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(54) Title: VEGAN PRODUCT FORMULATIONS AND METHODS THEREOF

(57) Abstract: The invention describes various plant-based food products such as a meat-mimic, fish mimic or a plant-based dairy product. The plant-based food formulations comprise a plant-based cellulosic material or a dry cellulosic material. Specifically, the invention describes a plant-based smoked salmon, cooked salmon, tuna-mimic and a white-lines mimic. The invention further describes a plant-based yogurt, a plant-based ice cream and a plant-based cream cheese. Furthermore, the invention also provides methods of manufacturing the above plant-based food formulations.

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VEGAN PRODUCT FORMULATIONS AND METHODS THEREOF

FIELD OF THE INVENTION

[1] This invention relates to vegan product formulations with improved nutritional quality, improved sensory characteristics, improved mouthfeel or a combination thereof. More specifically, the invention relates to vegan product formulations that mimic meat and dairy products.

BACKGROUND OF THE INVENTION

[2] The rapid improvement in the global demand for meat (Bryant & Barnett, 2018) and dairy products (Cardello et al., 2022; Adesogan & Dahl, 2020) allied to economic reasons, and also ethical and environmental concerns due to the lack of sustainability associated with the increase of the conventional meat production system (Alexander et al., 2017; Asgar et al., 2010), create a disparity between future demand and the capacity of conventional meat production to supply the market. Thus, there is an increasing need for meat and dairy products alternatives production to mitigate major concerns associated with animal welfare issues, negative impact on the environment, climate changes, and global public health issues in the near future (Zhang et al., 2020; Lee et al., 2020; Cardello et al., 2022).

[3] Seafood plant-based substitutes represent an attractive market due to factors such as independence from population and geographical constraints, fewer health risks, including seafood allergies, reduced loss in the supply chain, high price points of many seafood products, and high release of carbon dioxide into the atmosphere each year because marine species are some of the most vulnerable to climate change. Moreover, the increase in investment in alternative seafood companies (alternative seafood companies raised $175 million in 2021, nearly double the amount raised in 2020), (GFI, 2021). In addition to seafood, dairy products also can be considered a good market due to the increased demand for milk in low- and middle-income countries. Currently, meat or dairy substitutes consumption is totalling 90%, 68% and 64% of vegans, vegetarians and pescatarians, respectively (Tonheim et al., 2022).

[4] Plant-based meat and dairy products analogs are promising alternatives to protein sources in the future. The plant-based option currently represents the biggest market among meat analogs with a prospect of market increase to over $21.23 billion US dollars by 2025 (Zion Market Report, 2019). Plant-based alternatives demonstrate to be an efficient substitute, mainly on the nutritional value aspect, for a wide range of consumers. However, most of the plant-based options are still considered ultra-processed foods and the sensory characteristics such as colour, flavour, and texture still represent a bottle-neck for this type of product being the main barrier to consumer acceptability (Lee et al., 2020; Asgar et al., 2010; Bohrer et al., 2019).

[5] A major issue with vegan products is to protect the natural colourants from washing away and avoid denaturation in low temperatures. Additional problems arise in recreating meat-like texture (fibres and mouthfeel). Traditionally, these problems have been addressed by utilizing ingredients or additives processed using harsh chemicals such as NaOH. In addition, commonly used vegan meat alternatives demonstrate an ultra-processed texture with artificial colourants, which is not favoured by many consumers. Moreover, although the dairy substitutes resemble the conventional products in colour and mouthfeel, different properties are still negatively impacting this type of product such as beany and painty off flavours, a chalky mouthfeel due to large insoluble particles, and a darker colour when compared to the cow's milk (Tonheim et al., 2022).

SUMMARY OF THE INVENTION

[6] The invention described herein relates to vegan or plant-based food products. The food-product could be any meat-mimic or seafood-mimic. Various plant-based food formulations are envisioned and can be prepared as described in the application. The plant-based food product such as cooked salmon may comprise various ingredients such as a bleached plant material or scaffold (cellulose based dry or wet); at least one texturized vegetable protein, isolated protein, or both; at least one thickening agent or gelling agent; and one or more food additives.

[7] The invention also describes another plant-based product or formulation such as smoked salmon with ingredients such as a bleached plant material or scaffold (cellulose based dry or wet), at least one cellulose material, at least one fatty acid group; at least one thickening/gelling agent; and one or more food additives. The food product may additionally comprise at least one oil.

[8] The invention described also provides a plant-based, vegan white lines mimic, or a white lines formulation. The ingredients of the white lines mimic or formulation include an egg-white substitute, a gelatin substitute, or both; any oil, preferably a vegetable oil; and a cellulose source. In addition, the plant-based white lines mimic may additionally comprise one or more food additives, one or more thickeners, one or more emulsifiers, salts, sugars, artificial sweeteners, water, or a combination thereof.

[9] The invention described also provides a plant-based yogurt formulation. The plant-based formulation may comprise a cellulosic material, at least one nanocellulose and/or one or more food additives.

[10] A method of manufacturing a plant-based food product such as cooked salmon is also described. The method involves a step of preparing a mixture comprising a bleached plant material or a bleached plant-based scaffold, at least one thickening/gelling agent, one or more food additives except calcium hydroxide, at least one oil, or a combination thereof. The mixture is then heated until a pre-determined temperature is reached or until a pre-determined period of time. The next step is to add Calcium Hydroxide to the mixture, followed by adding at least one texturized vegetable protein, isolate protein, or both to the mixture, and mixing the ingredients manually

or by electronic means to prepare a dough. The dough i.e. the final mixture is then wrapped and vacuum sealed to prepare the plant-based food product.

[11] The invention also describes another method of preparing the plant-based food product such as smoked salmon. The method may comprise a step of preparing a dry mixture comprising at least one cellulose material, at least one thickening/gelling agent, at least one texturized vegetable protein, at least one isolate protein or a combination thereof. The method further comprises a step of preparing a wet mixture comprising a bleached plant material or bleached plant-based scaffold, at least one oil, at least one fatty acid group, water, or a combination thereof, followed by a step of mixing the wet mixture continuously with intermittent breaks to add any additional food additives. The method further includes a step of pouring the dry mixture slowly in the wet mixture to prepare a final mixture which is heated for a predetermined period until a desired temperature is reached. This is followed by a step of adding one or more preservatives to the final mixture and wrapping the final mixture and vacuum sealing it to prepare the plant-based food product.

[12] A method of manufacturing a plant-based/vegan yogurt formulation is also described. A cellulosic material and/or at least one nanocellulose is homogenized to prepare a homogenized cellulose mixture which is followed by adding one or more food additives, a protein source, a fat source, a sugar source, a bacterial source, a nitrogen source, at least one growth factor, or a combination thereof, to the homogenized cellulose mixture. The final mixture is then allowed to ferment for a predetermined time to prepare the plant-based yogurt formulation.

[13] A plant-based food product, a plant-based tuna or plant-based fish product is provided. The plant-based food product may comprise the following ingredients: a) a dry cellulosic material; b) at least one texturized vegetable protein; c) at least one thickening/gelling agent; and d) one or more food additives.

[14] Another plant-based food product such as a plant-based tuna or plant-based fish product is provided. The plant-based food product comprises water; a dry cellulosic material; a thickening/gelling agent from Konjac gum, Xanthan Gum, k-carrageenan, or a combination thereof; a texturized protein such as Fava Protein; a flavoring agent from a Fish Flavor, a Tuna flavour, or both; a coloring agent from Supra red, Magna Ruby, Red No. 40, or a combination thereof; a vegetable oil such as Flaxseed oil; a yeast extract; a food additive such as Salt, Sorbitol, or both; and a fatty acid such as Omega 3.

[15] A plant-based ice cream product is also described. The plant-based ice cream comprises a cellulosic material, at least one thickening/gelling agent, at least one starch, at least one milk alternative and one or more food additives.

[16] Another plant-based ice cream is also described. The ice-cream comprises a cellulosic material preferably a plant-based material; a texturized vegetable protein such as fava protein, at least one thickening/gelling agent such as locust bean, cashew, or both; at least one starch such as arrowroot, cornstarch, or both; one or more food

additives such as water; at least one flavoring agent such as coffee, hazelnut paste or both; at least one oil such as coconut oil, at least one milk alternative from cashew milk or oat milk, and at least one sugar source such as dry sugar, glucose or both.

[17] A plant-based cheese product is also described. The plant-based cheese comprises a cellulosic material, a plant-based texturizer, a vegetable oil and one or more food additives.

[18] Use of plant-based cellulosic material is also described. The cellulosic material may be used to prevent or decrease the formation of ice crystals in the plant-based cheese or to improve texture and water retention capacity of the plant-based cheese. The plant-based cellulosic material may also be used to prepare plant-based meat, fish and tuna formulations and plant-based dairy formulations as described in the application.

BRIEF DESCRIPTION OF DRAWINGS

[19] Figure 1 shows images of FIMT-102 and FIMT-103 formulations before the formulations were cooked.

[20] Figure 2 shows images of FIMT-102 and FIMT-103 formulations after they were cooked.

[21] Figure 3 shows a chart-based comparison of the sensory characteristics of FIMT-102 and FIMT-103 formulations rated from 1 to 9.

[22] Figure 4 shows images of the FIMT-108 and FIMT-109 before cooking.

[23] Figure 5 shows images of FIMT-108 and FIMT-109 formulations after they were cooked.

[24] Figure 6 shows a chart-based comparison of the sensory characteristics of FIMT-108 and FIMT-109 formulations rated from 1 to 9.

[25] Figure 7 shows an image of FIMT-108 before cooking.

[26] Figure 8 shows sensory analysis of FIMT-108 rated on a scale from 1 to 9.

[27] Figure 9 shows an image of FIMT 105 A and FIMT 105 B formulations before cooking.

[28] Figure 10 shows an image of FIMT 105 A and FIMT 105 B formulations after cooking.

[29] Figure 11 shows sensory analysis of FIMT-105A and FIMT-105B rated on a scale from 1 to 9.-

[30] Figure 12 shows an image of the three formulations FIMT-099, FIMT-100 and FIMT-101 before cooking.

[31] Figure 13 shows an image of FIMT-099, FIMT-100 and FIMT-101 after cooking.

[32] Figure 14 shows sensory analysis of FIMT-099, FIMT-100 and FIMT-101 rated on a scale from 1 to 9.

[33] Figure 15 provides a comparison between the FIMT-172 (left) and FIMT-173 (right) formulations.

[34] Figure 16 shows the FIMT-173 formulation before the cooking process.

[35] Figure 17 provides a comparison between formulations FIMT- 172 and FIMT-173 sensory analysis results.

[36] Figure 18 provides the mechanical testing analysis of salmon standards (bottom 4 graphs i.e. Figure 18B) and FIMT-052 samples (top 4 graphs i.e. Figure 18A).

[37] Figure 19 shows the samples of conventional Atlantic salmon and Salmon plant-based Salmon prototype (left) and an image of the LabMaster - Aw equipment (right).

[38] Figure 20 shows the samples of plant-based Salmon prototype and conventional Atlantic Salmon after the cooking process to determine the cooking loss.

[39] Figure 21 shows samples of conventional Atlantic Salmon (left), and plant-based Salmon (right) for colour analysis and the apparatus used for the colour analysis.

[40] Figure 22 shows images of samples of conventional Atlantic Salmon (left), and plant-based Salmon (right) for density.

[41] Figure 23 provides the mechanical test graph from the Chinook cooked salmon.

[42] Figure 24 provides the mechanical test graph from Plant-based cooked salmon.

[43] Figure 25 tabulates the distribution of the sensory attributes from the plant-based cooked salmon prototype (FIMT-104) compared to the reference (Chinook salmon).

[44] Figure 26 provides a Radar Graph of the sensory attributes from the plant-based cooked salmon prototype (FIMT-088) compared to the reference (Chinook salmon).

[45] Figure 27 shows an image of cooked plant-based salmon prototype during the cooking process (dry-heating).

[46] Figure 28 shows an image of the cooked plant-based salmon prototype plated.

[47] Figure 29 shows an image of the cooked plant-based salmon prototype plated.

[48] Figure 30.1 shows an image of water loss after regular freezing (-18℃) and thaw cycle. Figure 30.2 shows an image of SSMT - 062 with no water loss after regular freezing (-18℃) and thaw cycle. Figure 30.3 shows an image of SSMT-061 after blast freezer. Figure 30.4 shows an image of SSMT-061 after it is thawed in the regular fridge for 4 days.

[49] Figure 31 provides a comparison between formulations SSMP -007 and SSMPC-008 sensory analysis results.

[50] Figure 32 shows the mechanical test graphs from the Conventional smoked salmon.

[51] Figure 33 shows the mechanical test graphs from Plant-based smoked salmon.

[52] Figure 34 shows an image of conventional smoked salmon plated.

[53] Figure 35 shows an image of smoked plant-based salmon prototype plated.

[54] Figure 36 provides the sensory analysis graph for the formulations in this section. Table 18 Sensory analysis for different attributes comparison among all samples.

[55] Figure 37 provides the comparison of the Mechanical hardness (N) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon).

[56] Figure 38 provides the comparison of the Mechanical cohesiveness (N) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon).

[57] Figure 39 provides the comparison of the Water loss (%) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon)

[58] Figure 40 shows images of MAM-004 (top left), MAM-005 (top middle), GC-003 (top right), GC-005 (bottom left), MAC-004 (bottom right).

[59] Figure 41 shows an image of MAC-029.

[60] Figure 42 provides a comparison between MAC-042 and MAC-043 formulations.

[61] Figure 43 shows images of MAC-030 and MAC031 respectively.

[62] Figure 44 shows pictures of the PAC-001 (PAC) vs. bamboo fiber cellulose (1%) (BFC) suspensions taken (LEFT) immediately after shaking, (MIDLLE) after sitting for 5 minutes, (RIGHT) after sitting for 4 hours.

[63] Figure 45 provides pictures showing the spreadability of the non fermented cellulosic material gels samples, formulations PAC-003, PAC-004, and PAC-005.

[64] Figure 46 shows a picture of the formulations PAC-003, PAC-004, and PAC-005 before (left) and after centrifugation.

[65] Figure 47 shows a graph showing the effect on viscosity caused by centrifugation for the formulations PAC-003, PAC-004 and PAC-005.

[66] Figure 48 shows a graph showing the distribution of the Viscosities of the Initial versus the two weeks stored samples.

[67] Figure 49 shows a graph comparing the viscosities of the commercial yogurts and cellulosic material homogenates. Samples PAC-007, 008, and 010 have protein in their composition where the dot lines represent the target viscosity values for regular and Greek yogurt.

[68] Figure 50 shows pictures of the cellulosic material homogenates before and after centrifugation.

[69] Figure 51 shows a picture of the plant-based homogenate before (LEFT) and after (MIDDLE) fermentation for 6h at 37℃. At right is the fermented gel after centrifugation.

[70] Figure 52 shows a picture of the high-protein cellulosic material homogenate gel.

[71] Figure 53 shows a diagram of the main steps to obtain plant-based yogurt using the cellulosic material scaffold.

[72] Figure 54 shows a diagram for the process flows to obtain plant-based yogurt using the cellulosic material scaffold.

[73] Figure 55A and Figure 55B provide a Sensory analysis graph for Tuna formulations.

[74] Figure 55C provides a comparison among the sensory parameters from samples TMPC-028 to TMPC-032.

[75] Figure 55D provides a comparison among the sensory parameters from samples TMPC-033 to TMPC-037.

[76] Figure 55E provides a comparison among the sensory parameters from samples TMPC-039 to TMPC-042.

[77] Figure 56 provides a comparison between regular ice cream and ice cream made with the cellulosic material and cellulose competitors.

[78] Figure 57 provides a comparison between milk ice cream (left) and regular ice cream fabricated in-house (right) - 5 min at room temperature.

[79] Figure 58 provides a comparison between regular ice cream and ice cream made with cellulosic material without egg (Egg substitution).

[80] Figure 59 provides a comparison between ice cream fabricated with Avicel (left) + vegan formulation (middle) + Methocel (right) after 1 h at room temperature.

[81] Figure 60 provides a comparison of the churning time among vegan ice-cream fabricated with cellulosic material, Avicel, methocel, and regular ice creams.

[82] Figure 61 shows the plant-based cream cheese control ((a) on the left) and fabricated with cellulosic material ((b) on the right) spread in a toast.

[83] Figure 62 shows the plant-based cream cheese control ((b) on the right) and fabricated with cellulosic material ((a) on the left) right after the freezing process.

[84] Figure 63 shows the plant-based cream cheese from the market (left), control fabricated in-house (middle), and fabricated with cellulosic material (right) after the thawing process at Room temperature.

[85] Figure 64 shows the comparison of the viscosity from cream cheeses containing cellulosic material concentration ranging from 0 to 3%.

DETAILED DESCRIPTION

[86] The following description is of preferred embodiments by way of example only and without limitation to the combination of features necessary for carrying the invention into effect.

[87] All terms are intended to be understood as they would be understood by a person skilled in the art. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the disclosure pertains. The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[88] Although various features of the present disclosure can be described in the context of a single embodiment, the features can also be provided separately or in any suitable combination. Conversely, although the present disclosure can be described herein in the context of separate embodiments for clarity, the present disclosure can also be implemented in a single embodiment.

[89] The following definitions supplement those in the art and are directed to the current application. Accordingly, the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting

DEFINITIONS

[90] In this application, the use of the singular includes the plural unless specifically stated otherwise. It must be noted that, as used in the specification, the singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise.

[91] In this application, the use of "or" means "and/or" unless stated otherwise. The terms "and/or" and "any combination thereof and their grammatical equivalents as used herein, can be used interchangeably. These terms can convey that any and all combinations are specifically contemplated. The term "or" can be used conjunctively or disjunctively, unless the context specifically refers to a disjunctive use.

[92] Furthermore, use of the term "including" as well as other forms, such as "include", "includes," and "included," is not limiting.

[93] Reference in the specification to "some embodiments," "an embodiment," "one embodiment" “alternate embodiment”, or "other embodiments" means that a particular feature, structure, or characteristic described in connection with the embodiments is included in at least some embodiments, but not necessarily all embodiments, of the present disclosures.

[94] As used in this specification and claim(s), the words "comprising" (and any form of comprising, such as "comprise" and "comprises"), "having" (and any form of having, such as "have" and "has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, unrecited elements or method steps. It is contemplated that any embodiment discussed in this specification can be implemented with respect to any method or composition of the present disclosure, and vice versa. Furthermore, compositions of the present disclosure can be used to achieve methods of the present disclosure.

[95] The term "about" in relation to a reference numerical value and its grammatical equivalents as used herein can include the numerical value itself and a range of values plus or minus 10% from that numerical value. The term "about" or "approximately" means within an acceptable error range for the particular value as determined by one of ordinary skill in the art, which will depend in part on how the value is measured or determined, i.e., the limitations of the measurement system. For example, "about" can mean within 1 or more than 1 standard deviation, per the practice in the art. Alternatively, "about" can mean a range of up to 20%, up to 10%, up to 5%, or up to 1% of a given value. In another example, the amount "about 10" includes 10 and any amounts from 9 to 11.

