list and fail to convince consumers from a sensorial perspective.

Summary of invention

The present invention is a superior vegan alternative to hard-boiled egg. The overall sensorial performance is greatly improved compared to prior art products. The product is a suspension and/or an emulsion based on legume protein, preferably soy isolate, vegetable oil, firming agent and water. The product undergoes a series of temperature steps and treatments, including cold-set gelation, heating and/or freezing which provide it with superior taste, appearance, and texture.

Brief description of the figures

Figure 1. Hardness score expressed relatively to cooked chicken egg yolk considering the following parameters: system, pH, firming agent and its concentration.

Figure 2. Hardness score expressed relatively to cooked chicken egg white considering the following parameters: system, pH, firming agent and its concentration.

5 Figure 3. Hardness score expressed relatively to cooked chicken egg mix considering the following parameters: system, pH, firming agent and its concentration.

Figure 4. Hardness score expressed relatively to cooked chicken egg yolk, egg white and egg mix for suspension samples without the cold set gelation step and considering the following parameters: pH, firming agent and its concentration.

10 Figure 5. Sensory scores for firm, pieces, compact and chewy attributes, expressed relatively to egg yolk considering the following parameters: system, pH, firming agent and its concentration.

Figure 6. Sensory firmness attribute score, expressed relatively to egg yolk, of four different recipes demonstrating the effect of firming agent addition (recipes 5 and 10) versus no addition of firming agent (recipes 3 and 8).

15 Figure 7. Sensory scores for firm, pieces, compact and chewy attributes, expressed relatively to egg white considering the following parameters: system, pH, firming agent and its concentration.

Figure 8. Sensory firmness attribute score, expressed relatively to egg white, of four different recipes demonstrating the effect of firming agent addition (recipes 4 and 10) versus no addition of firming agent (recipes 2 and 8).

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Embodiments of the invention

The invention relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product. The hard-boiled egg analogue product may be an egg white analogue, or an egg yolk analogue, or an egg mix analogue product.

The invention further relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising providing a plant protein suspension; ensuring the pH of the suspension is between pH 5 to 10; adding a firming agent and mixing; optionally performing a cold set gelation; and performing a freezing step.

- 5 The invention further relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising providing a plant protein suspension; adding oil to the suspension and mixing to form an emulsion; ensuring the pH of the emulsion is between pH 5 to 10; adding a firming agent and mixing; optionally performing a cold set gelation; and performing a freezing step.
- 10 The invention relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising providing a plant protein suspension; ensuring the pH of the suspension or emulsion is between pH 5 to 10, preferably between 7 to 9; adding a firming agent and mixing; optionally performing a cold set gelation at between 0 to 30°C to form a gel; and performing a freezing step to modulate the gel strength.
- 15 The invention relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising providing a plant protein suspension; adding oil to the suspension and mixing to form an emulsion; ensuring the pH of the suspension or emulsion is between pH 5 to 10, preferably between 7 to 9; adding a firming agent and mixing; optionally performing a cold set gelation at between 0 to 30°C to form a gel; and
- 20 performing a freezing step to modulate the gel strength.

The invention relates to a method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising: a) providing a plant protein suspension; b) optionally adding oil to the suspension and mixing to form an emulsion; c) ensuring the pH of the suspension or emulsion is between pH 5 to 10, preferably between 7 to

25 9; d) adding a firming agent and mixing; e) optionally performing a cold set gelation at between 0 to 30°C to form a gel; f) performing a freezing step to modulate the gel strength.

In one embodiment, the plant protein suspension in step a) is a legume protein suspension. The legume protein suspension is preferably a pulse protein suspension. The pulse protein suspension is, for example, a soy protein suspension.

5 In one embodiment, the plant protein suspension in step a) has a protein concentration of between 3 to 30 wt%. Preferably, the plant protein suspension in step a) has a protein concentration of between 5 to 15 wt%, or about 11 wt%.

In one embodiment, the suspension is heated in step a) to at least 60°C, preferably to at least 90°C. In one embodiment, the emulsion is heated in step b) to at least 60°C, preferably to at least 90°C.

10 In one embodiment, the cold set gelation is performed at between 0 to 10°C.

In one embodiment, freezing step f) is performed at a temperature below the crystallization temperature of the gel.

In one embodiment, freezing step f) is performed at a temperature which is above the secondary melting transition temperature (T_m') of the suspension or emulsion.

15 In one embodiment, freezing step f) is performed at a temperature which is below the secondary glassy transition temperature (T_g') of the suspension or emulsion.

In one embodiment, freezing step f) is performed at a temperature which is

a) above the secondary melting transition temperature (T_m') of the suspension or emulsion;
and

20 b) below the secondary glassy transition temperature (T_g') of the suspension or emulsion.

In one embodiment, step e) is not optional and said method further comprises a heat treatment step after step e), for example pasteurization.

In one embodiment, the firming agent is a soluble mineral salt. Preferably, the firming agent is calcium chloride or potassium chloride.

The invention further relates to a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, made from a suspension or an emulsion.

In one embodiment, the egg analogue product is an egg yolk analogue product. In one embodiment, the egg analogue product is an egg white analogue product. In one embodiment,
5 the egg analogue product is an egg mix analogue product.

In one embodiment, the suspension comprises plant protein, preferably pulse protein, firming agent and water.

In one embodiment, the emulsion comprises plant protein, preferably pulse protein, firming agent and water, and further comprises a lipid component.

10 In one embodiment, the suspension or emulsion further comprises a carbohydrate-based ingredient. In one embodiment, the suspension or emulsion further comprises a flavor. In one embodiment, the suspension or emulsion further comprises a color.

Typically for emulsion recipes, between 16 to 28, or 18 to 26, or 20 to 24, or about 22% w/w oil, for example rapeseed oil, is added.

15 Typically, the plant protein isolate is hydrated, for example at least at 60°C, at least at 70°C, at least at 80°C, at least at 90°C, or at about 95°C. Hydration may be for about 15 minutes, for example under mixing.

Typically, the mixture is cooled down to below 65°C, for example using an ice bath for about 4 minutes.

20 Typically, a fine emulsion with a fat droplet particle size distribution with a D_{90} of less than 10 microns is formed.

The pH can be further adjusted under stirring to reach the desired value, for example by using HCl or KOH 1 M, followed by the addition of CaCl_2 as a firming agent, when required.

In one embodiment, the suspension or emulsion undergoes different temperature procedures. In one embodiment, the suspension or emulsion undergoes cold-set gelation. In one embodiment, the suspension or emulsion undergoes heating. In one embodiment, the suspension or emulsion undergoes freezing.

- 5 Typically, the suspension and emulsion molded recipes are stored at about 4 °C for about 24 hours. This induces the cold-set gelation step and to obtain suspension and emulsion gels.

Typically, a heat treatment step is performed, for example using a steam oven at about 120 °C for about 14 minutes for a suspension.

- 10 Typically, a heat treatment step is performed, for example using a steam oven at about 120 °C for about 14 minutes for an emulsion.

The heat treatment step achieves 71 °C as an internal temperature in the product for food safety purposes.

- 15 For suspension recipes, the freezing step may be performed at less than 0°C, or less than -1°C, or less than -2°C, or less than -3°C, or less than -4°C, or less than -5°C, or less than -7°C, or at about -8°C. For suspension recipes, the freezing step may be performed at between -20°C and 0°C, or between -18°C and -2°C, between -14°C and -4°C, or between -10°C and -6°C.

- 20 For emulsion recipes, the freezing step may be performed at less than -40°C, or less than -50°C, or less than -55°C, or less than -60°C, or less than -65°C, or less than -70°C, or less than -75°C, or at about -80°C. For emulsion recipes, the freezing step may be performed at between -100°C and -60°C, or between -95°C and -65°C, between -90°C and -70°C, or between -85°C and -75°C.

Frozen gels are thawed until reaching room temperature for about 2 hours.

In one embodiment, the protein concentration is between 3 to 30 wt%. In one embodiment, the protein concentration is between 5 to 15 wt%. In one embodiment, the protein concentration is about 11 wt%.

In one embodiment, the firming agent is a soluble salt of monovalent ions. In one embodiment, the firming agent is a soluble salt of divalent ions. In one embodiment, the firming agent is a soluble salt of trivalent ions.

In one embodiment, the firming agent is a soluble salt of calcium. In one embodiment, the firming agent is a soluble salt of magnesium. In one embodiment, the firming agent is a soluble salt of potassium. In one embodiment, the firming agent is a soluble salt of sodium. In one embodiment, the firming agent is a soluble salt of phosphates. In one embodiment, the firming agent is a soluble salt of mixtures thereof of magnesium, potassium, sodium, and phosphates. In one embodiment, the firming agent has an ion concentration between 1 – 100 mmol/100 g. In one embodiment, the firming agent has an ion concentration of about 20 mmol/100g.

In one embodiment, the water concentration is between 15 to 97 wt%.

In one embodiment, the lipid component is liquid oil, or melted fat, preferably vegetable oil, and wherein the lipid concentration is up to 50 wt%, preferably about 22 wt%.

In one embodiment, the product has the sensory attributes, preferably texture, of a cooked chicken egg.

The invention further relates to a plant based cooked egg analogue product, preferably solid, made by a method according to the invention.

The invention further relates to a plant based cooked egg analogue product according to the invention, suitable for direct consumption or as part of a preparation.

20

Detailed description of the invention

Suspension recipe

The method of the invention comprises making or providing a plant protein suspension. Typically, the plant protein suspension is a soy protein suspension. The plant protein suspension comprises between 8 to 14, or 9 to 13, or 10 to 12, or about 11 % protein w/w. Typically, a firming agent is added. The firming agent may be Calcium Chloride Dihydrate, for example at between 10 to 30,

or between 12 to 28, or between 14 to 26, or between 16 to 24, or between 18 to 22, or about 20 mmol / kg. Between 80 to 94, or between 82 to 92, or between 84 to 90, or between 86 to 88, or about 87 % w/w water is added. Typically, the plant protein isolate is hydrated, for example at least at 60°C, at least at 70°C, at least at 80°C, at least at 90°C, or at about 95°C. Hydration may be for about 15 minutes, for example under mixing. Typically, the mixture is cooled down to room temperature, for example using an ice bath for about 30 minutes for pH adjustment. The pH can be further adjusted under stirring to reach the desired value, for example by using HCl or KOH 1 M, followed by the addition of CaCl₂ as a firming agent, when required.

Emulsion recipe

The method of the invention comprises the making or providing a plant protein emulsion. Typically, the plant protein emulsion is a soy protein emulsion. The plant protein emulsion comprises between 4 to 13, or 5 to 12, or 6 to 11, or about 8.5 % protein w/w. Typically, a firming agent is added. The firming agent may be Calcium Chloride Dihydrate, for example at between 10 to 30, or between 12 to 28, or between 14 to 26, or between 16 to 24, or between 18 to 22, or about 20 mmol / kg. Between 61 to 75, or between 63 to 73, or between 65 to 71, or between 67 to 69, or about 68 % w/w water is added. Typically, between 16 to 28, or 18 to 26, or 20 to 24, or about 22% w/w oil, for example rapeseed oil, is added. Typically, the plant protein isolate is hydrated, for example at least at 60°C, at least at 70°C, at least at 80°C, at least at 90°C, or at about 95°C. Hydration may be for about 15 minutes, for example under mixing. Typically, the mixture is cooled down to below 65°C, for example using an ice bath for about 4 minutes. A fine emulsion with a fat droplet particle size distribution with a D₉₀ of less than 10 microns is formed. The pH can be further adjusted under stirring to reach the desired value, for example by using HCl or KOH 1 M, followed by the addition of CaCl₂ as a firming agent, when required.

Further recipe treatments

Typically, the suspension and emulsion molded recipes are stored at about 4 °C for about 24 hours. This induces the cold-set gelation step and to obtain suspension and emulsion gels. A heat treatment step is performed, for example using a steam oven at about 120 °C for about 14 minutes (suspension) and 15 minutes (emulsion). This is to achieve 71 °C as an internal

temperature in the product for food safety purposes. The suspension and emulsion gels are stored at about -8 °C and about -80 °C for about 7 days. This to modulate the gel strength. Frozen gels are thawed until reaching room temperature for around 2 hours.

Example suspension recipes

5 A suspension recipe of the invention may be made using substantially the same method as described herein. The suspension recipe may comprise the same ingredients in substantially the same amounts as described for recipes 1 to 6, preferably recipes 4, 5, and 6, in Table 1. The firming agent may be calcium chloride. The firming agent may be potassium chloride. The pH may be adjusted to between 7 to 9, or to about 7, or to about 8, or to about 9. The protein
10 concentration may be about 11% w/w. The final pH after addition of firming agent may be between 6.91 to 8.92, or about 6.91, or about 6.99, or about 7.75, or about 7.82, or about 7.87, or about 8.92.

Example emulsion recipes

An emulsion recipe of the invention may be made using substantially the same method as
15 described herein. The emulsion recipe may comprise the same ingredients in substantially the same amounts as described for recipes 7 to 12, preferably recipe 10, in Table 1. The firming agent may be calcium chloride. The firming agent may be potassium chloride. The pH may be adjusted to between 7 to 9, or to about 7, or to about 8, or to about 9. The protein concentration may be about 8.5% w/w. The lipid concentration may be about 22% w/w. The final pH after addition of
20 firming agent may be between 6.99 to 9.15, or about 6.99, or about 7.00, or about 7.77, or about 7.89, or about 8.05, or about 9.15.

Cooked egg white analogue recipe

A cooked egg white analogue recipe may be made in substantially the same way as recipes 6 or 10 described herein. For example, a suspension and/or an emulsion recipe may be followed.
25 Typically, the pH is adjusted to above pH 8. Typically, a firming agent at about 20 mmol / kg is added. Typically, a freezing step at about - 8 °C is performed.

Cooked egg yolk analogue recipe

A cooked egg white analogue recipe may be made in substantially the same way as recipes 4, 5, or 6 described herein. For example, a suspension recipe may be followed. Typically, the pH is adjusted to above pH 8. Typically, a firming agent at about 20 mmol / kg is added. Typically, a freezing step at about – 8 °C is performed.

5 *Cooked egg mix analogue recipe*

A cooked egg white analogue recipe may be made in substantially the same way as recipes 4 or 5 described herein. For example, a suspension recipe may be followed. Typically, the pH is adjusted to above pH 8. Typically, a firming agent at about 20 mmol / kg is added. Typically, a freezing step at about – 8 °C is performed.

10 *Definitions*

When a product or emulsion is described herein in terms of wt%, this means a mixture of the ingredients on a wet basis, unless indicated otherwise.

As used herein, the terms “about” or “substantially” are understood to refer to numbers in a range of numerals, for example the range of -30% to +30% of the referenced number, or -20% to +20% of the referenced number, or -10% to +10% of the referenced number, or -5% to +5% of the referenced number, or -1% to +1% of the referenced number. All numerical ranges herein should be understood to include all integers, whole or fractions, within the range.

As used herein, the term “analogue” is considered to be an edible substitute of a substance in regard to one or more of its major characteristics. A “hard-boiled egg analogue” as used herein is a substitute of hard-boiled egg in the major characteristics of purpose and usage. Preferably, the egg analogue product is an analogue of chicken egg. Preferably, the egg analogue is a substitute of chicken egg and is statistically similar, or has to within 60 – 100% to the texture of chicken egg, for example statistically similar firm, pieces, compact, or chewy texture of chicken hard-boiled egg.

As used herein, the term “vegan” refers to an edible composition which is entirely devoid of animal products, or animal derived products, for example eggs, milk, honey, fish, and meat.

As used herein, the term “vegetarian” relates to an edible composition which is entirely devoid of meat, poultry, game, fish, shellfish or by-products of animal slaughter.

As used herein, a “protein isolate” comprises at least 70 wt% protein, more preferably at least 80 wt% protein, or about 87 wt.% protein, or about 91.5 wt% protein.

Soy protein isolate may comprise about 87 wt% protein, about 3.5 wt% fat, about 3.5 wt% fiber.

Those skilled in the art will understand that they can freely combine all features of the present

invention disclosed herein. In particular, features described for the compositions of the present invention may be combined with the method or uses of the present invention and vice versa.

Further, features described for different embodiments of the present invention may be combined. Where known equivalents exist to specific features, such equivalents are incorporated as if specifically referred to in this specification.