[96] The term “plant-derived cellulosic material” refers to mercerized or bleached plant material, plant part or tissue thereof. The mercerized or bleached plant material may be cellulose-based dry or wet material.

[97] To overcome the defects of the prior art, the inventors propose recreating vegan products with improved formulations that mimic traditional meat products or dairy products, which would allow consumers to choose a gastronomic experience that does not involve animal cruelty. The inventors have set out to recreate production processes that usually present challenges and issues on animal welfare, public and environmental health, global warming, and impact on global food prices inflation.

[98] In some embodiments, vegan formulations within the Salmon family such as smoked salmon and cooked salmon are provided. In some alternate embodiments, vegan products mimicking traditional dairy products, such as vegan yogurt are provided. Apart from developing high-quality formulations that can mimic the whole muscle other than just an ultra-processed meat product, the claimed formulations also reproduce or rather recreate products with the similar nutritional value expected of the traditional meal.

EMBODIMENTS

[99] In an embodiment of the invention, a vegan or plant-based food product is provided. The food-product could be any meat-mimic or seafood-mimic. Various plant-based food formulations could be envisioned and prepared as described in the application. In one embodiment of the invention, the plant-based food product may comprise various ingredients such as a bleached plant material (cellulose-based dry or wet) or bleached plant—

based scaffold; at least one texturized vegetable protein, isolate protein, or both; at least one thickening agent or gelling agent; and one or more food additives. In certain embodiments there could be more than one bleached plant material or scaffold (cellulose based dry or wet) in the formulation. In some embodiments, the food product may include a higher proportion of one or more of the ingredients listed above.

[100] In another embodiment of the invention, the plant-based food product may additionally comprise at least one cellulose material, at least one oil or both. A variety of food-grade ingredients known in art may be added to the plant formulation/product.

[101] In certain embodiment, the bleached plant material or scaffold (cellulose based dry or wet) may be derived from any plant-based tissue or plant part that may be used to prepare the food-product. In certain embodiment, the bleached plant material or scaffold (cellulose based dry or wet) is derived from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, potato, grape skin, or a combination thereof.

[102] In certain embodiments, the at least one texturized vegetable protein may be any food-grade vegetable protein known in the art. In an exemplary embodiment, the texturized vegetable protein may be derived from mung bean, fava bean, brown rice, pea, wheat, zein or a combination thereof.

[103] In certain embodiments, the at least one isolate protein may be any isolate protein known in the art. For instance, some non-limiting examples are whey isolate, whey concentrate, whey hydrolysate, milk protein, mung bean, fava bean, brown rice, pea, wheat, zein, or a combination thereof.

[104] In certain embodiments, the at least one thickening agent or gelling agent may be any known thickening or gelling ingredients used in the art. For instance, some non-limiting examples are konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cornstarch, potato starch, modified starch, cellulose ethers (Methocel), xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar) or a combination thereof.

[105] In certain embodiments, the one or more food additives may be any flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

[106] In certain embodiments, the at least one cellulose material may be any known food-grade cellulose material in the art. For instance, some non-limiting examples are bamboo fibre, woven bamboo fibre, potato fibre or any combination thereof. The at least one oil may be any known plant-based, food-grade oil in the art e.g. a vegetable oil.

[107] In certain embodiments, the concentration of the bleached plant material or scaffold (cellulose based dry or wet) in the food-product or formulation may range from 10%-80%, in some instances it may range from 20% to 70%. The concentration of the at least one texturized vegetable protein, isolate protein or both is may range from 2% to 60%, in some instance it may range from 5% to 50%. A person skilled in the art would understand that the concentration of ingredients could be varied to alter the mouthfeel, texture and taste of the product.

[108] In certain embodiments, the concentration of the bleached plant material or scaffold (cellulose based dry or wet) in the formulation could be in the range of 30%-80%. In certain embodiments, the concentration of the plant material is in the range of 40% to 70%. In certain other embodiments, the concentration of the at least one texturized vegetable protein, isolate protein or both in the formulation is in the range of 3% to 35%. In certain other embodiments, the concentration of the texturized or isolate protein or their combination in the formulation is in the range of 5% to 20%.

[109] The plant-based food product or formulation as described hereinbefore may be used for manufacturing a plant-based meat product or a vegan meat product or a plant-based meat mimic. Some non-limiting examples may a plant-based salmon mimic, a plant-based fish-fillet mimic, or a plant-based salmon like product. It is expected that the mouthfeel, sensory feel and texture of the plant-based meat mimic or meat product are similar to a regular meat-based product or meat product. The plant-based recipes resemble are almost identical or resemble quite closely to the actual meat products. In fact, in certain embodiments, the proximate composition, protein content, or chemical properties of the plant-based meat mimic are similar to the meat-based product.

[110] In certain embodiments, the bleached cellulose-based plant material may be replaced by microcrystalline cellulose or any other commercially available cellulose.

[111] In another aspect of the invention, another plant-based food product is provided. In an exemplary embodiment, the plant-based formulation or food product generally comprises water, mung bean protein crisp, isolate protein, sunflower oil, konjac gum ,Ca(OH)2, salt, Plant-derived cellulosic material, bleached plant material, tapioca starch, wheat TVP, brilliant orange, astaxanthin, watermelon pink, flavorcan masker, new salmon flavor, glucone delta lactone, and kappa carrageenan.

[112] In another aspect of the invention, another pant-based food product is provided. In an exemplary embodiment, the food product generally comprises water, isolate mung bean protein, sunflower oil, algae oil, methyl cellulose, Plant-derived cellulosic material, bleached plant material, pea protein, watermelon pink, baked salmon flavour, natural salmon flavour type, or yeast extract.

[113] In certain embodiments, the above plant-based food product recipes or formulations are used to prepare a cooked salmon mimic.

[114] In another aspect of the invention, a plant-based food product is provided. The plant-based product or formulation comprises ingredients such as a bleached plant material or scaffold (cellulose based dry or wet), at least one cellulose material, at least one fatty acid group; at least one thickening/gelling agent; and one or more food additives. In certain exemplary embodiment, the food product may additionally comprise at least one oil. In certain embodiments, the plant-based food product may additionally comprise at least one texturized vegetable protein, isolate protein, or both. The at least one texturized vegetable protein, isolate protein, could be any known protein in the art.

[115] In certain exemplary embodiments, the bleached plant material or scaffold (cellulose based dry or wet) may be derived from any known plant tissue or plant part. For instance, the bleached plant material or scaffold (cellulose based dry or wet) is derived from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, potato, grape skin, or a combination thereof.

[116] In certain exemplary embodiments, the at least one texturized vegetable protein may be mung bean, fava bean, brown rice, pea, wheat, zein or a combination thereof. The at least one isolate protein could be any food grade isolate protein. Some non-limiting examples could be whey isolate, whey concentrate, whey hydrolysate, milk protein, mung bean, fava bean, brown rice, pea, wheat, zein, or a combination thereof.

[117] In certain embodiments, the at least one thickening/gelling agent may any known food grade thickening or gelling agents known in the art. Some non-limiting examples could be konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cornstarch, potato starch, modified starch, cellulose ethers (Methocel), xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar) or a combination thereof.

[118] In certain embodiments, the one or more food additives may be selected from flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, , preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

[119] Various known fatty acid groups can be used in the plant-based food product. In certain embodiments, the at least one fatty acid group is Omega 3 or Omega 6. The plant-based food product of claim 18, wherein the at least one cellulose material is bamboo fibre, woven bamboo fibre, potato fibre or any combination thereof.

[120] In certain exemplary embodiments, the concentration of the bleached plant material or scaffold (cellulose based dry or wet) may be in the range of 10% to 80%. In certain other embodiments, the concentration of the bleached plant material or scaffold (cellulose based dry or wet) may be in the range of 20% to 70%.

[121] In certain embodiments, the concentration of the bleached plant material or scaffold (cellulose based dry or wet) in the formulation could be in the range of 30%-80%. In certain embodiments, the concentration of the plant material is in the range of 40% to 70%. In certain other embodiments, the concentration of the at least one texturized vegetable protein, isolate protein or both in the formulation is in the range of 3% to 35%. In certain other embodiments, the concentration of the texturized or isolate protein or their combination in the formulation is in the range of 5% to 20%.

[122] In certain embodiments, above plant-based food-product or formulation may be used for manufacturing a plant-based meat product or a vegan meat product or a plant-based meat mimic. For instance, the plant-based food product may be for manufacturing a plant-based salmon mimic, a plant-based fish-fillet mimic, or a salmon like product. In certain embodiments, the mouthfeel, sensory feel and texture of the plant-based meat mimic are similar to or closely resemble a meat-based product.

[123] It is expected that the mouthfeel, sensory feel and texture of the plant-based meat mimic or meat product are similar to a regular meat-based product or meat product. The plant-based recipes are almost identical or resemble quite closely to the actual meat products. In fact, in certain embodiments, the proximate composition, protein content, or chemical properties of the plant-based meat mimic are similar to the meat-based product.

[124] In certain embodiments, the bleached cellulose-based plant material may be replaced by microcrystalline cellulose or any other commercially available cellulose.

[125] In certain exemplary embodiments, the plant based food-product may comprise water, mercerized or bleached or bleached apple, bamboo fiber, konjac gum, k-carrageenan, calcium hydroxide, citric acid, salt, smoked salmon flavour, paprika, fiesta pink, omega 3, and flaxseed oil.

[126] In certain embodiments, the plant based product recited above may be for manufacturing a plant-based smoked salmon mimic.

[127] In certain embodiments, the plant-based food product or formulation described hereinbefore could be used for manufacturing a plant-based meat mimic, a plant-based seafood mimic, a plant-based snack, a plant-based processed food product, or a plant-based frozen food-product. In some other embodiments, the vegan food product could be used for manufacturing a plant-based salmon mimic, a plant-based fish-fillet mimic, a plant-based food-product with a higher shelf life. In some embodiments, the food-mimics may include meat-like flavoring to enhance the mouthfeel of the product. The mouthfeel, sensory feel, characteristics, taste, chewiness, consistency and texture of the plant-based meat mimic or food product are similar or identical to a meat-based product.

[128] In another aspect of the invention, a plant-based or vegan white lines mimic or a white lines formulation is provided. The white lines mimic or formulation may comprise an egg-white substitute, a gelatin substitute, or both;

any oil, preferably a vegetable oil; and a cellulose source. In addition, the plant-based whilte lines mimic may additionally comprises one or more food additives, one or more thickeners, one or more emulsifiers, salts, sugars, artificial sweeteners, water, or a combination thereof.

[129] In some embodiments, the egg-white substitute could be any know egg-substitute in the art. In some other embodiment, the egg-substitute is aquafaba. In some embodiments, the gelatin substitute could be any know substitute in the art. In some embodiments, the gelatin substitute is agar agar. In some embodiments, the formulation may comprise any known oil in the art. In some embodiments, the formulation may comprise may comprise a vegetable oil. In some other embodiments, the vegetable oil is sunflower oil.

[130] In certain embodiments, the plant-based white line mimic may comprise any known cellulose source in the art. In certain embodiments, the cellulose source may be plant-derived cellulosic material or bleached plant material or methyl cellulose (e.g. methocel).

[131] In certain embodiments, the plant-based mimic or formulation may additionally comprise other ingredients for flavoring or taste masking or improving the texture or appearance of the formulation. In some embodiments, the mimic additionally comprises xanthan gum.

[132] In another embodiment of the invention, a plant-based yogurt formulation is provided. The plant-based or vegan yogurt formulation may comprises at least one cellulose source and one or more food additives. The plant-based formulation may comprise a cellulosic material, at least one nanocellulose and one or more food additives.

[133] In certain embodiments, the plant-based yogurt may additionally comprise other ingredients for instance a protein source, a fat source, a sugar source, a bacterial source, a nitrogen source, at least one growth factor, or a combination thereof.

[134] In certain embodiments, the at least one nanocellulose source could be cellulose nanofibres. The cellulose nanofibres could be in a composition or in a slurry form. The at least one or more food additives selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or any combination thereof.

[135] In some embodiments, the plant-based yogurt may contain the at least one or more food additive may be any food additive known in the art. The at least one or more food additive may also be selected from xanthan gum, carrageenan, guar gum, pectin, modified starches, starch acetate, hydroxypropyl starch, cationic starch, carboxymethylated starch and other modified starches, Alginates, or carboxymethylcellulose (CMC).

[136] In certain embodiments, the protein source could be selected from any plant protein source known in the art. In some embodiments, the protein source maybe selected from a vegetable protein or a protein isolate. For instance, the protein source could be mung bean isolate, fava bean isolate, brown rice isolate, soybean isolate, or a hydrolyzed protein from any of these sources.

[137] In certain embodiments, the plant-based yogurt may comprise alt least one bacterial source. In some embodiments, the yogurt may comprise one or more bacterial sources. For instance, the bacterial source could be Bacillus bulgaricus. The viscosity of the yogurt could be adjusted as needed and using a variety of ingredients and viscosity modulators known in the art. For instance, the viscosity may range from 8 Pa.s to 80 Pa.s.

[138] In certain embodiments, use of a bleached plant material or scaffold (cellulose based dry or wet) for production of a plant-based seafood or meat product is provided. In certain other embodiments, use of a combination of cellulosic material and/or a nanocellulose is provided for manufacturing a plant-based yogurt formulation. In certain other embodiments, use of aquafaba to mimic white lines in a plant-based meat mimic is provided.

[139] In another aspect of the invention, use of a bleached plant material or scaffold (cellulose based dry or wet) for production of a plant-based seafood or meat product is provided. Any known plant-based material, plant parts, plant tissues, plant-based scaffolds, or plant components may be used for production of a plant-based seafood or meat product. In certain exemplary embodiments, use of a combination of a cellulosic material and/or a nanocellulose to manufacture a plant-based yogurt formulation is provided. In other embodiment, use of aquafaba to mimic white lines in a plant-based meat mimic is provided.

[140] In another aspect of the invention, a method of manufacturing a plant-based product, is provided. The plant-based product may be any plant-based meat mimic, or plant-based vegan product. In certain exemplary embodiments, the method is to manufacture a plant-based cooked salmon product or mimic.

[141] The method involves a step of preparing a mixture comprising a bleached plant material or a bleached plant-based scaffold, at least one thickening/gelling agent, one or more food additives except calcium hydroxide, at least one oil, or a combination thereof. The mixture is then heated until a pre-determined temperature is reached or until a pre-determined period of time. The next step is to add Calcium Hydroxide to the mixture, followed by adding at least one texturized vegetable protein, isolate protein, or both to the mixture, and mixing the ingredients manually or by electronic means to prepare a dough. The dough i.e. the final mixture is then wrapped and vacuum sealed to prepare the plant-based food product.

[142] In certain embodiments, the method further comprises freezing the vacuum sealed food product and placing it in a sous-vide machine. The freezing step may be carried out for a period of 30 minutes to a few hours

and could be carried out for 24 hours. In certain exemplary embodiments, the vacuum sealed food product may be frozen for a period of 1-4 hours.

[143] In certain embodiments, the method may further comprise a step of unwrapping the vacuum sealed food product, cutting the cutting the food product at an angle to create layers; and then spreading white lines between the layers and resealing the food product.

[144] In certain other embodiments, the method may further comprise a step of storing the vacuum sealed food product in a fridge or a freezer until the food product is consumed. For instance, the food product may be stored for a long period of time and taken out only when it is to be consumed.

[145] In certain embodiments, the method may comprise an additional step of pre-soaking the at least one texturized vegetable protein, isolate protein or both in water prior to adding to the mixture. The method may further comprise a step of squeezing the pre-soaked protein(s) to remove excess water prior to adding to the mixture.

[146] In certain other embodiment, the method may further comprise a step of shredding the pre-soaked proteins prior to adding to the mixture.

[147] In certain exemplary embodiments, the bleached plant material or bleached plant-based scaffold may be kept aside with the at least one texturized vegetable protein, the isolate protein, or both and are later added to the mixture simultaneously.

[148] In certain embodiments, the method may comprise a step of placing the vacuum sealed food product in the sous-vide machine. The temperature in the sous-vide machine may vary greatly and can be maintained at a range of 40ºC – 90ºC. In certain embodiments, the temperature of 50ºC – 80ºC is maintained for a period of 10 minutes – 180 minutes. In certain embodiments, the final mixture may be allowed to stand for a predetermined period prior to wrapping and vacuum sealing it.

[149] In certain embodiments, the step of mixing is generally carried out by mixing by hand, a robotic coupe, a mixer or by a dispersive mixing technique to mix the ingredients uniformly.

[150] In certain embodiments, the method may be for preparing the plant-based food product as defined hereinbefore. The method may be utilized for manufacturing a plant-based meat product, such as a smoked salmon meat mimic. The method may comprise a step of preparing a dry mixture comprising at least one cellulose material, at least one thickening/gelling agent, at least one texturized vegetable protein, at least one isolate protein or a combination thereof. The method further comprises a step of preparing a wet mixture comprising a bleached plant material or bleached plant-based scaffold, at least one oil, at least one fatty acid group, water, or a combination thereof, followed by a step of mixing the wet mixture continuously with intermittent breaks to add any

additional food additives. The method further includes a step of pouring the dry mixture slowly in the wet mixture to prepare a final mixture which is heated for a predetermined period until a desired temperature is reached. This is followed by a step of adding one or more preservatives to the final mixture and wrapping the final mixture and vacuum sealing it to prepare the plant-based food product.

[151] In an exemplary embodiment, optionally the method may include a step of adding calcium hydroxide to the dry mixture.

[152] Generally, the step of mixing is carried out by mixing by hand, a robotic coupe, a mixer or by a dispersive mixing technique which allows the components/ingredients to mix uniformly. In certain embodiments, the method may involve a step of mixing the final mixture and heating it until the desired temperature of 70ºC – 100ºC is reached.

[153] In another embodiment, the method may further comprise the steps of freezing the vacuum sealed mixture and placing it in a sous-vide machine; and storing the vacuum sealed mixture in a fridge or a freezer until the food product is consumed.

[154] In certain exemplary embodiments, the method includes placing the vacuum sealed food product in the sous-vide machine at a temperature of 40ºC – 90ºC. In certain embodiments, the temperature may be in the range of 50ºC – 80ºC, or for a period of 0.5 minute – 5 minutes.

[155] In an embodiment of the invention, the freezing step may be carried out overnight for a period of 12 hours, 24 hours, 48 hours or more. In certain embodiments, the freezing step may be carried out using a blast freezer to prevent formation of ice crystals. In certain other embodiments, the method may further comprise a step of unwrapping the vacuum sealed food product; followed by cutting the food product at an angle to create layers; and then spreading white lines between the layers and resealing the food product. This allows creation of a product with white lines. In certain embodiments, the one or more preservative may be citric acid. Overall, the above method steps may be employed for preparing the plant-based food product or the plant-based salmon mimic.