Further advantages and features of the present invention are apparent from the figures and non-limiting examples.

EXAMPLES

Example 1

Vegan hard-boiled egg analogue recipes

Six soy-based suspension recipes (1-6) were made using soy protein isolate (11 % protein w/w), Calcium Chloride Dihydrate (CaCl_2) (20 mmol / kg) as the firming agent, and water (87 % w/w). Soy protein isolate was hydrated at 95 °C for 15 minutes under constant mixing (approx. 1,100 rpm). The mixture was cooled down to room temperature, using an ice bath for 30 minutes for pH adjustment. The pH was further adjusted under stirring to reach the desired value by using HCl or KOH 1 M, followed by the addition of CaCl_2 as a firming agent, when required. The final pH was measured. All recipes were molded in metallic rings of 3.2 cm diameter and 2 cm height, which had previously been oiled using rapeseed oil and covered with food-wrap plastic. The description of the suspension recipes can be observed in Table 1.

Six soy-based emulsion recipes (7-12) were made using soy protein isolate (8,5 % protein w/w), Calcium Chloride Dihydrate (CaCl_2) (20 mmol / kg) as the firming agent, water (68 % w/w), and rapeseed oil (22% w/w), as the lipid component. Soy protein isolate was hydrated at 95 °C for 15 minutes under constant mixing (approx. 1,100 rpm). The mixture was cooled down to below 65

°C, using an ice bath for 4 minutes, to avoid destabilization when forming the emulsion. After, rapeseed oil (22 % w/w) was added as the lipid component, under intensified mixing conditions (approx. 10,200 rpm). This emulsification step formed a fine emulsion with a fat droplet particle size distribution with a D_{90} of less than 10 microns. The mixture was cooled down to room temperature, using an ice bath for 30 minutes for pH adjustment. The pH was furthered adjusted under stirring to reach the desired value by using HCl or KOH 1 M, followed by the addition of CaCl_2 as a firming agent, when required. The final pH was measured. All recipes were molded in metallic rings of 3.2 cm diameter and 2 cm height, which had previously been oiled using rapeseed oil and covered with food-wrap plastic. The description of the emulsion recipes can be observed in Table 1.

The suspension and emulsion molded recipes were stored at 4 °C for 24 hours to induce the cold-set gelation step and to obtain suspension and emulsion gels. Afterwards, a heat treatment step was performed using a steam oven at 120 °C for 14 minutes (suspension) and 15 minutes (emulsion), to achieve 71 °C as an internal temperature in the product for food safety purposes. Finally, the suspension and emulsion gels were stored at -8 °C and -80 °C for 7 days in order to modulate the gel strength. Frozen gels were thawed until reaching room temperature for around 2 hours. These gels were analyzed for Texture Profile Analysis (TPA) and sensory analysis.

Table 1. Description of suspensions and emulsions recipes.

Recipe	System	Firming agent	Concentration (mmol / kg)	Adjusted pH	Protein concentration (%)	Lipid concentration (%)	Final pH (after firming agent)
1	Suspension	N/A	0	7	11	0	6,99
2	Suspension	N/A	0	8	11	0	7,87
3	Suspension	N/A	0	9	11	0	8,92
4	Suspension	CaCl_2	20	8	11	0	6,91
5	Suspension	CaCl_2	20	9	11	0	7,75
6	Suspension	KCl	20	8	11	0	7,82
7	Emulsion	N/A	0	7	8,5	22	6,99
8	Emulsion	N/A	0	8	8,5	22	8,05
9	Emulsion	N/A	0	9	8,5	22	9,15
10	Emulsion	CaCl_2	20	8	8,5	22	7,00
11	Emulsion	CaCl_2	20	9	8,5	22	7,77

12	Emulsion	KCl	20	8	8,5	22	7,89
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Example 2

Analytical texture characterization using cooked chicken egg as reference

5 Analytical texture characterization of the generated gels for each recipe was performed using the TPA method (<https://www.rheologylab.com/services/texture-analysis/>), applied with a TA.HDplusC Texture Analyzer from Stable Micro Systems company. The TPA method involves a double compression, standardized in volume and shape, using a compression plate with a 75mm diameter. The suspension and emulsion gels were analyzed for TPA to obtain an average value
10 of three replicates.

Three cooked chicken egg systems (egg white, egg yolk and egg mix) were used as the reference to which the suspension and emulsion gels were compared in terms of TPA. Each egg system was properly and homogenously mixed, and then molded just like the suspension and emulsion recipes, in metallic rings of 3.2 cm diameter and 2 cm height, previously oiled using rapeseed oil
15 and covered with food-wrap plastic. A heat treatment step was performed to obtain cooked egg yolk, white and mix. As for the suspension and emulsion gels, a steam oven at 120 °C was used, but with different times: 11 minutes for the egg white, 8 minutes for the egg yolk and 9 minutes for the egg mix. The egg systems used as reference (egg white, egg yolk and egg mix) were analyzed for TPA to obtain an average value of 4 replicates.

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Example 3

Sensory analysis using cooked chicken egg as reference

Rate All That Apply (RATA) sensory methodology was applied for assessing the suspension and emulsion gels, and the chicken egg references (egg white and egg yolk). Panelists (n = 12, Nestlé
25 employees), were trained based on the sensory glossary (Table 2), and a warm-up sample (cooked chicken egg white and egg yolk), with given attribute rankings, that was used prior to each sensory evaluation session to set the scale for the defined attributes before the gels assessment. Panelists were asked to check the attributes they considered appropriate for describing samples and then to rate the intensity of the applicable terms using a 5-point

structured scale with anchors ‘just noticeable’, ‘slight’, ‘moderate’, ‘high’ or ‘very high’. A total of three sessions were conducted, using a sensory glossary with terms about texture perception and flavour and taste. Data were collected with EyeQuestion® software in individual sensory booths, under red light, and were analyzed using EyeOpenR® software (Logic 8, Elst, the Netherlands). The attributes displayed in the figures for the following examples correspond to firm, pieces, compact and chewy that are described in Table 1.

Table 2. Sensory texture attributes used in the examples

Attribute	Description
Firm	The force required to deform a product using the molars.
Pieces	Extent to which a product can be chewed in single pieces that don’t form a homogeneous mass
Compact	Dense and heavy texture resulting from a lack of air in the product. Opposite: aerated (aerated to compact).
Chewy	The degree to which a sample takes a number of chews until the product is ready for swallowing.

Two cooked chicken egg systems (egg white and egg yolk) were used as a reference and warm-up samples, to which the suspension and emulsion gels were compared in terms of sensory analysis. For their preparation, water was set to boiling point and chicken eggs were added for 10 min to obtain cooked egg white and egg yolk.

Example 3

Plant based cooked egg analogue hardness texture performance by TPA and its comparison to cooked chicken egg yolk, egg white and egg mix.

Figures 1 to 3 show a comparison of the average of different suspension and emulsion gel recipes for the “hardness” texture parameter measured by TPA. The hardness is expressed relative to that of cooked chicken egg yolk, egg white and egg mix, respectively. The preparation and cooking of the gel recipes and cooked chicken egg references, as well as the methodology for the

TPA, were performed according to example 1. Error bars represent the standard deviation of the average recipes used for comparison.

The results in Figure 1 show an average of 3 different suspension recipes (recipes 4, 5 and 6), with and without freezing step, that have between 60 – 140 % of the texture property (hardness) of the cooked chicken egg yolk, as referred to in example 1.

This figure demonstrates that, by considering the recipes 4, 5 and 6 of plant based cooked egg analogue, to be comparable to the cooked chicken egg yolk, a suspension, with high pH (adjusted suspension pH above 8), a firming agent (20 mmol / kg), and a freezing step at – 8 °C are needed.

The results in Figure 2 show an average of 2 different recipes, a suspension (recipe 6) and an emulsion (recipe 10), with and without freezing step, that have between 60 – 140 % of the texture property (hardness) of the cooked chicken egg white, as referred to in example 1.

This figure demonstrates that, by considering the recipes 6 and 10 of plant based cooked egg analogue, to be comparable to the cooked chicken egg white, a suspension and/or an emulsion with high pH (adjusted suspension/emulsion pH above 8), a firming agent (20 mmol / kg), and a freezing step at – 8 °C are needed.

The results in Figure 3 show an average of 2 different suspension recipes (recipes 4 and 5), with and without freezing step, that have between 60 – 140 % of the texture property (hardness) of the cooked chicken egg mix, as referred to in example 1.

This figure demonstrates that, by considering recipes 4 and 5 of plant based cooked egg analogue, to be comparable to the cooked chicken egg mix, a suspension with high pH (adjusted suspension pH above 8), a firming agent (20 mmol / kg), and a freezing step at – 8 °C are needed.

Example 4

Comparison to cooked chicken egg yolk, egg white and egg mix for samples without the cold set gelation step

The results in Figure 4 show a suspension recipe with 20 mmol / kg CaCl_2 and pH 9, without the cold gelation step, that have between 60 – 140 % of the texture property (hardness) of the cooked chicken egg yolk, egg white and egg mix, as referred in example 1.

5 Example 5

Plant based cooked egg analogue texture performance by sensory analysis and its comparison to cooked chicken egg yolk and egg white.

Sensory data, acquired according to the methodology described in example 1, were processed with EyeOpenR[®] software (Logic 8, Elst, the Netherlands). The least significant difference (LSD) is plotted to the bar charts to show a proxy of the panel intra-variability. The confidence level was set to 5% (p-value <0.05). LSD bars overlapping signifies the recipe is not significantly different than cooked chicken hard-boiled egg yolk and egg white

Figure 5 shows a comparison of the average values of sensory attributes firm, pieces, compact and chewy for suspension recipes with firming agent (recipes 4, 5 and 6) and all emulsion recipes with firming agent (recipes 10, 11 and 12). These values are expressed relatively to the ones of cooked chicken egg yolk and are displayed compared to the 60 – 140 % range of the sensory properties of the cooked chicken egg yolk.

This figure demonstrates that, by considering recipes 5, 6 and 10 of plant based cooked egg analogue, to be comparable to the cooked chicken egg yolk, a suspension and/or an emulsion with high pH (adjusted suspension/emulsion pH above 8), a firming agent (20 mmol / kg), and a freezing step at – 8 °C are needed. It can be observed that recipe 5 performs slightly out of range for the attribute “chewy”, as well as recipes 6 and 10 for the attribute “compact”. However, the LSD bars are overlapping with the cooked chicken egg yolk 60 – 140 % range of the sensory attributes described, thus this signifies that recipes 5, 6 and 10 are statistically comparable to the cooked chicken egg yolk for the four attributes.

Figure 6 shows the firmness sensory attribute average value for different suspension recipes with and without firming agent at pH 9 (recipe 5 and recipe 3, respectively) and different emulsion

recipes with and without firming agent at pH 8 (recipe 10 and recipe 8, respectively). The results show that the recipes with firming agent (recipes 5 and 10) have between 60 – 140 % of the firmness sensory attribute of the cooked chicken egg yolk and are performing better than the recipes without firming agent (recipes 3 and 8). Also, it demonstrates that to be comparable to the cooked chicken egg yolk, a suspension and/or an emulsion with high pH (adjusted suspension/emulsions pH above 8), and a freezing step at – 8 °C are needed.

Figure 7 shows a comparison of the average value of sensory attributes firm, pieces, compact and chewy for suspension recipes with firming agent (recipes 4, 5 and 6) and all emulsions with firming agent (recipes 10, 11 and 12). These values are expressed relatively to the ones of cooked chicken egg white and are displayed compared to the 60 – 140 % range of the sensory properties of the cooked chicken egg white.

This figure demonstrates that, by considering recipes 5 and 10 of plant based cooked egg analogue, to be comparable to the cooked chicken egg white, a suspension and/or an emulsion with high pH (adjusted suspension/emulsion pH above 8), a firming agent (20 mmol / kg), and a freezing step at – 8 °C are needed. It can be observed that recipe 10 performs slightly out of range for only one (“compact”) out of the four sensory attributes. Except for the sensory “compact” attribute related to recipe 10, recipes 5 and 10 are statistically comparable to the cooked chicken egg white.

Figure 8 shows the firmness sensory attribute average value for different suspension recipes with and without firming agent at pH 8 (recipe 4 and recipe 2, respectively) and different emulsion recipes with and without firming agent at pH 8 (recipe 10 and recipe 8, respectively). The results show that the recipes with firming agent (recipes 4 and 10) have between 60 – 140 % of the firmness sensory attribute of the cooked chicken egg white and are performing better than the recipes without firming agent (recipes 2 and 8). Also, it demonstrates that to be comparable to the cooked chicken egg white, a suspension and/or an emulsion with high pH (adjusted suspension/emulsions pH above 8), and a freezing step at – 8 °C are needed.

Claims

1. A method of making a plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, said method comprising:

- 5 a. Providing a plant protein suspension;
- b. Optionally adding oil to the suspension and mixing to form an emulsion;
- c. Ensuring the pH of the suspension or emulsion is between pH 5 to 10, preferably between 7 to 9;
- d. Adding a firming agent and mixing;
- 10 f. Performing a freezing step,

wherein the firming agent is a soluble mineral salt.

2. The method of making a product according to claim 1, said method after step d. comprising the step of:

- e. performing a cold set gelation at between 0 to 30°C.

- 15 3. The method of making a product according to any one of claims 1 and 2, wherein the plant protein suspension in step a) is a legume protein suspension, preferably a pulse protein suspension, for example a soy protein suspension and wherein the plant protein suspension in step a) has a protein concentration of between 3 to 30 wt%, preferably between 5 to 15
- 20 wt%.

4. The method of making a product according to any one of claims 1 to 3, wherein (i) the suspension is heated in step a) to at least 60°C, preferably to at least 90°C; or (ii) the emulsion is heated in step b) to at least 60°C, preferably to at least 90°C.

5. The method of making a product according to any one of claims 1 to 4, wherein the cold set gelation is performed at between 0 to 10°C.
6. The method of making a product according to any one of claims 1 to 5, wherein freezing step f) is performed at a temperature below the crystallization temperature of the gel.
- 5 7. The method of making a product according to any one of claims 1 to 6, wherein freezing step f) is performed at a temperature which is
- a. above the secondary melting transition temperature (T_m') of the suspension or emulsion; and
 - b. below the secondary glassy transition temperature (T_g') of the suspension or
- 10 emulsion.
8. The method of making a product according to any one of claims 2 to 7, wherein said method further comprises a heat treatment step after step e), for example pasteurization.
9. The method of making a product according to any one of claims 1 to 8, wherein the soluble mineral salt firming agent is calcium chloride or potassium chloride.
- 15 10. The method of making a product according to any one of claims 1 to 9, wherein the product is an egg white analogue, or an egg yolk analogue, or an egg mix analogue product.
11. The method of making a product according to claim 10, wherein the product is an egg white analogue and the method comprises
- a. Providing a plant protein suspension;
 - b. Ensuring the pH of the suspension is between 7 to 9, or about pH 8;
 - c. Adding a potassium chloride and mixing; and
 - d. Performing a freezing step.
- 20
12. The method of making a product according to claim 10, wherein the product is an egg
- 25 white analogue and the method comprises

- a. Providing a plant protein suspension;
 - b. Adding oil to the suspension and mixing to form an emulsion;
 - c. Ensuring the pH of the suspension is between 7 to 9, or about pH 8;
 - d. Adding a calcium chloride and mixing; and
 - 5 e. Performing a freezing step.
13. The method of making a product according to claim 10, wherein the product is an egg yolk analogue and the method comprises
- a. Providing a plant protein suspension;
 - b. Ensuring the pH of the suspension is between 7 to 9, or between pH 8 to 9;
 - 10 c. Adding a firming agent and mixing; and
 - d. Performing a freezing step.
14. The method of making a product according to claim 10, wherein the product is an egg mix analogue and the method comprises
- a. Providing a plant protein suspension;
 - 15 b. Ensuring the pH of the suspension is between pH 8 to 9;
 - c. Adding calcium chloride and mixing; and
 - d. Performing a freezing step.
15. The method of making a product according to any one of claims 10 to 14, wherein the product is an egg white, egg yolk, or egg mix analogue and the pH after addition of firming agent is between pH 6.5 to 8.
- 20
16. A plant-based cooked egg analogue product, for example a hard-boiled egg analogue product, made from a suspension or an emulsion, wherein the suspension or emulsion

comprises plant protein, preferably pulse protein, firming agent and water, and wherein the emulsion further comprises a lipid component.