[156] A cast may also be used to shape the food product. The product may also be cut after the freezing step at an angle to add white lines prior to vacuum sealing it. In some cases, the vacuum sealed mixture may be placed on an ice bath prior to storing it in the fridge. In some cases, the protein content of the product may be improved or increased by adding additional quantity of the texturized vegetable protein or the isolate protein. A zero position calibration could also be performed prior to wrapping and sealing the final mixture.

[157] In another aspect of the invention a method of manufacturing a plant-based or vegan yogurt formulation is provided. The method involves a step of homogenizing a plant-based or plant-derived cellulose and at least one nanocellulose to prepare a homogenized cellulose mixture. The method further comprises a step of adding one or

more food additives, a protein source, a fat source, a sugar source, a bacterial source, a nitrogen source, at least one growth factor, or a combination thereof, to the homogenized cellulose mixture. The mixture is then allowed to ferment for a predetermined time to prepare the plant-based yogurt formulation.

[158] In certain embodiments, the method further comprises a step of adding at least one growth factor, vitamin or both to the homogenized cellulose mixture. The method may also involve a step of performing homogenization in a mixer at a high speed and/or high shear rate. The method may also involve a step of optionally centrifuging the homogenized cellulose mixture to adjust the viscosity of the formulation. The method may also involve a step of optionally letting the homogenized cellulose mixture to sit for a predetermined time prior to the mixing step. The method may also involve a step of optionally adding flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof, to the homogenized cellulose mixture. The method may also involve a step of packing and storing the plant-based/vegan yogurt formulation.

[159] In another aspect of the invention, another plant-based food product is provided. The plant-based food product may comprise the following ingredients:
a) a dry cellulosic material;
b) at least one texturized vegetable protein;
c) at least one thickening/gelling agent; and
d) one or more food additives.

[160] In a further embodiment, the plant-based food product may additionally comprise at least one oil, at least one fatty acid, or both.

[161] In a further embodiment, the dry cellulosic material used as an ingredient in the plant-based food product is derived from a plant material. The plant material may be from apple, onions, pear, banana, mango, corn cob, fruit pomace, carrots, palm heart, watermelon, melon, kale residues, produces residues, fava residue, oat residue, potato, potato residue, grape skin, or a combination thereof. In an exemplary embodiment, the concentration of the plant-based cellulosic material is in the range of 0.1% - 25%, preferably in the range of 0.5% - 10%.

[162] In a further embodiment, the at least one texturized vegetable protein is derived from mung bean, fava bean, soy, brown rice, pea, wheat, zein or a combination thereof. The concentration of at least one texturized vegetable protein such as fava bean is in the range of 1.0g – 35.0g, preferably in the range of 1.5 g – 20.0 g.

[163] In a further embodiment, wherein the at least one thickening/gelling agent is konjac gum, tapioca starch, kappa-carrageenan, methylcellulose, cornstarch, potato starch, modified starch, cellulose ethers, xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar) or a combination thereof.

The concentration of at least one thickening / gelling agent such as kappa-carrageenan is in the range of 0.15 g – 2.25 g, preferably in the range of 0.25 g – 1.25 g.

[164] In a further embodiment, the one or more food additives may be selected from the group of flavouring agents, colouring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

[165] In a further embodiment, the flavouring agent may be from a plant-based fish flavour, a tuna flavour, or any similar fish flavour or a combination thereof.

[166] In a further embodiment, the colouring agent may be from Magna Ruby, Supra Red, Red No. 40, or any similar colouring agent or a combination thereof.

[167] In a further embodiment, the at least one oil may be any vegetable oil such as flaxseed oil, sunflower oil, coconut oil, peanut oil, olive oil or a combination thereof. In a further embodiment, the at least one fatty acid may be Omega 3, Omega 6, or any other fatty acid with similar properties.

[168] In a further embodiment, the concentration of the dry cellulosic material is in the range of 1% to 3%, and the concentration of the at least one texturized vegetable protein is in the range of 0.3% to 1%.

[169] In a further embodiment, the food product described above is a plant-based tuna mimic or any other fish-mimic, where the mouthfeel, sensory feel and texture of the plant-based tuna mimic or fish-mimic is similar to a regular tuna product or fish product.

[170] In another aspect of the invention, a plant-based food product is provided. The plant-based food product comprises water; a dry cellulosic material; a thickening/gelling agent from Konjac gum, Xanthan Gum, k-carrageenan, or a combination thereof; a texturized protein such as Fava Protein; a flavoring agent from a Fish Flavor, a Tuna flavour, or both; a coloring agent from Supra red, Magna Ruby, Red No. 40, or a combination thereof; a vegetable oil such as Flaxseed oil; a yeast extract; a food additive such as Salt, Sorbitol, or both; and a fatty acid such as Omega 3.

[171] In another aspect of the invention, a plant-based ice cream product is provided. The plant-based ice cream comprises a cellulosic material, at least one thickening/gelling agent, at least one starch, at least one milk alternative and one or more food additives.

[172] In a further embodiment, the ice-cream product may additionally comprise at least one vegetable oil, a texturized vegetable protein, a sugar source, or a combination thereof.

[173] In a further embodiment, the at least one or more food additives may be selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or in combination thereof.

[174] In a further embodiment, the cellulosic material may be derived from a plant material. The plant material may be obtained from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, kale residue, watermelon, melon, produces residue, potato, potato residue, grape skin, or a combination thereof.

[175] In a further embodiment, the texturized vegetable protein may be derived from mung bean, fava bean, brown rice, pea, wheat, soy, zein or a combination thereof.

[176] In a further embodiment, the at least one thickening/gelling agent may be locust bean, konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cellulose ethers , xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar), cashew, or a combination thereof.

[177] In a further embodiment, the at least one starch is arrowroot, cornstarch, potato starch, modified starch, or a combination thereof.

[178] In a further embodiment, the at least one vegetable oil is coconut oil and the at least one milk alternative is almond milk, cashew milk or oat milk.

[179] In a further embodiment, the concentration of the cellulosic material in the plant-based ice cream may be in the range of 0.3 – 2.5%, preferably in the range of 0.3 – 1.5%.

[180] In a further embodiment, the viscosity of the ice cream may be in the range of 40000 cps – 110000cps, preferably in the range of 70000 – 90000 cps.

[181] In a further embodiment, the meltiness, mouthfeel, creaminess, texture and other attributes of the ice cream are similar to regular dairy-based ice cream.

[182] In another aspect of the invention, another plant-based ice cream is provided. The ice-cream comprises a cellulosic material preferably a plant-based material; a texturized vegetable protein such as fava protein, at least one thickening/gelling agent such as locust bean, cashew, or both; at least one starch such as arrowroot, cornstarch, or both; one or more food additives such as water; at least one flavoring agent such as coffee, hazelnut

paste or both; at least one oil such as coconut oil, at least one milk alternative from cashew milk or oat milk, and at least one sugar source such as dry sugar, glucose or both.

[183] In another aspect of the invention, a plant-based cheese is provided. The plant-based cheese may comprise a cellulosic material, a plant-based texturizer, a vegetable oil and one or more food additives.

[184] In a further embodiment, the one or more food additives in the plant-based cheese may be selected from the group of flavouring agents, colouring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or in combination thereof.

[185] In a further embodiment, the cellulosic material in the cheese may be derived from a plant material. The plant material may be obtained from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, kale residue, produce residue, potato, potato residue grape skin, or a combination thereof. In a further embodiment, the concentration of the cellulosic material may be in the range of 0.1% - 10%, preferably in the range of 0.5% to 5%.

[186] In a further embodiment, the plant-based texturizer may be derived from potato, banana, or any similar vegetable. In a further embodiment, the plant-based texturizer may be Perfectasol or any similar texturizer known in the art.

[187] In a further embodiment, the vegetable oil may be flaxseed oil, coconut oil, olive oil, sunflower oil, peanut oil, or any other vegetable oil.

[188] In a further embodiment, the plant-based cheese may additionally comprise a milk alternative. The milk based alternative may be almond milk, cashew milk or oat milk or oat flour.

[189] In another aspect of the invention, use of plant-based cellulosic material is provided. The cellulosic material may be used to prevent or decrease the formation of ice crystals in the plant-based cheese or to improve texture and water retention capacity of the plant-based cheese.

[190] The plant-based cellulosic material may also be used to prepare plant-based meat, fish and tuna formulations and plant-based dairy formulations as described above.

EXPERIMENTAL DATA

[191] The core biomaterial technology is based on the decellularization and mercerization/bleaching of plant tissues. The biomaterial is derived directly from plants, utilizing proprietary methods that avoid the harsh

requirements of traditional cellulose processing. For the production of food-grade biomaterials, the entire process utilizes simple ingredients, relies on food-grade chemicals and GRAS ingredients/additives, and can be efficiently adapted to the kitchen environment to create food-grade edible products. The cellulose derived from plants is a readily available low-cost raw material, more affordable to work with than engineered bioscaffolds, versatile, and demonstrates overall biocompatibility in vitro. The processes described herein allow for the creation of different food textures by creating biomaterials in which the mechanical properties of the matrix can be controlled. In addition, the process results in plant-derived biomaterials with unique viscous, mechanical and water-absorbent properties ideal for food applications.

[192] In the present invention, vegan products mimicking conventional meat alternatives have been recreated within the Salmon family such as smoked salmon, cooked salmon and tuna, with high-quality sensory characteristics achieved using bleached cellulosic material material to improve the stability, texture and other sensory attributes of the final product. The final vegan products possess some of the nutritional characteristics similar to the traditional meal with improved fiber content.

[193] Vegan prebiotic products with similar physicochemical characteristics of milk yogurt were obtained by fermentation of plant proteins with bacterial strains including but not limited to *Lactobacillus bulgaricus* and *Streptococcus thermophilus* using the bleached cellulosic material material that acts as a scaffold gel for fermentation holding the probiotic bacteria, improving the formulation stability and reducing the needs for additives.

[194] Vegan dairy products such as vegan ice cream and vegan cream cheese with similar physicochemical characteristics to traditional ice cream and cream cheese were obtained using the cellulosic material that improves the formulation stability and reduces the need for additives.

FORMULATIONS AND EXPERIMENTAL DATA

[195] Without wishing to be bound by theory or experimental results, the following paragraphs describe the nature of the invention by way of examples only. The experiments or specific examples of materials, ingredients, and formulations described should not be construed as limiting the scope of the invention. A person skilled in the art would readily understand and appreciate that other materials were not specifically described and also form part of the invention.

A. Plant-based seafood substitutes

1. Cooked Salmon Formulation

First the inventors set out to develop a vegan salmon formulation that would mimic traditionally available cooked salmon fillet.

1.1. Development of the texture from the plant-based salmon fillet.

1.1.1 Gelation step

1.1.1.1. Objective

The objective was to improve the texture of the plant-based salmon prototype by adding a gelation step of the protein isolate before adding it to the formulation.

1.1.1.2. Treatment

The inventors developed two vegan salmon formulations, which were referred to as FIMT-102 and FIMT-103 for ease of reference. In the first formulation (FIMT-102), 70% Mung bean isolate, 20% Fava bean isolate, and 10% Brown rice isolate were used without the additional step. In the second formulation (FIMT-103), 70% Mung bean isolate, 20% Fava bean isolate, and 10% Brown rice isolate were used after performing an additional step of combining the isolate protein and Plant-derived cellulosic material or bleached plant material - sous vide at 90℃ for 30 minutes.

1.1.1.3. Protocol

The formulations were prepared using the following protocol:

1. Weigh all of the ingredients in separate containers.
2. The isolate protein was combined with the Plant-derived cellulosic material or bleached plant material and added to the Sous Vide at 90℃ for 30 mins.
3. Soak the two TVPs (mung bean and wheat) in separate bowls for at least 15 minutes.
4. Squeeze excess water out from the TVPs.
5. Add everything in the thermomix except the $Ca(OH)_2$ and the TVP proteins.
6. Mix at speed 5 for 30 seconds. Transfer the formulation to a plastic container and heat it up in the microwave for 20 seconds at high power.
7. Transfer the formulation back into the thermomix.
8. Add the calcium hydroxide and mix again for 30 seconds at speed 5.
9. Weigh the colourants separately.
10. Shred mung TVP in the robot coupe.

11. Add the TVP and the colourants. Mix by hand until the colourants are mixed properly and the dough becomes sticky.

12. Use the fish filet mould to shape the formulation into a fish filet. With a knife, remove the formulation from the mould and put it on the cutting board. Cut a piece of plastic wrap and wrap the fish filet tightly in it. Place the fish filet in a vacuum seal bag.

13. Place the samples in the freeze for at least 3 hours. After that unwrap the filets from the plastic wrap and place them on the cutting board. Using a chef's knife, start from the big part of the filet, and cut at an angle of 45 degrees.

14. With an offset spatula, spread a thin layer of "white lines" between the formulation layers. Place the pieces back together and vacuum seal them.

15. Place the sealed bags in the sous-vide machine for one hour at 60°C. After one hour, take out the samples from the sous-vide and put them in an ice bath for 15 minutes. Once the samples are at room temperature, store them in the fridge until the cooking process (dry heating) in the oven for 10 min at 300°F.

1.1.1.4. Formulations

The following are exemplary embodiments of the two vegan salmon formulation developed by the inventors:

FIMT-102	*FIMT-103*
- 74 g Water	- 74 g Water
- 20 g Mung bean protein crisp	- 20 g Mung bean protein crisp
- 24.85 g Isolate protein	- 24.85 g Isolate protein
- 7.1 g Fava Bean Protein	- 7.1 g Fava Bean Protein
- 3.5g Brown rice protein	- 3.5g Brown rice protein
- 26.5 g Sunflower oil	- 26.5 g Sunflower oil
- 2 g Konjac gum	- 2 g Konjac gum
- 6 g 0.5 M Ca(OH)2	- 6 g 0.5 M Ca(OH)2
- 1 g Salt	- 1 g Salt
- 112 g Plant-derived cellulosic material	- 112 g Plant-derived cellulosic material
- 2 g Tapioca Starch	- 2 g Tapioca Starch

- 16.5 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan	- 16.5 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan

1.1.1.5. Results and highlights

Figure 1 shows images of the two formulations before the formulations were cooked.

Figure 2 shows images of the two formulations after they were cooked.

Figure 3 shows a chart-based comparison of the sensory characteristics or analysis of the two formulations rated from 1 to 9. The chart compares the overall appearance, color, flavor, texture, white lines, and fibery texture of FIMT-102 and FIMT-103. It is pertinent to note that in FIMT-102, the mixture of proteins was added to the formulation directly while in FIMT-103, the mixture of proteins and Plant-derived cellulosic material or bleached plant material was mixed first and then vacuum-sealed in a plastic bag. The mixture was allocated in a Sous-Vide for 30 mins at 90 ℃. After that, the mixture was added to the ice bath for 15 minutes.

It was observed that the texture of FIMT-102 was better than the texture of FIMT-103. The fibre texture was the same in both of the formulations. However, the flavour wasn't ideal and the proteins that were added made the fish / salmon drier and less juicy.

1.1.1.6. Conclusion

The texture in the formulation that received the protein powder directly was more favourable than the one added to the Sous Vide.

1.1.2. Increase the Texturized protein and decrease the isolate protein contents

It was hypothesized that increasing the texturized protein and decreasing the isolate protein contents would improve the bite and mouthfeel of the cooked salmon.

1.1.2.1. Objective

The objective was to improve the bite and mouthfeel of the cooked salmon prototype.

1.1.2.2. Treatments

The new vegan salmon formulations were referred to as FIMT-108 and FIMT-109 for ease of reference. In FIMT - 108, the inventors worked on increasing the texturized protein and decreasing the isolate protein. In FIMT- 109, the inventors increased the texturized protein, decreased the isolate protein, and additionally added locust bean.

1.1.2.3. Protocol

These new formulations were prepared by performing the following steps:

1. Weigh all of the ingredients in separate containers.
2. Soak the two TVPs in separate bowls for at least 15 minutes.
3. Squeeze excess water out from the TVPs.
4. Add everything in the thermomix except the $Ca(OH)_2$ and the TVP proteins.
5. Mix at speed 5 for 30 seconds. Transfer the formulation to a plastic container and heat it up in the microwave for 20 seconds at high power.
6. Transfer the formulation back into the thermomix.
7. Add the calcium hydroxide and mixed again for 30 seconds at speed 5.
8. Weigh the colourants separately.
9. Shred mung TVP in the robot coupe.
10. Add the TVP (mung bean and wheat) and the colourants. Mix by hand until the colourants are mixed properly and the dough becomes sticky.
11. Use the fish filet mould to shape the formulation into a fish filet. With a knife, remove the formulation from the mould and put it on the cutting board. Cut a piece of plastic wrap and wrap the fish filet tightly in it. Place the fish filet in a vacuum seal bag.
12. Place the samples in the freeze for at least 3 hours. After that unwrap the filets from the plastic wrap and place them on the cutting board. Using a chef knife, start from the big part of the filet, and cut at an angle of 45 degrees.

13. With an offset spatula, spread a thin layer of “white lines” between the formulation layers. Place the pieces back together and vacuum seal them.

14. Place the sealed bags in the sous-vide machine for one hour at 60℃. After one hour, take out the samples from the sous-vide and put them in an ice bath for 15 minutes. Once the samples are at room temperature, store them in the fridge until the cooking process (dry heating) in the oven for 10 min at 300℉.

1.1.2.4. Formulation

The following are exemplary embodiments of the new vegan salmon formulation developed by the inventors:

FIMT-108	*FIMT-109*
- 84 g Water	- 84 g Water
- 20 g Mung bean protein crisp	- 20 g Mung bean protein crisp
- 15 g Isolate protein	- 15 g Isolate protein
- 26 g Sunflower oil	- 26 g Sunflower oil
- 10 g Konjac gum	- 10 g Konjac gum
- 6 g 0.5 M Ca(OH)2	- 6 g 0.5 M Ca(OH)2
- 1 g Salt	- 1 g Salt
- 90 g Plant-derived cellulosic material	- 90 g Plant-derived cellulosic material
- 2 g Tapioca Starch	- 2 g Locust Bean
- 40 g Wheat TVP	- 40 g Wheat TVP
- 0.04 g Brilliant Orange	- 0.04 g Brilliant Orange
- 0.04 g Astaxanthin	- 0.04 g Astaxanthin
- 0.15 g Watermelon Pink	- 0.15 g Watermelon Pink
- 0.9 g Flavorcan Masker	- 0.9 g Flavorcan Masker
- 3 g New Salmon Flavor	- 3 g New Salmon Flavor
- 0.6 g Glucone delta lactone	- 0.6 g Glucone delta lactone
- 2.5 g Kappa Carrageenan	- 2 g Kappa Carrageenan

1.1.2.5. Results and highlights

Figure 4 shows images of the FIMT-108 and FIMT-109 before cooking. Figure 5 shows images of the two formulations after they were cooked. Figure 6 shows a chart-based comparison of the sensory characteristics or

analysis of the two formulations rated from 1 to 9. The chart compares the overall appearance, color, flavor, texture, white lines and fibery texture of FIMT-108 and FIMT-109.