17. The product according to claim 16, wherein the suspension or emulsion further comprises a carbohydrate-based ingredient, flavor, and color.

5 18. The product according to any one of claims 16 and 17, wherein the suspension or emulsion undergoes cold-set gelation, heating and/or freezing.

19. A plant based cooked egg analogue product made by a method according to any one of claims 1 to 15.

Figure 1.

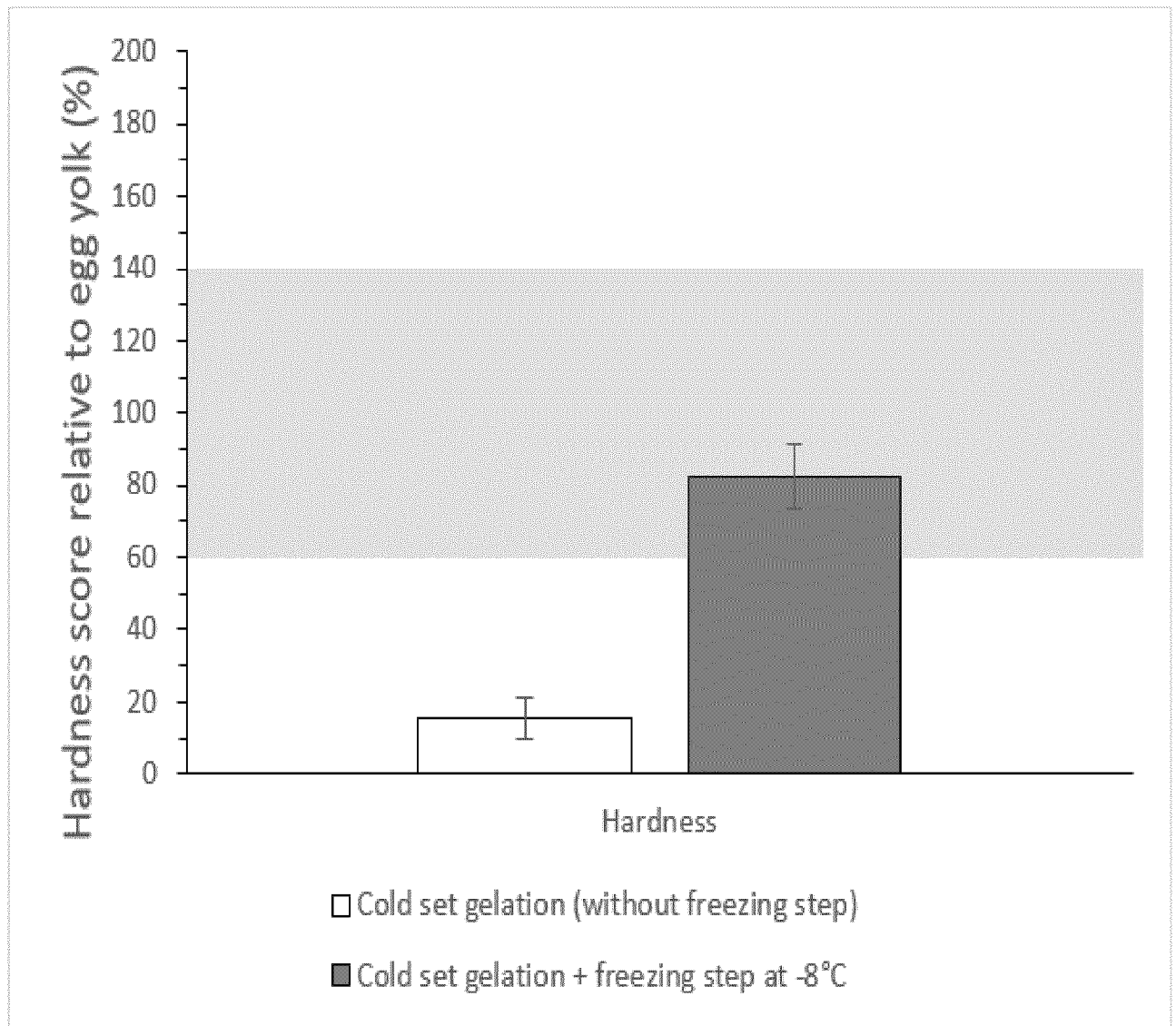


Figure 2.

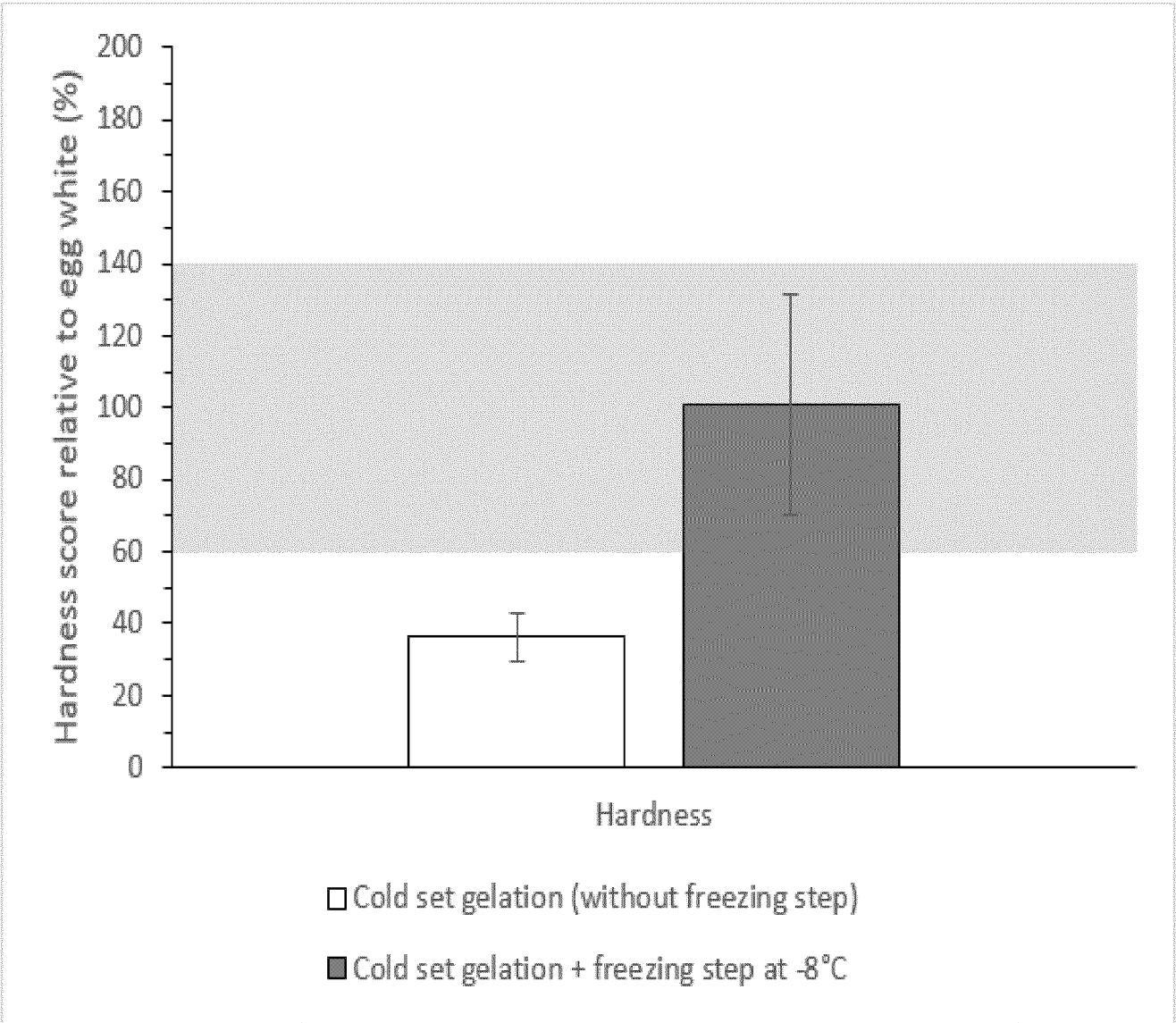


Figure 3.