It was observed that the texture and fibery texture in FIMT-109 were preferred. The only difference between the two formulations was the locust bean. The texture of FIMT-109 was softer than the texture of FIMT-108 by which less cereal taste was presented.

1.1.2.6. Conclusion

As noted earlier, the formulation prepared using the locust bean was the one preferred in the majority of attributes analyzed. In the formulation, the locust bean gum acts as a thickener, stabilizer, emulsifier and gelling agent, and this ingredient is approved in the majority of countries worldwide.

1.2. Plant-based cooked salmon filet formulations to improve the flavour.

1.2.1. Objective

The objective was to improve the flavour by changing the flavour in order to have a more fishy flavour.

1.2.2. Treatment

FIMT-108 was prepared using 3g of new salmon flavour

1.2.3. Protocol

The protocol followed above in section **1.1.2.3.** was followed here as well.

1.2.4. Formulation

The new FIMT-108 formulation included the following ingredients.

FIMT-108

- 84 g Water
- 20 g Mung bean protein crisp
- 15 g Isolate protein
- 26 g Sunflower oil

- 10 g Konjac gum
- 6 g 0.5 M Ca(OH)2
- 1 g Salt
- 90 g Plant-derived cellulosic material
- 2 g Tapioca Starch
- 40 g Wheat TVP
- 0.04g Brilliant Orange
- 0.04 g Astaxanthin
- 0.15 g Watermelon Pink
- 0.9 g Flavorcan Masker
- 3 g New Salmon Flavor
- 0.6 g Glucone delta lactone
- 2.5 g Kappa Carrageenan

1.2.5. Results and highlights

Figure 7 shows an image of FIMT-108 before cooking. Figure 8 shows sensory analysis of FIMT-108 rated on a scale from 1 to 9. It was observed that the flavour was preferred in this formulation compared to old formulations like FIMT-102 and FIMT-103. The flavour in FIMT-108 received the best rate so far as 7 which was higher than previous scores which received a rating of around 4. The moist texture was presented in this formulation and that can be due to the high amount of water absorbed by wheat TVP.

1.2.6. Conclusion

Therefore, it was concluded that the new flavour enhanced the fishy smell that played a role in enhancing the salmon flavour in the formulation.

1.3. Improvement of the nutritional profile of the plant-based salmon fillet.

1.3.1. Objective

In this experiment, the objective was to increase the protein content of the fish fillet sample.

1.3.2. Treatments

New formulations FIMT-105A and FIMT-105B were tested in this protocol.

1.3.3. Protocol

The protocol followed above in section **1.1.2.3.** was followed in this experiment. However, the formulation FIMT-105A utilized 36.8 g of wheat TVP and the formulation was mixed using a robot coupe. In contrast, the formulation FIMT-105B utilized 36.8 g of wheat TVP and the formulation was mixed by hand.

1.3.4. Formulations

The formulations contained the following ingredients.

FIMT-105 A	*FIMT-105 B*
- 74 g Water - 20 g Mung bean protein crisp - 35.5 g Isolate protein - 26.5 g Sunflower oil - 2 g Konjac gum - 6 g 0.5 M Ca(OH)2 - 1 g Salt - 80.5 g Plant-derived cellulosic material - 2 g Tapioca Starch - 36.8 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon	- 74 g Water - 20 g Mung bean protein crisp - 35.5 g Isolate protein - 26.5 g Sunflower oil - 2 g Konjac gum - 6 g 0.5 M Ca(OH)2 - 1 g Salt - 80.5 g Plant-derived cellulosic material - 2 g Tapioca Starch - 36.8 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink

Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan	- 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan

1.3.5. Results and highlights

Figure 9 shows an image of FIMT 105 A and FIMT 105 B formulations before cooking and Figure 10 shows an image of FIMT 105 A and FIMT 105 B formulations after cooking. Figure 11 shows sensory analysis of FIMT-105A and FIMT-105B rated on a scale from 1 to 9. It was observed that FIMT-105 A was rated the highest regarding the overall appearance, colour and white lines. The overall appearance and colour were favoured because of the robot coupe. FIMT-105 A also presented a pasty texture (no fibery texture). In contrast, the texture of FIMT-105 B was fibery. The overall appearance was not good because of the big chunks presented on the surface of the fish fillet.

1.3.6. Conclusion

Based on the above experiment, it was concluded mung bean TVP should be shredded alone and mixed by hand to keep the fibery texture in the sample.

1.4. Plant-based fish fillet formulations to improve the hydrating step for the texturized protein.

1.4.1. Objective

The objective here was to improve the hydrating step on the plant-based cooked salmon process of fabrication.

1.4.2. Treatments

In this experiment, three formulations a) FIMT-099 (i.e. Control where TVP was hydrated in a conventional way); b) FIMT-100 (i.e. Control where the TVP was hydrated with seaweed) and c) FIMT-101 (i.e. Control with TVP hydrated using steam).

1.4.3. Protocol

In this experiment, the protocol described in section **1.2.3.** was followed. In the FIMT-100, the TVP was hydrated with water prior boiled with seaweed. In contrast, in FIMT-101, the TVP was hydrated using the steam step.

1.4.4. Formulations

The following ingredients were used to prepare the three formulations.

FIMT-099	*FIMT-100*	*FIMT-101*
- 74 g Water - 20 g Mung bean protein crisp - 35.5 g Isolate protein - 26.5 g Sunflower oil - 2 g Konjac gum - 6 g 0.5 M Ca(OH)2 - 1 g Salt - 112 g Plant-derived cellulosic material - 2 g Tapioca Starch - 16.5 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan	- 69 g Water - 20 g Mung bean protein crisp - 35.5 g Isolate protein - 26.5 g Sunflower oil - 2 g Konjac gum - 6 g 0.5 M Ca(OH)2 - 1 g Salt - 117 g Plant-derived cellulosic material - 2 g Tapioca Starch - 16.5 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan	- 60 g Water - 20 g Mung bean protein crisp - 35.5 g Isolate protein - 26.5 g Sunflower oil - 2 g Konjac gum - 6 g 0.5 M Ca(OH)2 - 1 g Salt - 126 g Plant-derived cellulosic material - 1 g Tapioca Starch - 16.5 g Wheat TVP - 0.04 g Brilliant Orange - 0.04 g Astaxanthin - 0.15 g Watermelon Pink - 0.9 g Flavorcan Masker - 1.2 g Salmon Flavor - 0.6 g Glucone delta lactone - 2 g Kappa Carrageenan

1.4.5. Results and highlights

Figure 12 shows an image of the three formulations FIMT-099, FIMT-100 and FIMT-101 before cooking. Figure 13 shows an image of FIMT-099, FIMT-100 and FIMT-101 after cooking. Figure 14 shows sensory analysis of FIMT-099, FIMT-100 and FIMT-101 rated on a scale from 1 to 9.

In FIMT-099: Mung Bean TVP was hydrated with hot water. The excess water was squeezed using a cheesecloth. After that, all the ingredients were mixed in the thermomixer with mung bean TVP and wheat TVP with the colours too. In FIMT-100, mung bean TVP was hydrated with hot water and seaweed. The excess water was squeezed

using a cheesecloth. After that, the ingredients were also mixed in the thermomixer with the mung bean TVP and wheat TVP with the colours too. In FIMT-101, mung bean TVP was steamed on the stove with boiling water. Since, mung bean TVP was not hydrated well, more Plant-derived cellulosic material or bleached plant material was added to the formulation. After that, the ingredients were also mixed in the thermomixer with mung bean TVP and wheat TVP along with the colours.

It was observed that the overall appearance of FIMT-099 and FIMT-100 were rated higher than FIMT-101 and that is because of the dark colour in FIMT-101. The dark colour in FIMT-101 was a result of hard mung bean TVP that was not hydrated well. Based on the sensory analysis results, FIMT-101 got the highest texture by which it was chewy and not pasty. The flavour in the three formulations was pretty much the same, by which the flavour of FIMT-100 was a little bit lower than the other even though seaweed should have added more flavour to it.

1.4.6. Conclusion

It was concluded that even though mung bean TVP was steamed for more time, they were hard and not hydrated well. Therefore, to compare the colour and fibery texture of formulations, two separate controls should be prepared, one where the mung bean TVP and the other ingredients are mixed by hand, and the other where a thermomix is used to mix the ingredients. It was also observed that utilizing choppers at high speeds can increase dispersive mixing and the pigments and dyes can be mixed uniformly to produce a colour that appears uniform.

1.5. Mouthfeel improvement of the plant-based cooked salmon

1.5.1. Objective

- The objective of this experiment was to improve the mouthfeel of the plant-based cooked salmon by trying different concentrations of lipids.

1.5.2. Treatments

The following formulations were prepared using the protocol provided in 1.5.3.

- FIMT-172
- FIMT-173

1.5.3. Protocol

1. Weigh all of the ingredients in separate containers.
2. Soak the TVP in boiling water 3X for at least 15 minutes.
3. Squeeze the excess water out from the TVPs.
4. Mix Plant-derived cellulosic material or bleached plant material or bleached plant material, Oil, Methylcellulose and iced water using a hand mixer until it forms a white gel

5. Combine algae oil and methylcellulose together. Mix to form (Methocel and oil) slurry.
6. Add the iced water and starting material to the slurry.
7. Using a hand immersion blender emulsify the mixture until a thick and pasty emulsion is formed.
8. Shred TVP in the robot coupe.
9. Add 30 % of Pea TVP and the colourants into the dry ingredient mixture. Mix by hand until the colourants are mixed properly and the dough becomes sticky. Mix the other 70 % of Pea TVP with the sticky mixture in the robot coupe.
10. Mix by hand until the colourants are mixed properly and the dough becomes sticky. Mix the other 70 % of Pea TVP with the sticky mixture in the robot coupe.
11. Used the fish filet mould to shape the formulation into a fish filet. With a knife, remove the formulation from the mould and put it on the cutting board. Cut a piece of plastic wrap and wrap the fish filet tightly in it. Placed the fish filet in a vacuum seal bag.
12. Place the samples in the freezer for at least 3 hours. After that unwrap the filets from the plastic wrap and place them on the cutting board. Using a chef's knife, start from the big part of the filet, and cut at an angle of 45 degrees.
13. With an offset spatula, spread a thin layer of “white lines” between the layers of the formulation. Place the pieces back together and vacuum seal them (Weigh the amount of white lines utilized in each filet and register the weight).
14. Place the sealed bags in the sous-vide machine for one hour. After one hour, take out the samples from the sous-vide and put them in an ice bath for 15 minutes. Once the samples were at room temperature, stored in the fridge until the next day
15. Preheat the oven to 300°F for 15 mins, remove the samples from the bag and remove the plastic wrap, wrap with aluminium foil, carefully seal all the edges of foil to form an enclosed packet, place the packet on a baking tray, and bake in a preheated oven for approximately 5-6 minutes until the internal temperature reach145°F/62-63°C.

1.5.4. Formulations

The following ingredients were used to prepare the formulations.

FIMT-172	FIMT-173
- 115.80 g Water	- 115.80 g Water
- 11 g Iced Water	- 11 g Iced Water
- 9.89 g Isolate mung bean protein	- 9.89 g Isolate mung bean protein
- 20.0 g Sunflower oil	- 30.0 g Sunflower oil
- 0.90 g Algae Oil	- 0.90 g Algae Oil

- 2.50 g Methyl cellulose vege form 183 - 55.80 g Plant-derived cellulosic material - 70.0 g Pea Protein TVP - 0.21 g Watermelon Pink - 6.0 g Baked Salmon Flavour - 7.0 g Natural Salmon Flavour Type - 0.9 g Yeast extract	- 2.50 g Methyl cellulose vege form 183 - 55.80 g Plant-derived cellulosic material - 60.0 g Pea Protein TVP - 0.21 g Watermelon Pink - 6.0 g Baked Salmon Flavour - 7.0 g Natural Salmon Flavour Type - 0.9 g Yeast extract

1.5.5. Results/Pictures

Figure 15 provides a comparison between the FIMT-172 (left) and FIMT-173 (right) formulations. Figure 16 shows the FIMT-173 formulation before the cooking process. Figure 17 provides a comparison between formulations FIMT- 172 and FIMT-173 sensory analysis results.

Table 1: The following table provides a comparison of sensory analysis results between formulations FIMT-172 and FIMT-173.

Sensory attributes	FIMT-172	FIMT-173
Overall appearance	6.7 ± 0.5a	8.0 ± 0.8a
Color	7.7 ± 1.0a	7.6 ± 1.2a
Flavour	7.7 ± 0.9a	7.7 ± 0.9a
Texture	6.5 ± 1.3b	8.5 ± 0.6a
White lines	7.5 ± 0.6a	7.5 ± 1.0a
Fibery Texture	6.0 ± 0.8b	8.3 ± 1.2a

(n=4 ± standard deviation)

1.5.5. Highlights

- For the fabrication of formulation FIMT-173 the robot coupe was utilized to shred the TVP, promoting the appearance of fish fibres.
- Comparing the formulations FIMT-172 and FIMT-173 sensory scores, was observed better ($P < 0.05$) texture parameters (texture and fibre texture) on FIMT-173 compared to the FIMT-172.
- The perception of better texture can be explained due to the greater oil concentration on the formulation FIMT-173.

1.5.6. Conclusions

The higher concentration of oil apparently positively affected the formulation FIMT-173. However, new test needs to be performed to confirm if the oil concentration has any influence on the mouthfeel and consequently on the texture of the formulation.

1.6. Plant-based salmon prototype characterization and comparison with the conventional Atlantic Salmon

1.6.1. Objective

The objective of this experiment was to characterize the plant-based cooked salmon prototype and compare it with the conventional Atlantic salmon.

1.6.2. Treatments

In this Experiment, the plant-based cooked Salmon prototype was compared with the conventional cooked Atlantic salmon.

1.6.3. Protocol

The parameters analyzed for this comparison were the nutritional value (which was analyzed by a third party), chemical (pH) and physical properties (Water activity - Aw, colour, texture, and cooking loss), analyzed internally

1.6.3.1. Mechanical Testing Analysis

1.6.3.1.1. Objective

The objective of this testing was to compare the instrumental texture between conventional salmon and plant-based prototype.

1.6.3.1.2. Protocol

The protocol and analyses were based on the following paper published on Centre for Industrial Rheology (https://www.rheologylab.com/services/texture-analysis/). In particular, the protocol followed was as follows:

- A salmon fillet and plant-based salmon prototype were cooked using dry heat for 10 min at 300°F and analyzed using instrumental texture analysis on the Mech-Tester.
- The sample FIMT-052 was compared to a standard salmon sample, with both samples being cooked.
- Each sample had 4 replicates, all of which had similar diameters (1 cm biopsy punches) and they were analyzed using the UniVert Mechanical Test System.
- Samples were shaped using a 50 mL falcon tube cutting into the sample, followed by shaving off excess material with a scalpel to achieve a reasonable circular diameter.
- The “zero position calibration” was performed.
- Before running the test, two perpendicular diameters were measured with the Vernier callipers.
- The settings for the test were: 50 N load cell and double compression analysis (two 50% compression) comparing parameters such as hardness, cohesiveness, and springiness.
- Data analysis was performed on Origin 2021 comparing Force (N) to Time (s).

1.6.3.1.3. Results and highlights

It was observed that the salmon standard was demonstrated to break apart more easily than the sample, with the sample providing more resistance. The salmon standard also tended to flake much more easily than the sample, which proved to be somewhat difficult in order to achieve viable results at times. Furthermore, the salmon standards were found to have higher ($P < 0.05$) cohesiveness, and springiness while similar ($P > 0.05$) hardness in comparison to the formulation. These results are justifiable, based on the physical attributes associated with each sample, as well as how they reacted in real-time to the double compression. Figure 18 provides the mechanical testing analysis of salmon standards (bottom 4 graphs i.e. Figure 18B) and FIMT-052 samples (top 4 graphs i.e. Figure 18A). Table 2 provides an instrumental texture comparison between Plant-based salmon and Standard salmon samples.

Table 2. Instrumental texture comparison between Plant-based salmon and Standard salmon sample.

Sample	Hardness (N)	Cohesiveness	Springiness (%)
Plant-based salmon	$10.59^{a}\pm3.65$	$0.24^{b}\pm0.04$	$32.05^{b}\pm2.08$

Atlantic salmon	6.33[a] ±3.55	0.39[a]±0.062	44.80[a]±6.82

n=4 ± standard deviation

a–b Means in a row without common superscripts are different (P < 0.05).

The double compression analysis of the samples proved to be a great method to measure several parameters from each sample and a crucial component for data analysis of samples, in order to mimic the salmon standard as closely as possible. More analysis and trials were performed moving forward to confirm data.

1.6.3.2. Water activity

1.6.3.2.1. Objective

The objective was to compare the water activity between conventional salmon and plant-based prototype.

1.6.3.2.2. Protocol

The water activity was performed in duplicate for both treatments, using the LabMaster - Aw equipment at La Cite. The equipment was calibrated according to the instructions of the equipment manufacturer. Figure 19 shows the samples of conventional Atlantic salmon and Salmon plant-based Salmon prototype (left) and an image of the LabMaster - Aw equipment (right).

1.6.3.3 pH analysis

1.6.3.3.1. Objective

The objective was to compare the pH between the conventional salmon and plant-based prototype.

1.6.3.3.2. Protocol

The pH was analyzed in duplicate for both formulations before and after the cooking process using the instrument Foodcare Meat pH tester, Code: HI981036. Both formulations were cooked using dry-heating in the conventional oven until the centre of the product achieved 63℃. Calibration and analysis were performed according to the instructions of the equipment manufacturer.

1.6.3.4. Cooking loss

1.6.3.4.1. Objective

The objective was to compare the cooking loss between the conventional salmon and plant-based prototype.

1.6.3.4.2. Protocol

The following steps were carried out in this experiment.

- The weights of raw and cooked treatments were recorded to calculate the cooking loss in duplicate.
- Percentage of total cooking loss was calculated following Kong et al. (2007)
- Cook loss = weight of raw sample−weight of cooked sample/weight of raw sample ×100%

Figure 20 shows the samples of plant-based Salmon prototype and conventional Atlantic Salmon after the cooking process to determine the cooking loss

1.6.3.5 Instrumental colour

1.6.3.5.1. Objective

The objective was to compare the instrumental colour between the conventional salmon and plant-based prototype.

1.6.3.5.2. Protocol

For the comparison between the colour of the two treatments, an app called “Color Grab” was utilized.

- The treatments were analyzed in triplicate.
- The samples were cut with the same width, length and height. Then, they were allocated in the same position inside the black box with the existing lighting.
- The same arrangement in the black box was utilized so the treatments could stay in the same position as well as the cell phone.
- The parameters analyzed were the lightness (L*), redness (a*), and yellowness (b*) and compared between the treatments.

Figure 21 shows samples of conventional Atlantic Salmon (left), and plant-based Salmon (right) for colour analysis and the apparatus used for the colour analysis.

1.6.3.6. Density

1.6.3.6.1. Objective

The objective was to compare the density between the conventional salmon and plant-based prototype.

1.6.3.6.2. Protocol

The following steps were performed for comparing the densities.

- The density (g/ml) of the treatments was determined using the following calculation: weight/volume in duplicate.

Figure 22 shows images of samples of conventional Atlantic Salmon (left), and plant-based Salmon (right) for density.

1.6.3.7. Nutritional profile

1.6.3.7.1. Objective

The objective of this experiment was to compare the proximate composition between the conventional salmon and plant-based prototype.

1.6.3.7.2. Protocol

The nutritional profile of the plant-based salmon prototype was analyzed from the third part for proximate composition and the conventional Atlantic salmon information was collected from the USDA database.

1.6.4. Results and highlights

The results of the comparison between plant-based salmon and conventional salmon are provided in Table 3 and Table 4 below.

Table 3. Comparison of the chemical and physical composition between the plant-based salmon prototype and conventional Atlantic salmon.

Type	Chemical and physical Attributes	Reference[1]	Test[2]
Chemical	pH	6.25[b]	6.64[a]
Physical	Aw	0.98[a]	0.99[a]
Physical	Density (g/cm^3)	0.75[a]	0.90[a]
Physical	Cooking loss (%)	18.31[a]	10.01[b]
Physical – Colour	L* (lightness)	75.37[a]	63.7[b]
Physical – Colour	a* (redness)	6.27[a]	11.33[a]

Physical – Colour	b* (Yellowness)	19.87[b]	38.03[a]
Physical – Texture	Hardness (N)	6.33[a]	10.59[a]
Physical – Texture	Springness (%)	43.80[a]	32.05[b]
Physical – Texture	Cohesiveness	0.39[a]	0.24[b]

[1] Cooked Atlantic salmon

[2] Cooked plant-based salmon

Table 4. Comparison of the nutritional composition between the plant-based salmon prototype and conventional Atlantic salmon.

Type	Attribute	Reference[1]	Test[2]
proximate composition	Calories kcal	208	227.9
proximate composition	Water g	64.9	61.5
proximate composition	Protein g	20.4	18.8
proximate composition	Ash g	1.13	1.3
proximate composition	Carbohydrate, by difference g	0	3.8
proximate composition	Fiber, total dietary g	0	2.7
proximate composition	Total Fat g	13.4	14.5
Minerals	Sodium mg	59	301
Sugar	Sugars g	0	0
Minerals	Calcium mg	9	16.8
Minerals	Iron mg	0.3	2.8
Minerals	Potassium mg	363	63.1
protein – aa	Tryptophan g	0.21	0.19
protein – aa	Threonine g	0.86	0.56
protein – aa	Isoleucine g	0.97	0.81

protein – aa	Leucine g	1.62	1.53
protein – aa	Lysine g	1.87	1.11
protein – aa	Methionine g	0.63	0.28
protein – aa	Cystine g	0.22	0.11
protein – aa	Phenylalanine g	0.85	1.13
protein – aa	Tyrosine g	0.76	0.55
protein – aa	Valine g	1.11	0.98
protein – aa	Arginine g	1.22	1.11
protein – aa	Histidine g	0.55	0.49
protein – aa	Alanine g	1.27	0.7
protein – aa	Aspartic acid g	2.02	1.82
protein – aa	Glutamic acid g	2.83	3.82
protein – aa	Glycine g	0.96	0.63
protein – aa	Proline g	0.72	1.07
protein – aa	Serine g	0.9	0.95
protein – aa	Hydroxyproline g	0.042	0

[1] Raw Atlantic Salmon (USDA) - 100g
[2] Raw plant-based salmon 100g

The plant-based salmon prototype demonstrated similar ($P>0.05$) water activity, density, redness, and hardness when compared to the conventional cooked salmon. From the comparison, it is evident that the prototype still needs to improve other physical parameters such as lightness, cohesiveness, springiness, and yellowness. However, compared to the conventional salmon, the plant-based version demonstrated a similar proximate composition (Calories, moisture, protein, lipid, and ash).

1.6.5. Conclusion

Based on the results presented above, it was concluded that the plant-based salmon prototype is in general comparable to conventional cooked salmon.

1.7. Plant-based salmon prototype instrumental and sensory comparison with the conventional Chinook Salmon

1.7.1. Instrumental Colour analysis

1.7.1.1. Objective

The objective was to compare the Conventional Chinook salmon to the Plant-based version in different colour parameters.

1.7.1.2. Treatment

The following two recipes were tested i.e. Chinook cooked salmon and plant-based cooked salmon (i.e. FIMT - 098)

1.7.1.3. Protocol

The following steps were carried out:

- A Color Analyzer Digital (CATUDIY Handheld Colorimeter) with 8mm Aperture was utilized to measure the instrumental colour.
- The colour analyzer was placed on the top of the samples to acquire the values from L* (lightness), a* (redness), and b* (Yellowness).
- The analysis was performed in duplicate.

1.7.1.4. Results and highlights

Table 5. Instrumental colour comparison between the conventional Chinook salmon and plant-baseds smoked salmon prototype.

Colour	**Chinook cooked salmon**	**plant-baseds cooked salmon (FIMT - 098)**
L^*	$61.43^a \pm 1.41$	$48.24^b \pm 1.34$
a^*	$18.32^a \pm 1.69$	$17.19^a \pm 0.37$
b^*	$33.7^a \pm 2.88$	$34.01^a \pm 1.85$

n=2 ± standard deviation

a–b Means in a row without common superscripts are different ($P < 0.05$).

Upon comparing the conventional cooked Chinook salmon to the Plant-based cooked salmon prototype it was observed that the prototype demonstrated a lower (P<0.05) lightness, potentially due to the difference in the water availability observed in the sensory analysis. In addition, both samples demonstrated similar (P>0.05) redness and yellowness, confirming the similar colour between the samples.

1.7.2. Texture analysis

1.7.2.1. Objective

The objective of this analysis was to compare the Conventional Chinook salmon to the Plant-based version in different texture parameters.

1.7.2.2. Treatment

The treatment involved Chinook cooked salmon and plant-baseds cooked salmon

1.7.2.3. Protocol

The protocol and analyses were based on the following paper: https://www.rheologylab.com/services/texture-analysis/.

- A salmon fillet and plant-based salmon prototype were cooked using dry heat for 10 min at 300°F and analyzed using instrumental texture analysis on the Mech-Tester.
- The plant-based prototype was compared to a standard salmon sample with both samples being cooked.
- Each sample had 2 to 3 replicates, all of which had similar diameters (1 cm biopsy punches) were taken and analyzed using the UniVert Mechanical Test System.
- Samples were shaped using a 50 mL falcon tube cutting into the sample, followed by shaving off excess material with a scalpel to achieve a reasonable circular diameter.
- The “zero position calibration” was performed.
- Before running the test, two perpendicular diameters were measured with the Vernier callipers.
- The settings for the test were: 50 N Load cell and double compression analysis (two 50% compression) comparing parameters such as hardness, cohesiveness, and springiness.
- Data analysis was performed on Origin 2021 comparing Force (N) to Time (s).

The mechanical test graph from the Chinook cooked salmon and the Plant-based cooked salmon are shown in Figures 23 and 24. The instrumental texture comparison between the Chinook cooked salmon and plant-baseds cooked salmon prototype using the mechanical test is shown in Table 6 below.

Table 6.

	Texture parameters			
Treatments	**Adhesiveness (N*s)**	**Hardness (N)**	**Cohesiveness**	**Springiness (%)**
Cooked Chinook Salmon	0	4.31^{b}±1.92	0.33^{a}±0.07	42.53^{a}±6.09
Cooked Salmon Prototype	0	23.30^{a}±2.90	0.45^{a}±0.09	63.65^{a}±3.38

n=3/4 ± standard deviation
a–b Means in a row without common superscripts are different (P < 0.05).

As seen from the above, no difference (P>0.05) was observed between the treatments on Adhesiveness, Cohesiveness, and Springiness. However, the prototype demonstrated a higher (P < 0.05) hardness when compared to the Chinook Salmon

1.7.3. Sensory Analysis (plant-based Cooked salmon - FIMT 104)

1.7.3.1. Objective

The objective of this analysis was to compare the Conventional Chinook salmon to the Plant-based version sensory attributes using a trained panel.

1.7.3.2. Treatment

The Chinook cooked salmon and plant-baseds cooked salmon (FIMT - 104) were used in this analysis.

1.7.3.3. Protocol

- **Method:** Difference from Reference
- **Objective:** Determine the direction and size of the difference between a standard and samp
- **Preparation of Samples:**
    - Cooked with canola oil and salt with dry heat for the same amount of time
- **Presentation of Samples:**

- Small section of the fillets removed (without skin) and placed in ramakins for aroma evaluation
- Remainder of the sample remains on the plate under a cloche
- Two forks and a knife for each panellist
- Standard labelled “Standard”
- Product to be characterized labelled “Product A”

- **Number of Panellists:** Minimum of 4-5

1.7.3.4. Results and highlights

Figure 25 tabulates distribution of the sensory attributes from the plant-based cooked salmon prototype (FIMT-104) compared to the reference (Chinook salmon). Figure 26 provides a Radar Graph of the sensory attributes from the plant-based cooked salmon prototype (FIMT-088) compared to the reference (Chinook salmon).

The following table provides a comparison between 2 different sensory analysis results on the Cooked Salmon prototype.

Table 7

		Sensory analyses	
	Attribute	**April 21**	**May 12**
AROMA	Cereal	5.0±1.4	4.3±1.0
	Fish	-3.6±0.9	-3.2±1.3
	Fatty	-4.0±1.4	-3.6±0.9
	Raw	-5.3±1.0	-4.6±1.1
VISUAL APPEARANCE	Shininess	-4.6±1.3	-3.6±1.9
	Thick Red	3.3±1.3	3.5±1.0
	Thick White	2.5±1.0	3.5±1.0
	Uniform	-3.6±0.5	-2.0±1.0
VISUAL TEXTURE	Elasticity	-4.2±1.3	-4.0±0.8
	Separation	-4.3±0.6	-3.0±1.7
	Stodgy	4.01±.4	3.3±1.0
	Fiber	-2.8±1.9	-3.8±0.5
COLOUR	Salmon	-4.0±1.8	-3.2±0.4

	(top)		
	Brown (top)	4.0±1.0	3.6±0.5
	Salmon	-3.0±0.0	-2.3±1.0
	Brown	2.5±0.6	1.3±0.6
	Uniform	-3.7±1.2	-2.3±0.6
TASTE	Salty	-5.0±2.8	-1.5±0.7
	Bitter	-2.0±1.0	-2.0±1.0
	Metallic	-5.0±1.4	-4.3±1.7
TEXTURE (IN-MOUTH)	Firm	3.5±1.0	3.0±0.0
	Juice	-3.0±0.0	-3.4±1.1
	Adhesion	2.3±1.2	2.3±0.6
	Cling	-2.8±0.5	-2.3±1.0
	Flake	-2.5±1.0	-3.4±1.1

n=6 ± standard deviation

The radar graph and attributes distribution demonstrated a High Risk of difference in the following attributes: Cereal aroma, Raw aroma, and Metallic taste. Thus, minus 4 attributes in the high-risk range compared to the previous sensory analysis, most of the attributes analyzed were considered Medium Risk of difference. In an ideal scenario, the target is to achieve a Low Risk of difference for all sensory attributes.

Figure 27 shows an image of cooked plant-based salmon prototype during the cooking process (dry-heating). Figure 28 shows an image of the cooked plant-based salmon prototype plated. Figure 29 shows an image of the cooked plant-based salmon prototype plated.

2. Plant-Based Smoked Salmon

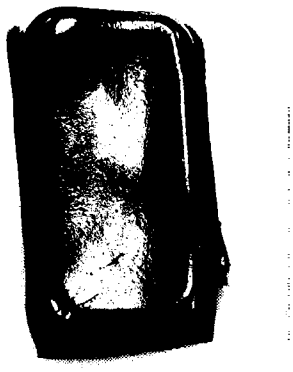
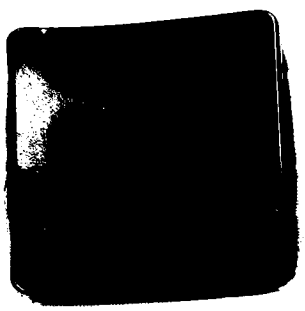
2.1. The inventors worked on developing a Plant-based smoked salmon which would mimic the traditional smoked salmon recipe in terms of smoked salmon texture, flavour and colour improvement.

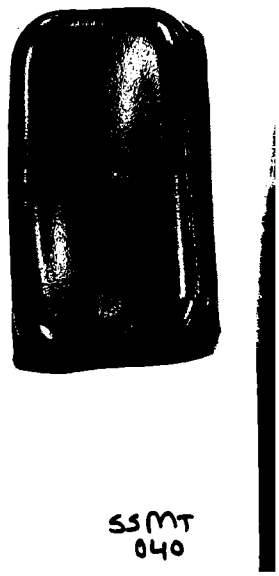
2.1.1. Objective

The objective was to achieve the smoked salmon type texture, flavour and colour. The following table lists the various formulations developed by the inventors and some observations that helped in perfecting the smoked salmon recipe.

2.1.1.1. Treatments, formulations and highlights

Formulation	**Picture**	**Highlights**
SSMT-037 • 4.95 g Konjac gum • 4.95 g Bamboo fibre • 0.76 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.2 g Fiesta pink • 0.2 g Paprika • 2 g Salt • 74.90 g water • 210.54g Mercerized or bleached or bleached apple • 0.60 g Omega 3 oil • 2.35 g Flaxseed oil	 SSMT 037	• Fish type texture • Minor resistance while cutting • No fish-like flavour

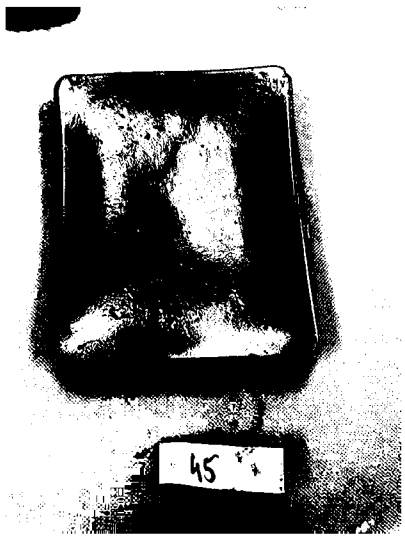
SSMT-038 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.60 g K-carrageenan • 0.12 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.2 g Fiesta pink • 0.2 g Paprika • 2 g Salt • 74.90 g water • 210.54g Mercerized or bleached or bleached apple • 0.60 g Omega 3 oil • 2.35 g Flaxseed oil	 SSMT 038	• Jelly type structure • Resistant while cutting • Fish like smell
SSMT-039 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.2 g Fiesta pink • 0.2 g Paprika • 2 g Salt • 74.90 g water • 210.54g Mercerized or	 SSMT 039	• Too smooth texture • Sticky while eating • No fish smell and taste

bleached or bleached apple • 1 g Citric acid • 0.60 g Omega 3 oil • 2.35 g Flaxseed oil		
SSMT-040 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.04 g Calcium Hydroxide • 30 g Cornstarch • 3.0 g Smoked salmon flavour • 0.2 g Fiesta pink • 0.2 g Paprika • 2 g Salt • 74.90 g water • 210.54g Mercerized or bleached or bleached apple • 1 g Citric acid • 0.12 g Omega 3 oil • 2.35 g Flaxseed oil		• Fish like texture • Fish like structure while chewing • No smoke / fish taste • Can be used as a control for upcoming formulation

SSMT-041 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.04 g Calcium Hydroxide • 30 g Cornstarch • 3.0 g Smoked salmon flavour • 0.2 g Fiesta pink • 0.2 g Paprika • 2 g Salt • 74.90 g water • 210.54g Mercerized or bleached or bleached apple • 1 g Citric acid • 0.12 g Omega 3 oil • 2.35 g Flaxseed oil		• Fish like texture • Fish like structure while chewing • No smoke / fish taste • Can be used as a control for upcoming formulation

SSMT-042 ● 4.95 g Konjac gum ● 4.95 g Bamboo fiber ● 0.60 g K-carrageenan ● 0.18 g Calcium Hydroxide ● 3.0 g Smoked salmon flavour ● 0.3 g Fiesta pink ● 0.12 g Paprika ● 2 g Salt ● 74.90 g water ● 245.86 g Mercerized or bleached or bleached apple ● 2.60 g Omega 3 oil ● 2.35 g Flaxseed oil ● 1 g Citric acid		● Prominent fishy/omega 3 smell and taste ● Fishy color while slicing ● Soft texture which resembles fish

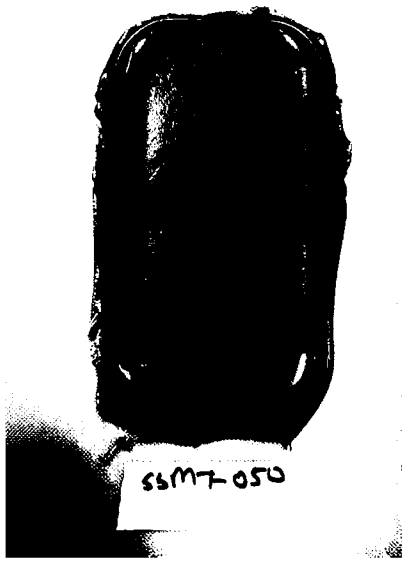
SSMT-043 ● 4.95 g Konjac gum ● 4.95 g Bamboo fiber ● 0.6 g K-carrageenan ● 0.18 g Calcium Hydroxide ● 3.0 g Smoked salmon flavour ● 0.4 g Fiesta pink ● 0.17 g Paprika ● 2 g Salt ● 74.90 g water ● 210.54g Mercerized or bleached apple ● 1 g Citric acid ● 0.60 g Omega 3 oil ● 2.35 g Flaxseed oil ● 1 g Citric acid ● 15.37 g Nigari		● Bitter in taste ● No fish like taste ● Fibrous and flaky in appearance

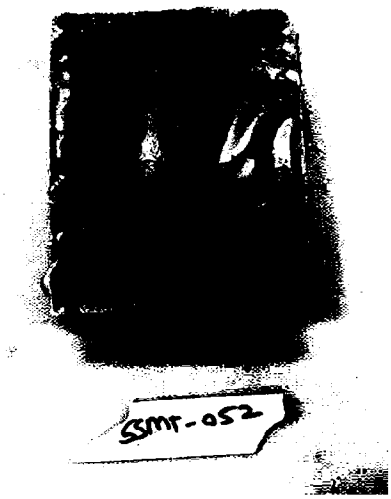
SSMT-044 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.4 g Fiesta pink • 0.14 g Paprika • 2 g Salt • 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 4.35 g Nigari		• Bitter in taste • Texture was similar to last formulation - flaky and fibrous • No significant fish taste
SSMT-045 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.3 g Fiesta pink • 0.17 g Paprika • 2 g Salt		• Oily in appearance like fish • Bit hard texture • Dense in texture while cutting