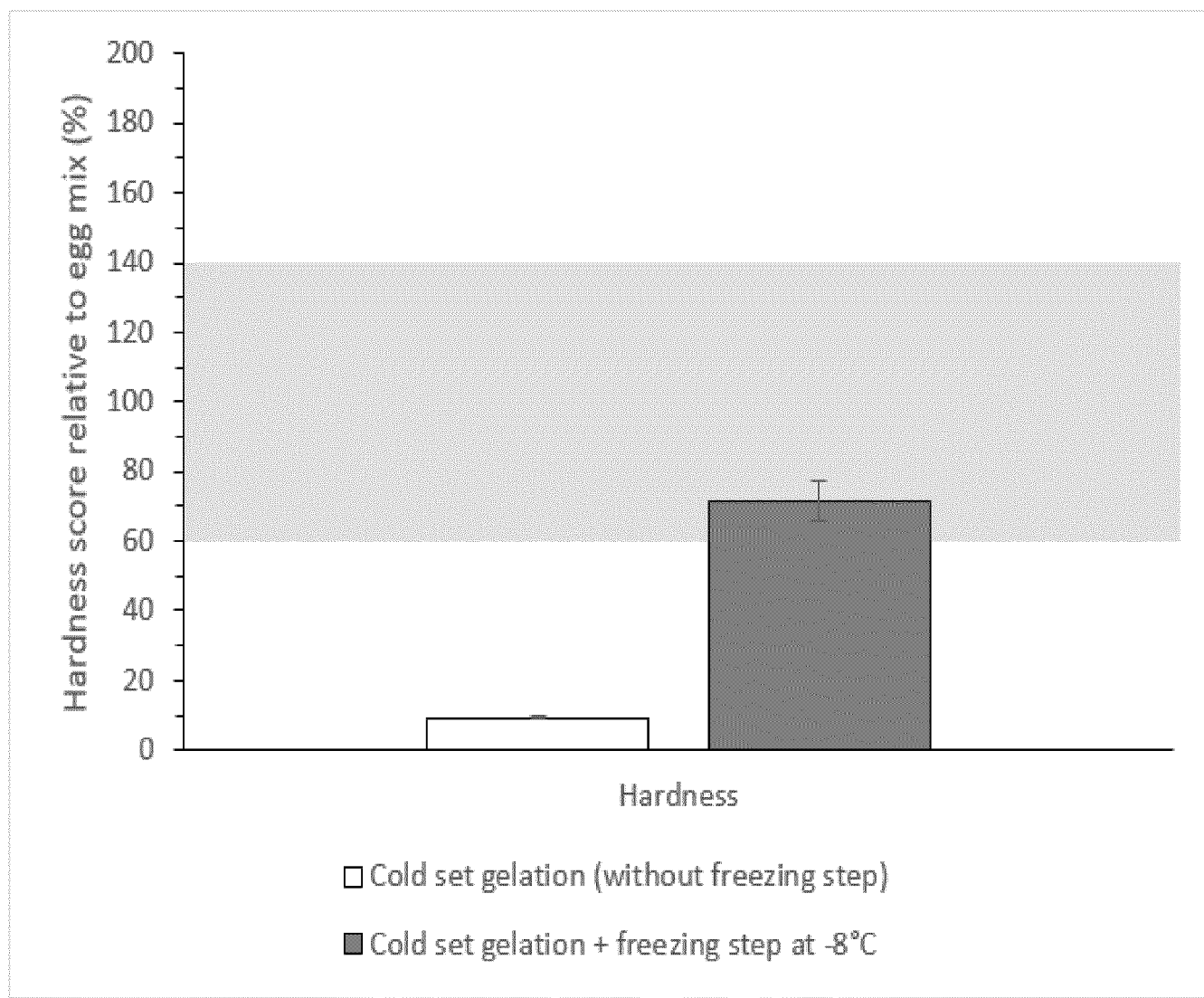


Figure 4.

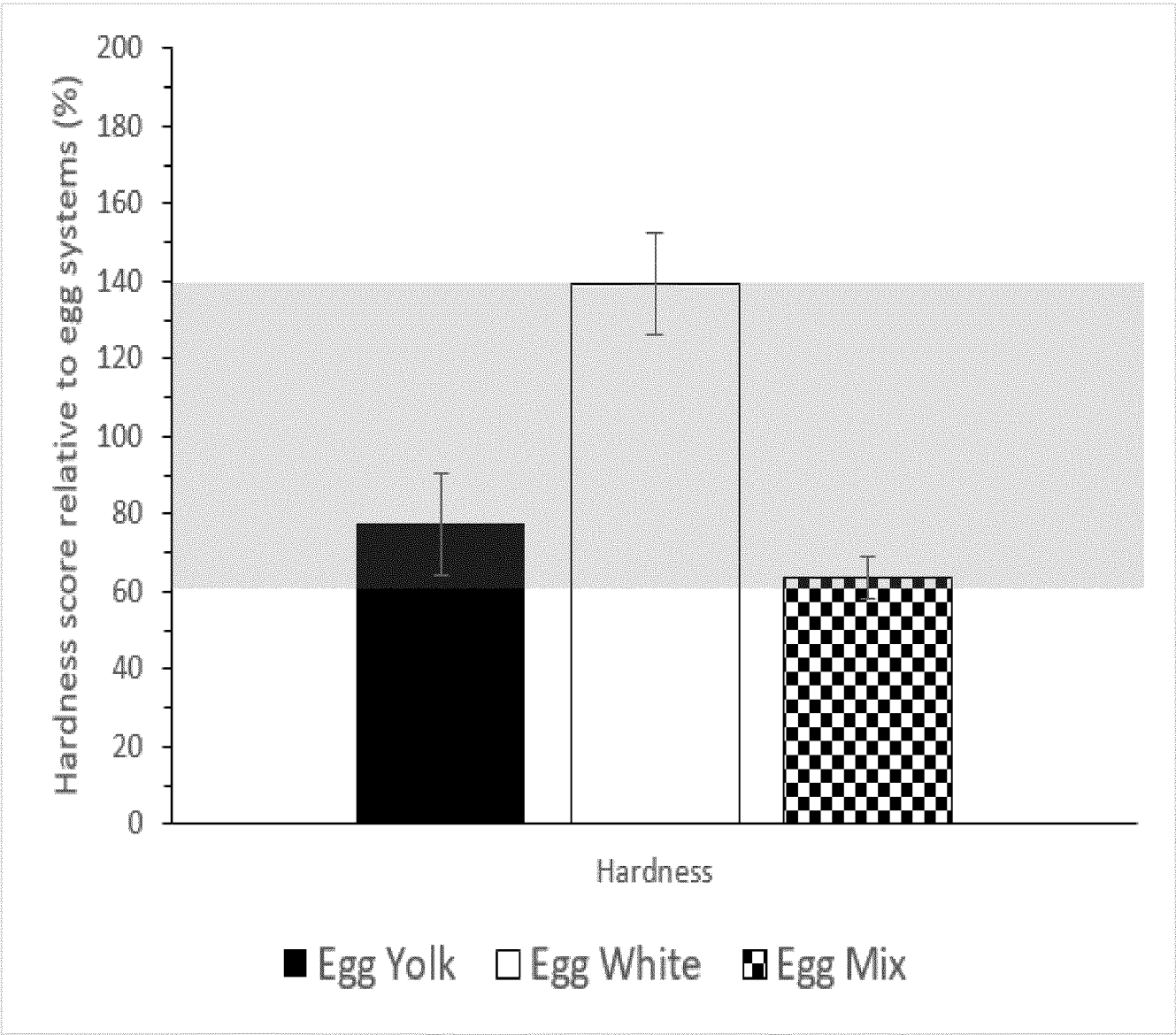


Figure 5.