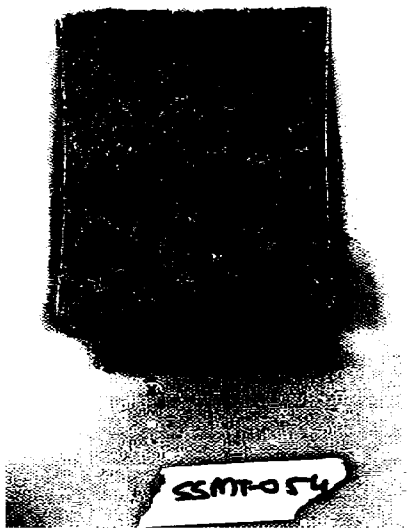
• 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 1.56 g Omega 3 oil • 4.35 g Flaxseed oil • 6.90 g Pea protein		
SSMT-046 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.3 g Fiesta pink • 0.14 g Paprika • 2 g Salt • 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 22.84 g Mung bean TVP		• Visual tiny chunks of protein strands while cutting • Bright in color • Protein taste while eating

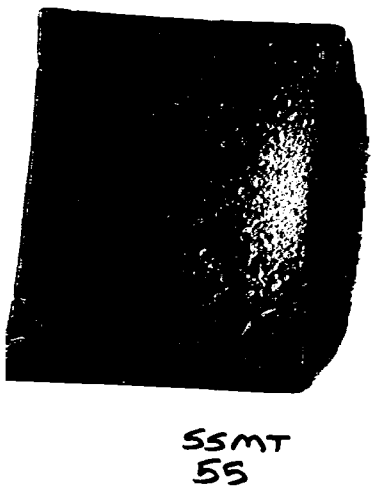
SSMT-047 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.3 g Fiesta pink • 0.12 g Paprika • 2 g Salt • 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 15.4 g Agave • 3.08 g Magnesium chloride		• Sweet in taste • Can feel bit of bitterness towards the end • Soft while cutting
SSMT-048 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.3 g Fiesta pink • 0.12 g Paprika		• Too smooth texture (soapy and doughy) • Too sticky while cutting • No fish like texture

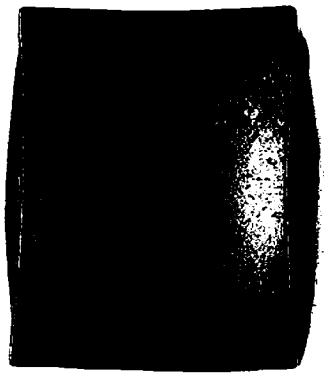
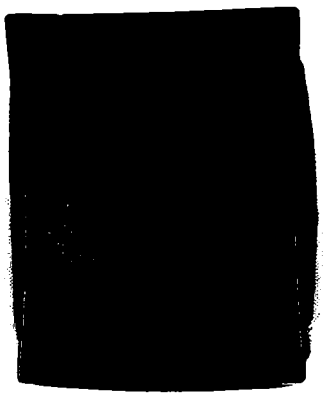
• 2 g Salt • 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 15.4 g pea protein		
SSMT-049 • 4.95 g Konjac gum • 4.95 g Bamboo fiber • 0.6 g K-carrageenan • 0.18 g Calcium Hydroxide • 3.0 g Smoked salmon flavour • 0.3 g Fiesta pink • 0.13 g Paprika • 2 g Salt • 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 7.7 g Magnesium chloride • 15.4 g Maple syrup	 SSMT-049	• Soft and flaky appearance • Mixture of bitter and sweet taste • No fish like taste

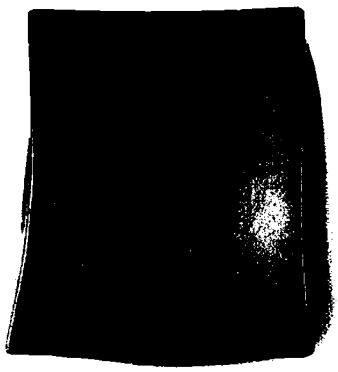
SSMT-050 ● 4.95 g Konjac gum ● 4.95 g Bamboo fiber ● 0.6 g K-carrageenan ● 0.18 g Calcium Hydroxide ● 3.0 g Maple Smoked salmon flavour ● 0.3 g Fiesta pink ● 0.13 g Paprika ● 2 g Salt ● 74.90 g water ● 245.86g Mercerized or bleached apple ● 1 g Citric acid ● 0.65 g Omega 3 oil ● 4.35 g Flaxseed oil ● 15.4 g Agave syrup		● Sweet in taste ● No smoky taste and not significant fish taste as sweetness is overpowering other taste ● Fish like texture
SSMT-051 ● 4.95 g Konjac gum ● 4.95 g Bamboo fiber ● 0.6 g K-carrageenan ● 0.18 g Calcium Hydroxide ● 3.0 g Maple Smoked salmon flavour ● 0.3 g Fiesta pink ● 0.13 g Paprika ● 2 g Salt		● Sweet in taste ● No smoky taste and not significant fish taste ● Little dense structure in comparison with fish

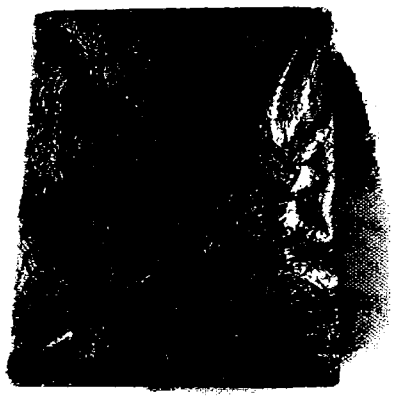
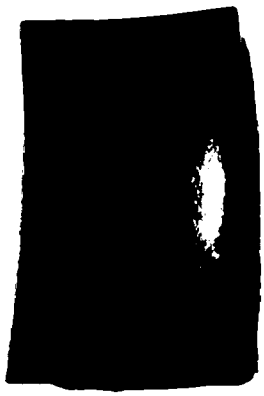
• 74.90 g water • 245.86g Mercerized or bleached apple • 1 g Citric acid • 0.65 g Omega 3 oil • 4.35 g Flaxseed oil • 9.24 g Agave syrup • 6.16g pea protein		
SSMT-052 • 67.12g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.12g Parika • 0.30g Fiesta pink • 1.24g Omega 3 • 6.0g Flaxseed oil		• Salmon like texture • Color resembling salmon

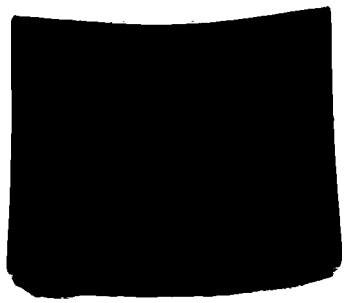
SSMT-053 • 67.12g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.12g Parika • 0.30g Fiesta pink • 1.55g Omega 3 • 16.45g Flaxseed oil		• Oily in appearance • No salmon like flavour • Bitter taste • Hard texture
SSMT-054 • 48.90g Water • 210g Mercerized or bleached apple • 6.0g isolate pea protein • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour		• Too squishy while eating • Doughy/soapy appearance • No salmon like flavour/taste

• 0.12g Parika • 0.30g Fiesta pink • 1.73g Omega 3 • 16.27g Flaxseed oil		
SSMT-055 • 38.59g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 6.25g Maple syrup • 1.20g Omega 3 • 13.80g Flaxseed oil • 1g Liquid maple extract		• Oily in appearance • Can feel sweetness of maple • Texture was nice

SSMT-056 • 42.34g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 12.5g Agave syrup • 1.20g Omega 3 • 3.80g Flaxseed oil • 1g Liquid maple extract		• Too soft texture • Can feel sweetness
SSMT-057 • 48.549g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 6.25g Maple syrup • 0.18g Calcium hydroxide • 1g Citric acid		• Evident maple flavour • Fish like texture

• 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil		
SSMT-058 • 50.84g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 5g Corn starch • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil	 SSMT 58	• Taste like cheese • Texture was nice but flavour/taste was not similar to fish

SSMT-059 • 40.84g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 5g Corn starch • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 13.80g Flaxseed oil	 SSMT 59	• Oily texture • Bitter in taste • Basic in smell
SSMT-060 • 43.34g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 12.5g Corn starch • 12.5g Trehalose • 0.18g Calcium hydroxide	 SSMT 60	• No bitter/sweet taste • Texture and color was similar to fish

• 1g Citric acid • 2g Salt • 3g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil		
SSMT-061 • 45.45g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 5g Corn starch • 5g Trehalose • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 2.5g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil	 SSMT-061	• Mild fishy flavour • Fishy texture • Dark in color

SSMT-062 • 45.45g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 5g Potato starch • 2.5g Trehalose • 2.5g Sorbitol • 0.18g Calcium hydroxide • 1g Citric acid • 2g Salt • 2.5g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil	 062	• Very soft and sticky while cutting • No fish flavour, can feel bit of sweetness • Dark in color
SSMT-063 • 47.45g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 2.5g Trehalose • 2.5g Sorbitol • 0.18g Calcium hydroxide	 SSMT-063	• Better fishy texture • Mild sweetness • Color resembling fish

• 1g Citric acid • 2g Salt • 2.5g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil		
SSMT-064 • 50.45g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 5g Tapioca starch • 1g Citric acid • 2g Salt • 2.5g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil		• Soapy/soft and mushy appearance • Pale in color • Smell like fish • Mild fish taste

SSMT-065 • 47.95g Water • 210g Mercerized or bleached apple • 4.83g Bamboo fiber • 4.83g Konjac gum • 0.60g k-carrageenan • 0.18g Calcium hydroxide • 5g Tapioca starch • 1g Citric acid • 2g Salt • 5g Smoked salmon flavour • 0.13g Parika • 0.25g Fiesta pink • 1.20g Omega 3 • 3.80g Flaxseed oil		• Soft in appearance • Taste and smell like fish • Non uniform texture • Whitre chunks inside the formulation

2.1.1.2. Protocol

The protocol for all the samples was similar just differing in some of the ingredients. The best gel from the aforementioned treatments was SSMT-060 which has a colour resembling real smoked salmon. Following is the protocol for the gel formulation.

1. Weigh the calcium Hydroxide in the mixing bowl.
2. Weigh Bamboo fibre and mix it with calcium hydroxide.
3. Weigh other dry ingredients - Konjac gum, K-carrageenan, Salt, Salmon flavour, corn starch, trehalose and mix it with previously weighed ingredients.
4. Empty 2 pills of vegan omega 3 pills in a separate container and add 4.65g of flaxseed oil into it. Mix both the oil and put the container aside for later use.
5. Weigh mercerized or bleached apple and water and mix both in a container
6. Add 0.12g of paprika and 0.25 grams of Fiesta pink to the aforementioned complex liquid.

7. Transfer the complex liquid into the thermomix bowl.
8. Close the thermomixer lids and spin the liquid ingredients for 5 seconds.
9. Open the lid and scrape the wall of the thermomixer with the help of a spatula.
10. Close the lid again and start the thermomixer at a lower speed.
11. Add the complex powder slowly to the thermomixer.
12. Stop the mixer after 15 seconds. Open the lid and scrape the wall of the mixer with a spatula.
13. Close the lid again and spin the mixture for 10 seconds.
14. Transfer the mix into a nonstick pan.
15. Heat the mixture on a gas stove until it reaches 85℃.
16. Turn off the stove once it reaches the desired temperature and adds the previously weighed omega 3 and flaxseed oil mixture.
17. Mix the oil mixture with continuous stirring for 20 seconds.
18. Transfer the mixture into a plastic container.
19. Place the plastic container into a vacuum seal bag and seal it using a vacuum sealer.

2.1.1.3 Results and highlights

The following tables provide the statistics values for the most promising formulations.

Table 8. Means[1] of sensory rating of SSMT-041-044.

Attributes	Samples			
	SSMT – 041	**SSMT-042**	**SSMT-043**	**SSMT-044**
Overall appearance	7.00 ± 0.00	5.75 ± 1.25	7.00 ± 1.41	6.50 ± 1.73
Color	7.50 ± 0.57	5.75 ± 1.25	6.75 ± 0.95	6.75 ± 1.50

Attributes	Samples			
	SSMT – 041	**SSMT-042**	**SSMT-043**	**SSMT-044**
Overall appearance	7.00 ± 0.00	5.75 ± 1.25	7.00 ± 1.41	6.50 ± 1.73
Texture	6.75 ± 0.50	6.00 ± 0.70	6.50 ± 1.29	6.25 ± 2.06
Flavour	6.75 ± 1.50	6.50 ± 0.57	5.25 ± 1.70	5.50 ± 1.73
Odour	6.75 ± 1.50	6.75 ± 0.97	5.50 ± 1.73	5.75 ± 1.70

n=4 ± standard deviation

Table 9. Means[1] of sensory rating of SSMT-052-055.

Attributes	Samples			
	SSMT – 052	**SSMT-053**	**SSMT-054**	**SSMT-055**
Overall appearance	6.33 ± 0.57	8.00 ± 1.00	7.00 ± 1.73	7.00 ± 1.00
Color	6.66 ± 0.57	7.33 ± 0.57	6.66 ± 1.08	7.00 ± 1.00
Texture	6.33 ± 0.57	6.00 ± 1.73	6.00 ± 1.00	7.33 ± 0.57
Flavour	6.00 ± 1.00	5.33 ± 0.57	6.00 ± 1.00	6.66 ± 0.57
Odour	5.66 ± 0.58	6.00 ± 1.00	6.00 ± 1.00	6.00 ± 1.00

n=4 ± standard deviation

Table 10. Means[1] of sensory rating of SSMT-056-059.

Attribute	Samples			
	SSMT-056	SSMT- 057	SSMT-058	SSMT-059
Overall appearance	7.33 ± 1.00	7.00 ± 0.00	7.00 ± 0.00	7.00 ± 1.00
Color	7.00 ± 1.00	7.00 ± 1.00	7.00 ± 0.00	6.00 ± 1.00
Texture	7.66 ± 0.57	6.66 ± 1.52	7.00 ± 0.00	6.66 ± 1.15
Flavour	6.33 ± 0.57	6.33 ± 0.57	5.00 ± 1.00	4.33 ± 0.57
Odour	6.66 ± 0.57	6.33 ± 0.57	6.00 ± 1.00	5.33 ± 1.52

n=4 ± standard deviation

Table 11. Means[1] of sensory rating of SSMT-060.

Sample	
Attributes	**SSMT-060**
Overall appearance	7.66 ± 1.15
Color	7.66 ± 1.15
Texture	7.33 ± 1.52
Flavour	6.00 ± 2.00
Odour	6.33 ± 2.08

n=4 ± standard deviation

- The addition of isolate protein and TVP proteins incorporated the cereal type taste in the formulation. In addition, the seaweed flakes gave dead fish odour and taste. The addition of maple and algae added a

sweet taste. So none of the ingredients were preferred to add to the formulation to improve flavour. The addition of TVP also affected the texture as it incorporated chunks of TVPs in the gel.

- The gel formulation was frozen using a regular freezer (-18℃) to see the freezing effect on the formulation. After 24 hours of freezing, period gels were taken out and texture was analyzed visually. Most of the formulations changed their structure after freezing. Remarkable water loss was observed in the formulation as shown in Figure 30.1. The only formulation that observed less water loss during the first trial was the one formulated using starch i.e. SSMT-058. In SSMT-062, as shown in Figure 30.2, trial was done with potato starch (due to its high capacity of water retention) and samples were frozen for 24 hours. The formulation showed less water loss with addition of potato starch.

- To avoid the issue with ice crystals, the formulation (SSMT-061) was frozen using a blast freezer at -40℃ as shown in Figure 30.3. The formulation was taken out of the freezer after 4 hours. No ice crystals/changes in texture were observed. The same formulation was thawed in the regular fridge for 4 days after being taken out of the blast freezer to understand the thawing process. No change in the texture or flavour was observed during the thawing process as seen in Figure 30.4.

- Figure 30.1 shows an image of water loss after regular freezing (-18℃) and thaw cycle. Figure 30.2 shows an image of SSMT - 062 with no water loss after regular freezing (-18℃) and thaw cycle .Figure 30.3 shows an image of SSMT-061 after blast freezer. Figure 30.4 shows an image of SSMT-061 after its thawed in the regular fridge for 4 days.

- A way to achieve / obtain a formulation which is stable after freezing could be by making the formulation with different concentrations of starch and sorbitol and placing them in a blast freezer and regular freezer to understand and compare texture changes in different freezing methods. The samples can be thawed after freezing in the regular fridge to observe texture change during the freeze-thaw process.

2.1.2 Objective

Minimum Viable Product for the plant-based smoked salmon with protein.

2.1.2.1. Treatments and highlights

The inventors worked on developing various formulations that would help in determining the minimum viable product for the smoked salmon recipe. The following table lists the various fomulations and observations of the inventors.

SSMPC-004 ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.13g Supra red liquid ● 0.08g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Pale in color ● Bread like texture ● Can feel fish like taste

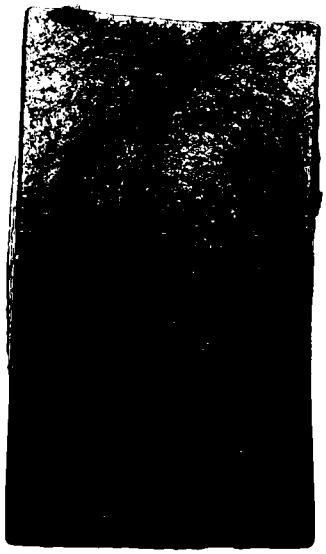
SSMPC-005 ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.13g Supra red liquid ● 0.05g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Pale in color ● Bread like texture ● Can feel fish like taste

SSMPC-006 ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.16g Supra red liquid ● 0.10g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Fishy and lumpy texture ● Flavour and odour resembling fish ● Salmon like color
SSMPC-007 ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid		● Fishy texture ● Flavour and odour resembling fish ● Salmon like color

• 2.20g Salt • 3.15g Sorbitol • 1.76g Fava bean protein • 3.0g Provesta Yeast • 2.61g Methocel Wega • 6.3g Natural salmon flavour • 0.15g Supra red liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil		
SSMPC-008 • 41.07g Water • 220.50g Mercerized or bleached apple • 4.97g Bamboo fiber • 4.97g Konjac gum • 0.63g k-carrageenan • 0.19g Calcium hydroxide • 1.25g Citric acid • 2.20g Salt • 3.15g Sorbitol • 1.76g Fava bean protein • 3.0g Provesta Yeast • 2.61g Methocel Wega • 6.3g Natural salmon flavour • 0.14g Supra red liquid		• Fishy texture • Flavour and odour resembling fish • Salmon like color • Shiny/oily appearance

• 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil		
SSMPC-008 A • 41.07g Water • 220.50g Mercerized or bleached apple • 4.97g Bamboo fiber • 4.97g Konjac gum • 0.63g k-carrageenan • 0.19g Calcium hydroxide • 1.25g Citric acid • 2.20g Salt • 3.15g Sorbitol • 1.76g Fava bean protein • 3.0g Provesta Yeast • 2.61g Methocel Wega • 6.3g Natural salmon flavour • 0.14g Supra red liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil		• Orange in appearance • Bread like texture • Fishy taste and odour

SSMPC-008 B ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.14g Supra red liquid ● 0.10g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Pale in appearance ● Texture away from fish, bread like porous texture ● Fishy taste and odour

SSMPC-007 A ● 41.07g Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.15g Supra red liquid ● 0.10g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Fishy flavour and texture ● Umami flavour ● Color closer to real salmon

SSMPC-007 B ● 41.07g Iced Water ● 220.50g Mercerized or bleached apple ● 4.97g Bamboo fiber ● 4.97g Konjac gum ● 0.63g k-carrageenan ● 0.19g Calcium hydroxide ● 1.25g Citric acid ● 2.20g Salt ● 3.15g Sorbitol ● 1.76g Fava bean protein ● 3.0g Provesta Yeast ● 2.61g Methocel Wega ● 6.3g Natural salmon flavour ● 0.15g Supra red liquid ● 0.10g paprika ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Umami flavour ● Color closer to real salmon ● Texture was porous and not fish like

SSMPC-007 C • 41.07g Iced Water • 220.50g Mercerized or bleached apple • 4.97g Bamboo fiber • 4.97g Konjac gum • 0.63g k-carrageenan • 0.19g Calcium hydroxide • 1.25g Citric acid • 2.20g Salt • 3.15g Sorbitol • 1.76g Fava bean protein • 3.0g Provesta Yeast • 2.61g Methocel Wega • 6.3g Natural salmon flavour • 0.15g Supra red liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil		• Umami flavour • Color closer to real salmon • Texture was porous and not fish like

2.1.2.2. Protocol

The following protocol was followed to develop each of the above formulations.