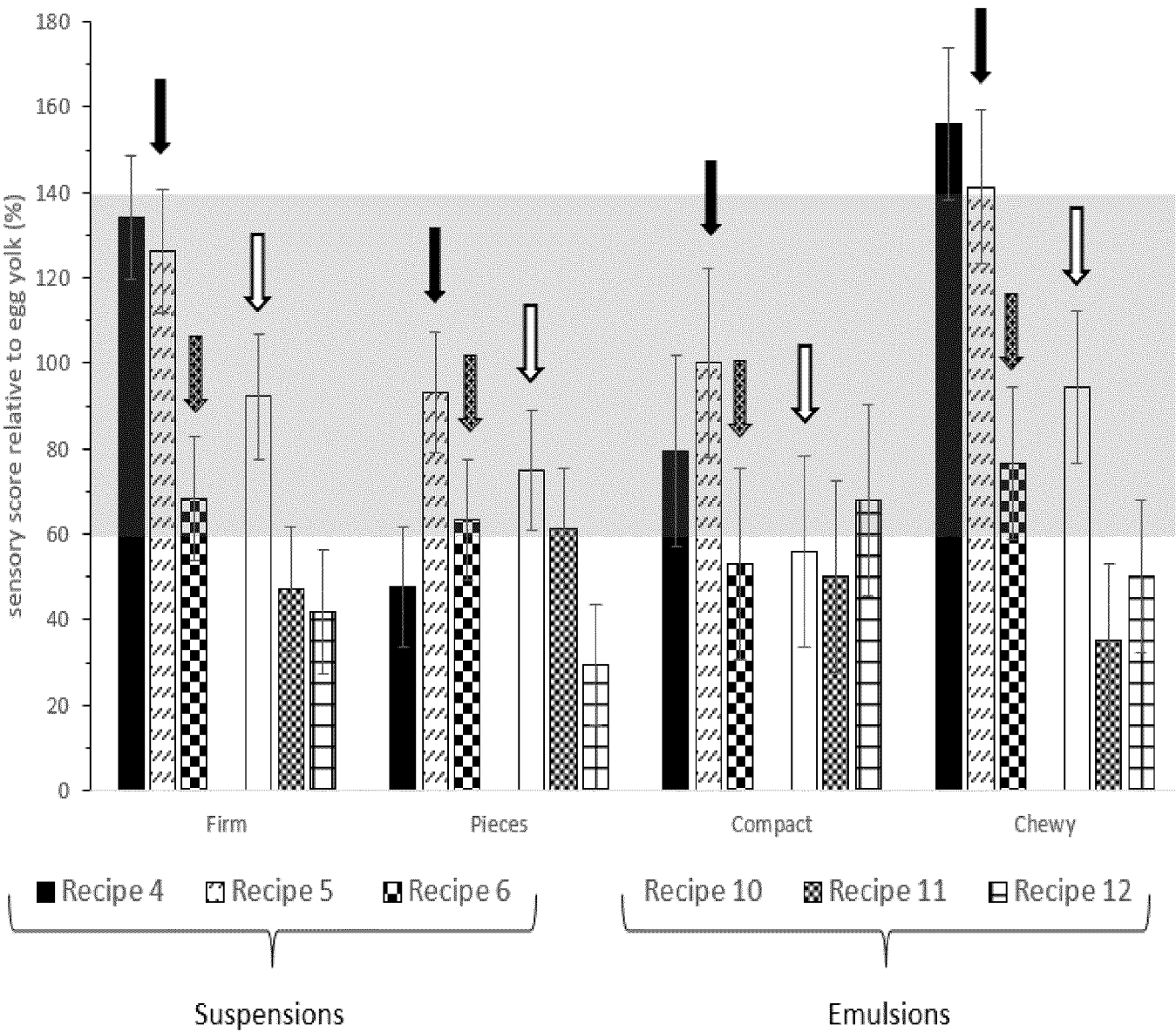


Figure 6.

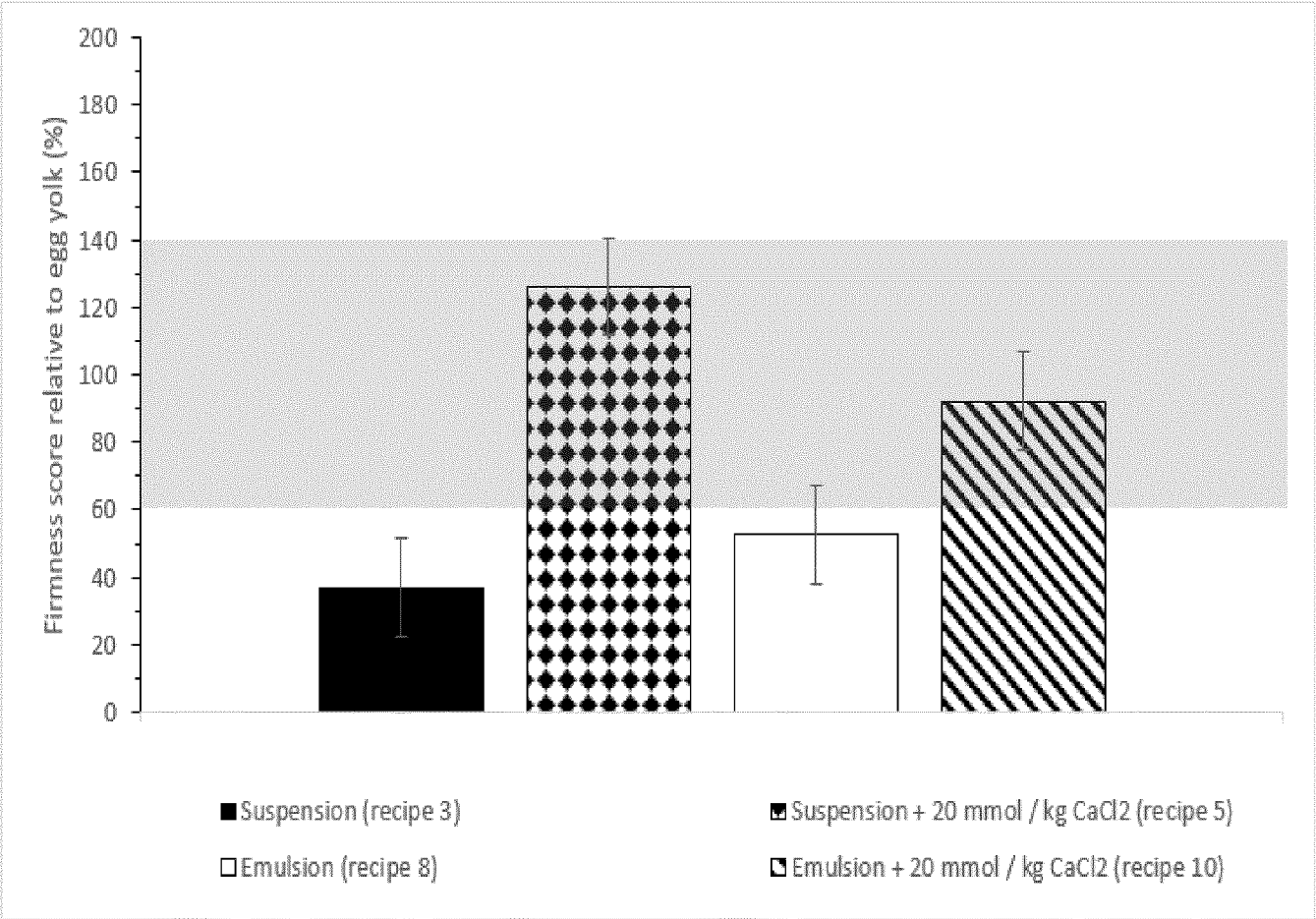


Figure 7.

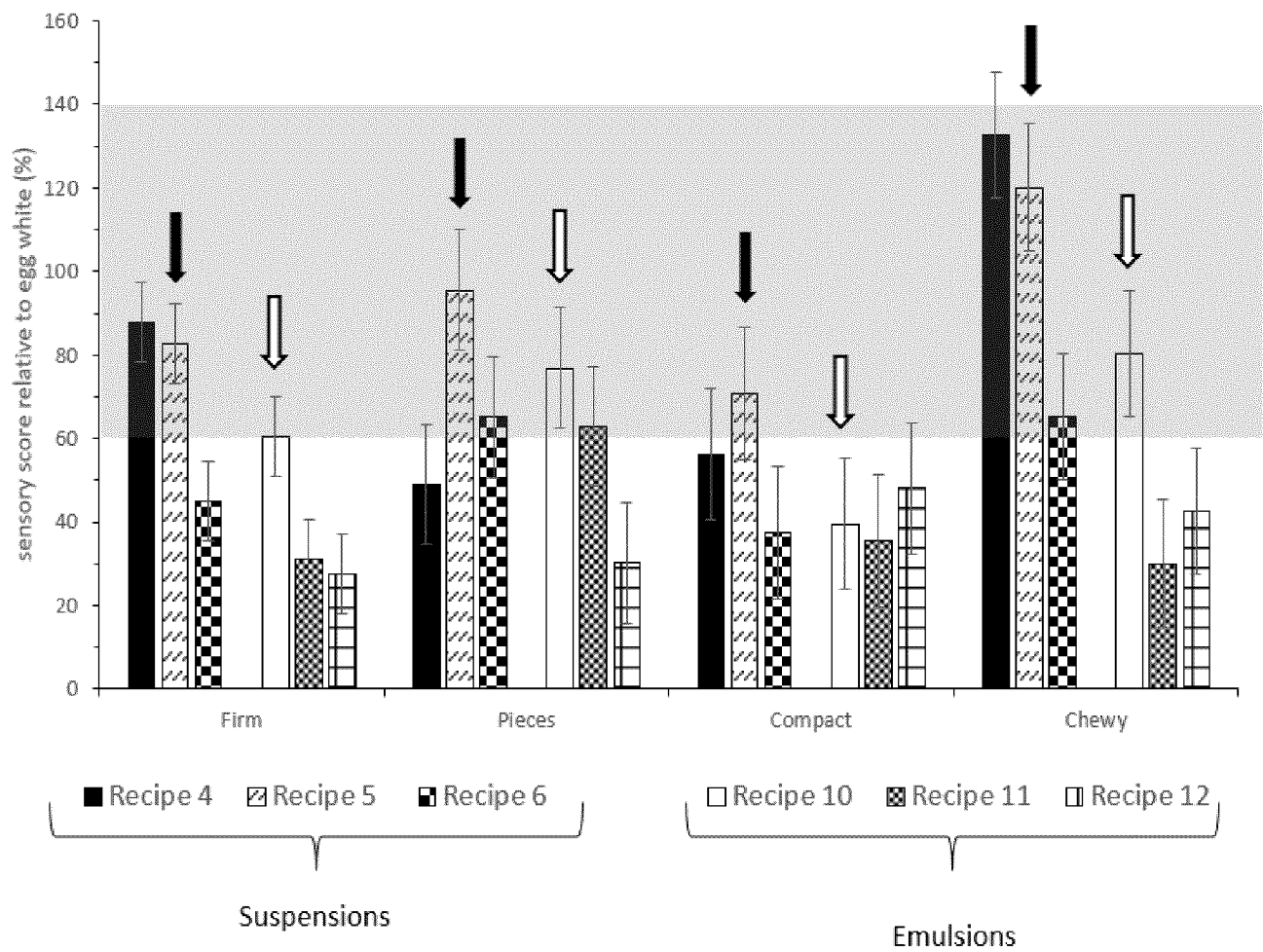
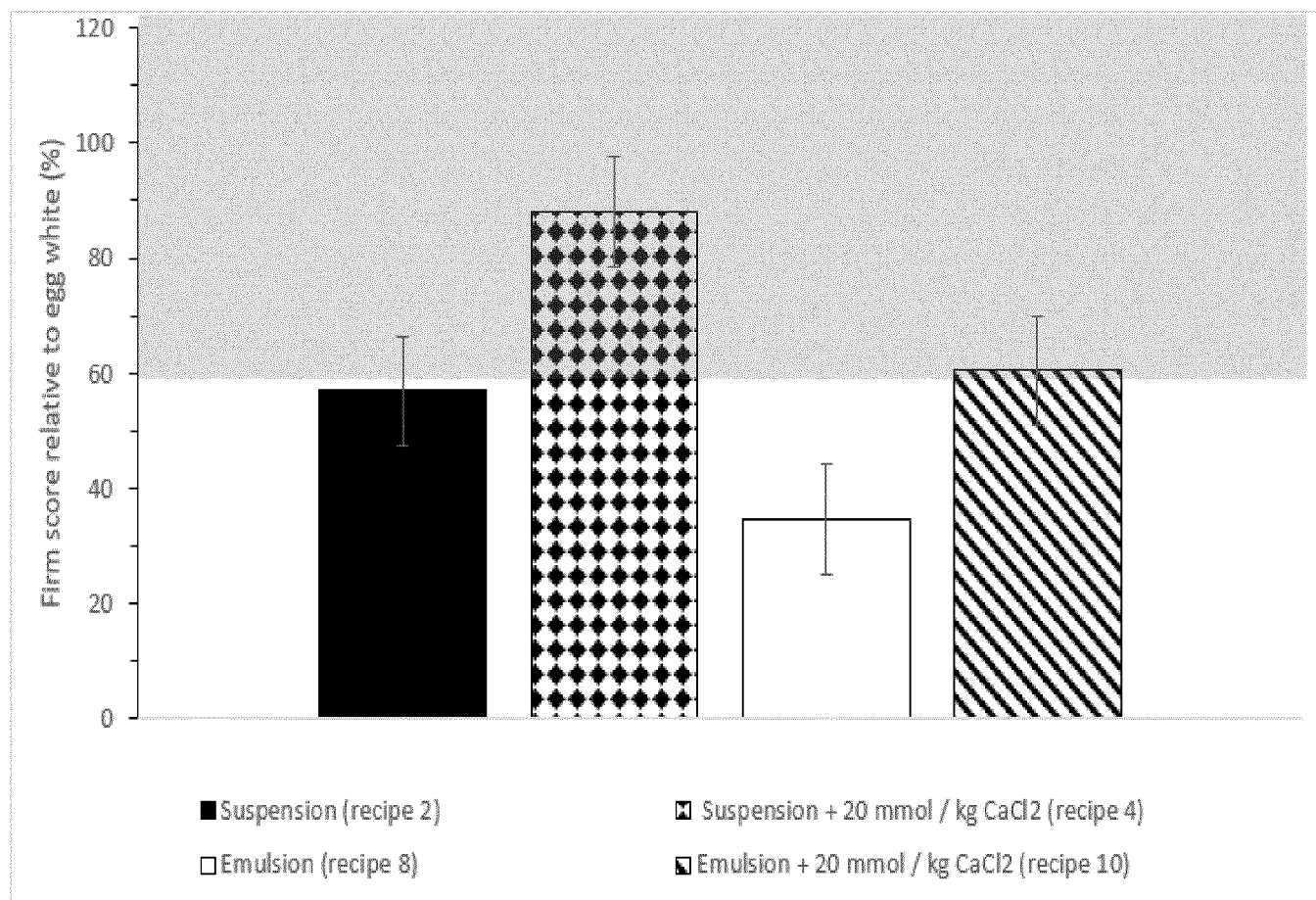


Figure 8.



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/068512

A. CLASSIFICATION OF SUBJECT MATTER					
INV.	A23D7/005	A23D7/05	A23J3/14	A23J3/16	A23L15/00
	A23L29/00	A23P30/10			
ADD.					
According to International Patent Classification (IPC) or to both national classification and IPC					
B. FIELDS SEARCHED					
Minimum documentation searched (classification system followed by classification symbols)					
A23D A23J A23L A23P					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)					
EPO-Internal					
C. DOCUMENTS CONSIDERED TO BE RELEVANT					
Category*	Citation of document, with indication, where appropriate, of the relevant passages				Relevant to claim No.
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Y	27 January 2022 (2022-01-27)				
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	8 February 1972 (1972-02-08)				
	example 1				

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	MINTEL;				
	31 January 2022 (2022-01-31),				
	anonymous: "Plant-Based Boiled Egg",				
	XP093105631,				
	Database accession no. 9349610				
	the whole document				

	- / - -				
☒ Further documents are listed in the continuation of Box C.					
☒ See patent family annex.					
* Special categories of cited documents :					
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"P" document published prior to the international filing date but later than the priority date claimed					
Date of the actual completion of the international search			Date of mailing of the international search report		
22 September 2024			02/10/2024		
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016			Authorized officer Steiner Ribeiro G.		

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2024/068512

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y	paragraphs [0001], [0043], [0047], [0050], [0051], [0057], [0066]; table 1 -----	9
X	JP 2017 169499 A (FUJI OIL CO LTD) 28 September 2017 (2017-09-28)	16, 19
A	paragraphs [0001], [0005], [0026], [0033] -----	1
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A	test example1 technical field paragraph [0037] - paragraph [0038] -----	1
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A	paragraphs [0001], [0022], [0026] -----	1

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