- The best gel from the above-mentioned treatments were SSMPC-007 and SSMPC-008 which have a colour resembling real salmon. Following is the protocol for the gel formulation.
- Weigh Calcium Hydroxide in the mixing bowl.
- Weigh Bamboo fibre and mix it with calcium hydroxide.
- Weigh other dry ingredients - Konjac gum, K-carrageenan, Salt, Salmon flavour, sorbitol, fava bean protein, yeast, methocel and mix it with previously weighed ingredients..

- Weight mercerized or bleached apple, water, flaxseed oil and omega 3 and mix it in a container
- Add Suprared liquid and paprika in the above-mentioned complex liquid.
- Transfer the complex liquid into the thermomix bowl.
- Close the thermomixer lids and spin the liquid ingredients for 5 seconds.
- Open the lid and scrap the wall of the thermomixer with the help of a spatula.
- Close the lid again and start the thermomixer at a lower speed.
- Add the complex powder slowly into the thermomixer.
- Stop the mixer after 15 seconds. Open the lid and scrap the wall of the mixer with a spatula.
- Close the lid again and spin the mixture for 10 seconds.
- Transfer the mix to a nonstick pan.
- Heat the mixture on a gas stove until it reaches 85℃.
- Turn off the stove once it reaches the desired temperature.
- Add citric acid to the formulation with continuous stirring for 20 seconds.
- Transfer the mixture into a plastic container.
- Place the plastic container into a vacuum seal bag and seal it using a vacuum sealer.

2.1.2.3. Results

- Sensory analysis was completed on all samples. Out of all the formulations, the most promising one were SSMPC-007 and SSMT-008. Following are the results for sensory analysis for both the formulations.

Figure 31 provides a comparison between the sensory analysis results of the formulations SSMP -007 and SSMPC-008.

The following table provides comparison between the sensory analysis results of formulations SSMPC-007 and SSMPC-008.

Table 12

Sensory attributes	SSMPC-007	SSMPC-008
Overall appearance	7.8 ± 0.5a	8.0 ± 0.8a
Color	7.5 ± 0.6a	7.8 ± 0.5a
Texture	7.5 ± 0.6a	7.5 ± 0.6a
Flavour	7.3 ± 1.7a	7.8 ± 1.0a
Odour	7.8 ± 1.3a	7.8 ± 1.3a

(n=4 ± standard deviation)

The following table provides comparison between SSMPC-007 and SSMPC-008 instrumental colour analysis results.

Table 13

Colorimetric parameters	SSMPC-007	SSMPC-008	Coho salmon
Lightness (L*)	44.01 ± 3.33	45.31 ± 2.72	44.15 ± 0.70
Redness (a*)	25.51 ± 1.48	27.78 ± 1.75	15.19 ± 1.19
Yellowness (b*)	26.58 ± 1.73	28.70± 1.63	19.19 ± 2.06

(n=3 ± standard deviation)

The following table provides T-test value comparing SSMPC-007 and SSMPC-008 colorimetric parameters to the Conventional Smoked coho salmon.

Table 14

Colorimetric parameters	SSMPC-007 (T-test)	SSMPC-008 (T-test)
Lightness (L*)	0.9545	0.5136
Redness (a*)	0.0007	0.0055
Yellowness (b*)	0.0089	0.0033

2.1.2.4. Highlights

- The goal of the trials from SSMPC-007 and SSMPC-008 was to define the best concentration of the Suprared liquid in the formulation. The objective was to improve the redness of the product.
- In the sensory analysis no difference was observed ($P > 0.05$) between SSMPC-007 and SSMPC-008 for all the attributes tested.
- Although statistically, the samples did not demonstrate a difference ($P > 0.05$) in the colour attribute, visually sample SSMPC-007 was more attractive.
- After a comparison between each of the treatments above to the Smoked salmon, it was observed that both treatments demonstrated similar ($P>0.05$) lightness, while greater ($P < 0.05$) redness and yellowness when compared to the real fish.
- A comparison between SSPMC-007 and SSMPC-008 showed that the first one exhibited greater redness and the second greater yellowness.

2.1.2.5. Conclusion

- The sample SSMPC-007 demonstrated more aesthetic appeal.

2.2. Plant-based smoked salmon prototype comparison with the conventional Smoked salmon prototype

2.2.1. Colour analysis

2.2.1.1. Objective

The objective was to compare the Conventional Chinook salmon to the Plant-based version in different colour parameters.

2.2.1.2. Treatments

The comparison was between Conventional Smoked Salmon and plant-baseds smoked salmon (SSMT - 038).

2.2.1.3. Protocol

The following steps were performed to prepare the formulations.

- A Color Analyzer Digital ((CATUDIY Handheld Colorimeter) with 8mm Aperture was utilized to measure the instrumental colour.
- The colour analyzer was placed on the top of the samples to acquire the values from L* (lightness), a* (redness), and b* (Yellowness).
- The analysis was performed just in one replicate.

The following table provides instrumental colour comparison between the conventional smoked salmon and plant-baseds smoked salmon prototype.

Table 15:

Colour	**Smoked salmon**	**plant-baseds Smoked salmon (SSMT - 038)**
L*	45.21	37.49
a*	11.43	11.65
b*	17.45	19.00

- Comparing the conventional smoked salmon to the smoked salmon prototype was observed that the prototype demonstrated a lower lightness, potentially due to the difference in the water availability.
- In addition, both samples demonstrated similar redness and yellowness. Thus, it is possible to infer that

in general, the smoked salmon prototype exhibits similar instrumental colour when compared to the conventional counterpart.

2.2.2 Sensory Analysis (plant-based Smoked salmon - SSMT 038)

The following table provides sensory analysis of the SSMT-038 formulation.

Table 16.

Attributes	plant-based (SSMT-038)	Smoked	Salmon
Overall appearance	7.3±0.58		
Color	7.7±0.58		
Texture	7.0±1.00		
Flavour	7.0±0.00		
Odour	6.7±0.58		

n =3, Average±Standard deviation

- Using a scale from 1 to 9, 9 being the most similar to the real smoked salmon, the formulation SSMT-038 was analyzed and for almost all the sensory parameters, the treatment received at least a score 7. Therefore, demonstrates that the plant-baseds smoked salmon is reaching closer sensory attributes when compared to the real smoked salmon.

2.2.3. Texture analysis

2.2.3.1. Objective

The objective was to compare the instrumental texture between the conventional salmon and plant-based prototype.

2.2.3.2. Treatments

The following two formulations Conventional Smoked Salmon and plant-baseds smoked salmon were compared.

2.2.3.3. Protocol

The protocol and analyses were based on the following paper: https://www.rheologylab.com/services/texture-analysis/.

- A smoked salmon and plant-based smoked salmon prototype were analyzed raw using instrumental texture analysis on the Mech-Tester.
- Each sample had 3 replicates, all of which had similar diameters (1 cm biopsy punches) were taken and analyzed using the UniVert Mechanical Test System.
- Samples were shaped using a 50 mL falcon tube cutting into the sample, followed by shaving off excess material with a scalpel to achieve a reasonable circular diameter.
- The “zero position calibration” was performed.
- Before running the test, two perpendicular diameters were measured with the Vernier callipers.
- The settings for the test were: 50 N Load cell and double compression analysis (two 50% compression) comparing parameters such as hardness, cohesiveness, and springiness.
- Data analysis was performed on Origin 2021 comparing Force (N) to Time (s).

The mechanical test graphs from the Conventional smoked salmon and from the Plant-based smoked salmon are shown in Figures 32 and 33 respectively.

Table 17 shown below provides instrumental texture comparison between the conventional smoked salmon and plant-baseds smoked salmon prototype using the mechanical test.

	Texture parameters			
Treatments	**Adhesiveness (N*s)**	**Hardness (N)**	**Cohesiveness**	**Springiness (%)**
Smoked Salmon Prototype	3.30^{a}± 0.61	11.71^{b}±0.94	0.60^{a}± 0.05	70.62^{a}±8.32
Smoked Sockeye Salmon	2.55^{a}± 0.46	28.23^{a}±6.66	0.48^{b}±0.02	59.88^{a}±3.40]

n=3 ± standard deviation

a–b Means in a row without common superscripts are different ($P < 0.05$).

- Based on the mechanical test results performed on the conventional and plant-based versions of the smoked salmon has observed no difference (P>0.05) for Adhesiveness and Springiness. Moreover, the conventional smoked salmon demonstrated higher (P<0.05) hardness while lower (P<0.05) than the smoked salmon prototype.

- Thus, it is possible to infer that some texture characteristics continue different between the samples. More development needs to be conducted to improve the similarities.

Figure 34 shows an image of conventional smoked salmon plated and Figure 35 shows an image of smoked plant-based salmon prototype plated.

2.3 Plant-based smoked salmon development (smoked salmon texture, flavour and colour improvement).

2.3.1 Comparison between the formulation with cellulosic material and formulations made with commercially available cellulose

2.3.1.1. Objective

The objective of this experiment was to compare the vegan smoked salmon made using the cellulosic material versus commercially available cellulose to analyze sensory feel, texture, and water loss (%) of the resulting formulations.

2.3.1.2. Treatments

The following formulations were prepared and tested.

- SSMPC - 134 - 2% of Avicel
- SSMPC- 135 - 2% of cellulosic material
- SSMPC- 136 - 2% of Creafibe
- SSMPC- 137 - 2% of Methocel

2.3.1.3. Equipment and materials

The following equipment and materials were used to conduct this experiment.

- Plastic containers
- Spoons
- Thermo mix Thermomixer

- Cooking pan
- Betty Crocker Plastic spatula
- Hanna HI pH meter
- ThermoPro TP01A Thermometer
- Thermo Fisher Droppers
- Thermo Fisher Scale

2.3.1.4. Protocol

2.3.1.4.1. Formulation

1. Weigh all the dry ingredients in a mixing bowl starting with the ingredient with lowest concentration.
2. Weigh plant-based Dry cellulose and water in the same container. Homogenise both until a smooth slurry is observed.
3. Weigh 0.1 g of paprika and 0.25g of Suprared liquid into a separate container.
4. Add vegan omega 3 oil in the above mentioned container along with 20.58 g of flaxseed oil. Add desired amount of water in the same container.
5. Transfer both the complex liquid into the thermomix bowls.
6. Close the thermomixer lids and spin the liquid ingredients for 5 seconds.
7. Open the lid and scrape the wall of the thermomixer with the help of a spatula.
8. Close the lid again and start the thermomixer at a lower speed.
9. Add the complex powder slowly to the thermomixer.
10. Stop the mixer after 15 seconds. Open the lid and scrape the wall of the mixer with a spatula.
11. Close the lid again and spin the mixture for 10 seconds.
12. Transfer the mix to a nonstick pan.

13. Heat the mixture on a gas stove until it reaches 65 C.
14. Once it reaches the desired temperature, turn off the stove.
15. Transfer the mixture to a plastic container.
16. Place the plastic container into a vacuum seal bag and seal it using a vacuum sealer.
17. Place the samples in the fridge and open them after 12 hours once the formulation will settle down.

2.3.1.4.2. Instrumental texture

The protocol and analyses were based on the following paper: https://www.rheologylab.com/services/texture-analysis/.

- Double compression analysis was conducted on samples FIMT-051 and a standard salmon sample, comparing parameters such as hardness, cohesiveness, springiness, and chewiness.
- Data analysis was performed on Origin, following LABSOP015R000, comparing Force (N) to Time (s).
- The protocol for the cell setup follows LABSOP017R000, and the compression follows closely to LABSOP015R000, with some minor details being changed
- These minor details include the changing of the run from one compression up to 50 N, to two 50% compressions
- Compared plant-based smoked salmon prototype to a standard salmon sample, with both samples being cooked
- Each sample had 4 replicates, all of which had similar diameters. Samples were shaped using a 50 mL falcon tube cutting into the sample, followed by shaving off excess material with a scalpel to achieve a reasonable circular diameter.

2.3.1.4.3. Sensory analysis

- The sensory analysis was performed by 6 different panellists.
- Sensory analysis was performed via blind taste and using the 9-point score scale having the maximum score for the real salmon.

- The attributes analyzed were: Overall appearance (OA), Colour (C), Texture (T), Flavour (F), and Odour (O).

2.3.1.4.4. Water Loss (%)

To compare the water loss, the following protocol was employed:

- Prepare the 3 different replicates for each treatment.
- Cut each block into 8 parts.
- Store the different 8 samples per treatment in the fridge using different vacuum packages.
- Take each part from the fridge pieces in different storage times (0 days to 7 days).
- The analyses was performed in triplicate.
- Store the bags in the fridge.
- Open each bag on a predetermined timeline and complete analysis.
- The loss in g was calculated by subtracting weight from day 0 initial weight using the following formula:

  WT Loss (%)= Minitial - Mend/Minitial *100 (Gibis et al., 2015)

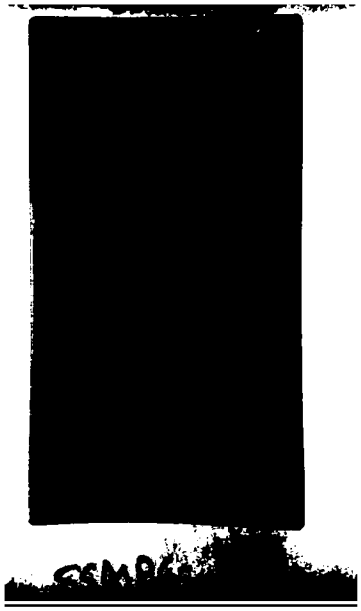
2.3.1.5. Formulations/ Results/Pictures/Highlights

The following table provides the recipes for formulations with ingredient concentration.

SSMPC-134	**SSMPC-135**
• 46.46 g Water • 214.20 g Distilled water • 6.30 g Avicel • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Salmon Flavor • 4.72g Natural Fish Flavor • 350 mg Vitamin B2 complex • 22 mg Vitamin D3 • 1.1 mg Vitamin A • 0.25g Supra red • liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil	• 46.06 g Water • 214.20 g Distilled water • 6.30 g Cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Salmon Flavor • 4.72g Natural Fish Flavor • 350 mg Vitamin B2 complex • 22 mg Vitamin D3 • 1.1 mg Vitamin A • 0.25g Supra red • liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil
SSMPC-136	SSMPC-137
• 46.06 g Water • 214.20 g Distilled water • 6.30 g Creafibe • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Salmon Flavor • 4.72g Natural Fish Flavor • 350 mg Vitamin B2 complex • 22 mg Vitamin D3	• 46.06 g Water • 214.20 g Distilled water • 6.30 g Methocel A4C • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Salmon Flavor • 4.72g Natural Fish Flavor • 350 mg Vitamin B2 complex • 22 mg Vitamin D3

• 1.1 mg Vitamin A • 0.25g Supra red • liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil	• 1.1 mg Vitamin A • 0.25g Supra red • liquid • 0.10g paprika • 1.5g Omega 3 • 20.58g Flaxseed oil

The following table provides pictures for formulation for each formulation.

The following table provides observations and analysis for all samples.

SSMPC-134 • Moist/Oily appearance • Bit more firm bite • Fishy flavour	**SSMPC-135** ● Moist/Oily appearance ● Fish like firm bite ● Fishy flavour
SSMPC-136 ● Oily appearance ● Fish like firm bite - close texture to real salmon ● Fishy flavour	SSMPC-137 ● Orange in color ● Sticky and Lumpy texture ● No prominent fishy taste like control sample ● Crumpled and lumpy while slicing

Figure 36 provides the sensory analysis graph for the formulations in this section. Table 18 Sensory analysis for different attributes comparison among all samples.

Sensory attributes	SSMPC-134	SSMPC-135	SSMPC-136	SSMPC-137
Overall Appearance	8.50 ± 0.55	8.50 ± 0.55	8.17 ± 0.75	2.17 ± 1.33
Color	8.67 ± 0.52	8.50 ± 0.55	8.33 ± 0.52	2.33 ± 1.63
Texture	7.67 ± 0.82	7.83 ± 0.41	7.17 ± 0.41	1.00 ± 0.00
Flavour	8.00 ± 0.62	8.00 ± 0.63	8.00 ± 0.89	3.33 ± 2.73
Odour	8.33 ± 0.52	8.33 ± 0.52	8.17 ± 0.75	4.00 ± 3.35

n=6 ± Standard Deviation

The following table shows the T-test Value for the formulations against SSMPC-135 (Control Formulation)
Table 19

Treatments	**T-test (AO)**	**T-test (C)**	**T-test (T)**	**T-test (F)**	**T-test (O)**
135X134	1.00	0.60	0.66	1.00	1.00
135X136	0.40	0.60	0.02	1.00	0.66
135X137	0.09	0.00	0.00	0.00	0.01

The following table provides comparison between the final vegan product (plant-based smoked salmon) produced using plant-based microcrystalline cellulose (MCC) features and using competitors from the market.

Table 20

The final vegan product features	Cellulose types*				Reference
	cellulosic material MCC	Avicel - Commercial MCC	Creafibre	Methylcellulose (4AC)	Real Smoked Salmon (Atlantic + Coho)
Sensory (texture)+	8.00	7.66	7.33	1.33	9.00
Hardness (N)#	19.73	12.01	10.50	3.01	28.22
Cohesiveness#	0.653	0.685	0.794	0.804	0.484
Water Loss (%) Day 01	1.03	2.44	2.09	6.01	1.85
Water Loss (%) Day 03	3.81	4.10	5.20	8.09	2.26

*The cellulose features are based on an internal experiment using a 2% final concentration of each cellulose described above in the final product.

+The sensory scores results are the average of 2 different sets of blind sensory analysis.

Figure 37 provides the comparison of the Mechanical hardness (N) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon). Figure 38 provides the comparison of the Mechanical cohesiveness (N) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon). Figure 39 provides the comparison of the Water loss (%) among the vegan smoked salmon produced with cellulosic material, vegan smoked salmon produced with other cellulose types (competitors) and the reference (Real smoked salmon).

2.3.1.7. Conclusions

- Formulation with Avicel is significantly comparable (P>0.05) with plant-based control samples in most of the product attributes.
- Numerically the vegan salmon fabricated with cellulosic material exhibited the best texture score.

- When compared the plant-based formulation with Creafibe, The only difference observed was with texture. Creafibe Avicel provides demonstrated a slightly softer firm texture in comparison to our cellulose.
- The formulation fabricated with Methocel did not form a gel. It was overall lumpy and sticky and far away from real salmon.
- Comparing the formulation produced with cellulosic material with the ones produced with other types of cellulose is possible to infer that the one containing the cellulosic material demonstrated:
    - Lower water loss compared to the competitors, exhibiting values similar to the real smoked salmon.
    - Higher hardness and lower cohesiveness than the competitors, numerically closer to the real smoked salmon.
    - Higher score for the sensory attribute texture when compared to the competitors.
- The cellulosic material contributed to creating a more natural product, resembling more the real reference when compared to the competitors in both parameters: sensory and physical.

3. Mimicking the white connective layer present in the salmon fillet.

The white stripes presented on the salmon fillet are constituted by connective tissue (myo-commata) congregated to a large proportion of the lipid. The white lines in the salmon fillet segment the red-coloured muscle tissue in vertical blocks, giving a zebra-like appearance. The red-coloured muscle located between the white stripes also contains fat but in a smaller concentration (Stien et al., 2007).

3.1. Optimization of the white portion of the fish prototype.

3.1.1. Objective

To improve the texture and appearance of the white lines for the final product. Based on articles by Thompson *et al.* (2012) and Reinoso *et al.* (2019), different treatments to improve the texture of the vegan mayonnaise were explored.

3.1.1.1. Treatments

The following formulations were prepared by the inventors.

GC-003

- 300 g water
- 6 g agar-agar
- 6 g methocel A4C

MAM-005:

- 30 g aquafaba (no salt added)
- 85.5 g sunflower oil
- 0.65 g $CaCl_2$
- 50 g plant-derived cellulosic material (NaOH)

- 1.7 g xanthan gum

MAM-004:

- 30 g aquafaba (no salt added)
- 85.5 g sunflower oil
- 0.65 g $CaCl_2$
- 100 g plant-derived cellulosic material (Sodium bicarbonate)
- 2.4 g xanthan gum

GC-005:

- 62.5 g aquafaba (no salt added)
- 178 g sunflower oil
- 5 g agar-agar
- 5 g methocel A4C

MAC-004:

- 200 g water
- 100 g aquafaba
- 300 g sunflower oil
- 12 g methocel A4C
- 12 g agar-agar

3.1.1.2.Protocol

The formulations were prepared by following the steps outlined below:

- GC-003: The water was boiled until 95℃ and then the agar-agar and methocell were added. They were then chilled in the fridge overnight.
- MAM-004, 005: Sunflower oil and calcium chloride were added slowly to the aquafaba in a thermomixer. The xanthan gum was then added to the mixture.
- GC-005: Aquafaba was heated to 95℃ and then the agar-agar, as well as methocel, were added. Sunflower oil was then added slowly to the mixture.
- MAM-004: Water was heated to 95℃ and then the agar-agar, as well as methocel, was added. Aquafaba was added slowly to the mixture in a thermomixer. Then the sunflower oil was added slowly to the mixture in a thermomixer.

Figure 40 shows images of MAM-004 (top left), MAM-005 (top middle), GC-003 (top right), GC-005 (bottom left), MAC-004 (bottom right).

3.1.1.3. Results and highlights

GC-003 was set in the fridge after storing overnight. The colour was transparent and not that pleasant to mimic the white lines of a salmon fillet. It did not melt during the cooking/baking process. In MAM-004, the consistency of the mayonnaise was perfect. The colour was not as pale as MAM-005. It did not melt during the cooking/baking process. In MAM-005, the consistency of the mayonnaise was perfect. The colour was also closer to the white lines of a salmon fillet than MAM-004. It did not melt during the cooking/baking process. In GC-005, the mayonnaise was breaking (the oil did not want to mix with the aquafaba-agar-methocel mixture). In MAC-004, the gel sets well in the fridge after storing overnight, although the texture was not as hard as GC-003. The colour was also pale, which is promising.

3.1.1.4. Conclusion

It was concluded that MAM-004 has the best texture and look when it was incorporated into the formulation. However, it was still a paste after the cooking process, which is not ideal for texture in the mouth. In contrast, MAC-004 was a promising way to make the white lines more solid. However, further tests were done for this gel.

3.1.2. Objective

The objective was to improve the texture of the white lines on the plant-based fish filet prototype.

3.1.2.1. Treatments

The following formulations were used MAC - 029 (as MAC023 - corn starch), MAC - 030 (26 g corn starch/6 g Methocel), and MAC - 031 (29 g corn starch/3 g Methocel).

3.1.2.2. Protocol

The protocol followed is outlined below.

1. All the ingredients were weighed in separate plastic containers.
2. Tapioca starch was added to the aquafaba. Tapioca starch was added slowly into the aquafaba but not at once.
3. Tapioca starch was mixed with the aquafaba using the hand mixer until all the tapioca starch was dissolved in the solution.

4. Water was heated until it reaches 95°C.
5. Hot water was added slowly into the methocel A4C in a thermomixer.
6. Starch and aquafaba mixture was added slowly into the methocel A4C solution in a thermomixer. Between these steps, the thermomixer should be on at a low speed.
7. The sunflower oil was added slowly into the mixture in the thermomixer until an emulsion formed. Keep watching when the gel is formed (It may be formed before using the whole amount of sunflower oil).

3.1.2.3. Formulations

The formulations were prepared using the following ingredients.

MAC-029

- Aquafaba (150 g)
- Sunflower oil (250 g)
- Water (150 g)
- Methocell A4C (12 g)
- Tapioca Starch (30 g)
- Corn Starch (20g)

MAC-030

- Aquafaba (150 g)
- Sunflower oil (250 g)
- Water (150 g)
- Methocell A4C (6 g)
- Tapioca Starch (30 g)
- Corn Starch (26g)

MAC-031

- Aquafaba (150 g)
- Sunflower oil (250 g)
- Water (150 g)
- Methocell A4C (3 g)
- Tapioca Starch (30 g)
- Corn Starch (29g)

3.1.2.4. Results and highlights

Figure 41 shows an image of MAC-029 and Figure 43 shows images of MAC-030 and MAC031 respectively

- It was observed that MAC-029 when mixing the ingredients it was liquidy, but when it was stored in the fridge for the next day it was more like a gel and sticky.
- All of the three formulations (MAC-029, MAC-030 and MAC-031) were too liquid when mixing.
- MAC-030 and MAC-031 were too liquid, but MAC-030 was more firm than MAC-031 and that is because of methocell A4C.
- Polysaccharides as known can be made to form gels through various mechanisms. Therefore, methylcellulose is used to form gels when it is heated by increasing the hydrophobic attraction between the methyl groups on the molecules. This means that as we increase the amount of methylcellulose in our white lines formulation, the formulations tend to be more bound (McClements, & Grossmann, 2021).

3.1.2.5. Conclusion

It was concluded that the cornstarch should be mixed with the hot water and methylcellulose because heat causes the starch to absorb moisture, swell, and rupture, releasing molecules that dissolve in water. Gelatinization causes irreversible damage to the crystal structure, and it is a phenomenon known as "gelatinization" (Feltre et al., 2020).

3.1.3. Objective

The objective was to improve the texture of white lines on the plant-based fish filet prototype eliminating the Aquafaba.

3.1.3.1. Treatments

The following formulations were prepared using the protocol outlined in 3.1.3.2.

- MAC-042
- MAC-043

3.1.3.2. Protocol

1. All the ingredients were weighed in separate plastic containers.
2. Mix all the dry and wet ingredients together except Iced water for 2 min.
3. Add iced water at last and mix everything using a hand blender until a thick slurry is formed (1min).
4. Refrigerate overnight (12h) for thick gel-type consistency.

3.1.3.3. Formulation

The formulations were prepared using the ingredients outlined in the table below.

MAC-042	MAC-043
• Aquafaba (150 g) • Sunflower oil (300 g) • Iced Water (150 g) • Methylcellulose Vega Pro (12 g) • Tapioca Starch (30 g) • Corn Starch (20g)	• Sunflower oil (150 g) • Water (150 g) • Methylcellulose Vega Pro (6 g) • Tapioca Starch (15 g) • Corn Starch (10g)

3.1.3.4. Results

Figure 42 provides a comparison between MAC-042 and MAC-043 formulations.

3.1.3.5. Highlights

- The formulation with absence of Aquafaba performed equally compared to the one containing the ingredient in terms of attachment and texture.
- A more pale and less white colour was noticed in the formulation prepared without the Aquafaba, providing a more natural appearance.

3.1.3.6. Conclusion/Next steps

The above formulations can also be prepared without Aquafaba.As Aquafaba ingredient has a small shelf life, it is believed that the absence will help on the scale up of the product fabrication.

4. Plant-based Yogurt development

4.1. Objective

The objective was to produce a functional food that presents the same nutritional value as yogurt using cellulosic material as a scaffold for probiotic bacterial strains.

4.2. Milk yogurt characteristics

- White gel emulsion with at least 3.25% of milk fat, 8.25% of Milk Solids Non-Fat (MSNF), and with a titratable acidity higher than 0.9 percent, expressed as lactic acid (CFR - Code of Federal Regulations Title 21 - FDA.).

- Thermostable gels can be obtained by blending with starch, gums, and proteins. The regular yogurt viscosity is about 1.0 to 8.0 Pa.s, and for the greek yogurt near 8 to 10 Pa.s; Labneh made with goat milk has values up to 15 Pa.s.

- The composition of 100 g of regular yogurt, produced with non skimmed milk is listed below:

    - Calories: 150
    - Fat: 8 g
    - Sodium: 113 mg
    - Carbohydrates: 11.4 g

- Fiber: 0 g
- Sugars: 11.4 g
- Protein: 8.5 g
- Calcium
- Phosphorus
- Selenium
- Zinc
- Vitamin B2 (riboflavin)
- Vitamin B5
- Vitamin B12
- Vitamin A

4.3. plant-based yogurt: state-of-art

Yogurt-type emulsion carrying probiotic bacteria is produced, with or without fermentation, by mixing high protein sources with sugar, thickeners, and emulsifiers.

- Protein sources like
  - Hulled soy beans
  - Coconut cream
  - Cashew “milk”
  - Hemp juice 96%
  - Oat
  - Soy
- In general the water extract of the protein source, with fat and sugar, is fermented with the regular microorganisms as usually made with milk. The destabilization of the plant protein structure caused by fermentation and acidification can lead to the weakening of the product structure and to aqueous phase separation during storage and the use of thickeners, and emulsifiers added before, after, or eventually produced during the fermentation.

4.4. Plant-based yogurt: Cellulose process

4.4.1 Protocol

4.4.1.1 Gel preparations

The Woven Bamboo Fibre (plant-based) cellulose was homogenized using the Dynamic MINIPRO MX069.1 7″ Immersion Blender With Homogenizer Attachment for 4 minutes at 10.000 rpm, room temperature. This sample was named PAC-001. In order to compare different sources of cellulose, the bamboo cellulose was homogenized in the same conditions, named BFC. Three nanocelluloses were homogenized at the same conditions with Cellulosic material and nanocelluloses to obtain the samples PAC-003, PAC-004 and PAC-005; the rate of cellulosic material:nanocellulose can be seen in Table 21. In order to observe the gel stability the samples PAC-003, PAC-004, and PAC-005 were centrifuged at 1000xG for 10 minutes then poured out the supernatant and the viscosity was measured again.

Table 21. Ingredient concentration for the yogurt formulations.

Treatments	Concentration (%)						
Sample	plant-basedCELULOSE	NF-COM-Regular	CNF-COM-Extra	CNF-Slurry-SMC	Xanthan	Titanium dioxide	Protein
PAC-003	76.92%	15.38%					
PAC-004	76.92%		15.38%				
PAC-005	76.92%			15.38%			
PAC-006	82.92%			16.58%		0.49%	
PAC-007	97.94%				1.96%	0.10%	
PAC-008	90.09%				1.80%		8.11%
PAC-009	76.63%			15.33%			8.05%

4.4.1.2 Viscosimetry and Stability test

Samples were analysed using a viscometer Anton Paar ViscoQC 300, spindle SC4-21 operating at 100 rpm, at room temperature, in triplicate. After two weeks in the fridge (8℃) the samples PAC-003, PAC-004 and PAC-005 were analyzed again. The viscosities measured can be seen in table 22.

4.5 Results

The homogenization process apparently produces a stable suspension using only cellulosic material, sample PAC (PAC-001) in Figure 43. The cellulose from bamboo showed aggregation and the fibers were very evident. New pictures were taken after sitting for 5 minutes, and again after sitting for 4 hours. It's visible that plant-based remains in suspension even after 4h while bamboo fiber quickly sinks to the bottom in Figure 44. Figure 44 shows images of PAC-001 vs. bamboo fibrer cellulose (1%) after shaking, after sitting for 5 minutes, and after sitting for 4 hours (from left to right).

4.5.1 Effect of the homogenization on the formulations PAC-003, PAC-004 and PAC-005

The PAC-001 gives a fluid suspension, while the mixtures of the plant-based with nanocelluloses demonstrated structure and gel behavior as can be seen in Figure 45. Figure 45 shows images of samples of the formulations PAC-003, PAC-004 and PAC-005, and their spreadability behavior. The centrifuged samples lost near 10% of their volume, Figure 45. The viscosity values, shown in table 14, were similar to the ones registered for greek yogurt near ~10 Pa.s and for the centrifuged samples the increase in the viscosity was 1.6, 1.3 and 1.2 higher than the PAC-003, PAC-004, and PAC-005 samples before, Table 21. Figure 46 shows samples of the formulations PAC-003, PAC-004, and PAC-005 before (left) and after centrifugation.

Table 22 shows the viscosity measured for the yogurt formulations right after the homogenization process and after two weeks in the fridge at 8℃.

Sample	Method	Average Viscosity (Pa.s)	STDDEV	Variance
	Normal	11.110	0.740	0.548
PAC-003	Centrifuged	18.273	1.130	0.730
	Normal	10.123	0.428	0.183
PAC-004	Centrifuged	13.577	1.540	2.373
	Normal	8.889	0.000	0.000
PAC-005	Centrifuged	10.616	0.855	0.731
	Normal	74.317	0.427	0.183
PAC-007	Centrifuged	54.567	2.807	7.881
PAC-008	Normal	179.033	6.304	39.743

Centrifuged	136.767	4.055	16.443

Figure 47 shows a comparison of the Viscosities of the Initial versus 2 weeks Stored homogenized plant-based & nanocellulose samples. The viscosity increased for almost all conditions tested with the exception of the non-centrifuged formula PAC-003, Figure 3. The Figure 47 helps to figure out the fact that the viscosity was concentrated in the region near 10 Pa.s increasing to 15 to 20 Pa.s after 2 weeks.

Figure 48 shows the distribution of the Viscosities of the Initial versus 2 weeks of Stored homogenized plant-based & nanocellulose samples. It is also possible to observe in Figure 48 that the viscosity distribution is near 9 to 12 for 5 of the 10 fresh samples measured.

4.5.2 Comparing the cellulosic material homogenized prototypes with commercial yogurts

The viscosity of the prototypes made with homogenized cellulosic material were compared with the ones of the commercial yogurts. The yogurt tested where:

- liquid yogurt
- regular yogurt (2% fat)
- greek yogurt
- plant-based regular smoothie

The plant-based product used was a smoothie, a cream in which the probiotic bacteria is mixed with the cream base, no fermentation was done. The cream formed after homogenization of cellulosic material with nanocellulose gave silkness and viscosity values higher than the plant-based smoothie. Adding protein to the mixture the creaminessand viscosity increased significantly, above the values observed for the regular yogurt and greek yogurt.

Figure 49 shows a comparison among commercial dairy and plant-based products produced with the plant-based starting material.

4.5.3 Samples with protein isolates and fermented

The samples with 8% of the isolated protein, PAC008, and PAC009 have shown an increase of the viscosity higher than the target value of 10 Pa.s which is the average value for greek yogurt. Figure 50 shows homogenized prototypes PAC-007 and PAC-008 before and after centrifugation. For this reason sample PAC009 was discarded and only the PAC008, with Cellulose based material, Xanthan gum, and protein (mung bean) was analyzed

4.5.4 Fermented sample

Sample PAC-010 was prepared with 1% of *Bacillus bulgaricus*, using 50% of cellulosic material and only 4% of protein, 4% of sucrose, 2% of yeast extract, and this mixture can be considered a functional smoothie considering the fact that it has probiotic bacteria. After 5 hours of fermentation at 36°C was observed an increase in adhesivity and the reduced pH from neutral to 4.8. The viscosity achieved was 23 Pa.s, similar to the regular yogurt. Most important is the fact that after the fermentation was not observed precipitated proteins, and after centrifugation and consequent gas removal. The remaining material was creamy and homogeneous, characteristics we are looking for using cellulosic material as a scaffold to recreate fermented functional food like yogurt.

Figure 51 shows the change in the aspect of plant-based smoothie (left); after 5 h fermenting with *Bacillus bulgaricus* (mid); centrifuged fermented cream (right).

4.5.5 Role of homogenization and a Proposal for Plant-based yogurt Production Process

The inventors have proposed the production of cellulosic material with a fermentation step that is a technological challenge for most of the plant-based yogurts concerning the instability and loss of structure given by the change in the pH during the metabolic process. It could be concerning to hold the probiotic bacteria owing to the capacity of scaffolding cells presented by cellulosic material and its stability to pH changes. For that, carbon and nitrogen sources should be added prior to the fermentation, as well as growth factors such as B complex vitamins and biotin.

One of the most advantageous aspects of cellulosic material is its capacity to form strong and stable emulsions after homogenization with oils and proteins. For that, the blend needs to be mixed with a homogenizer probe at 10k rpm for up to 5 minutes giving the consistency as shown in the Figure 46, where cellulosic material was the base for the PAC-008 prototype with 8% of protein. Is important to note that the cellulosic material has only ~1% of dry matter; it means that 1g in 100 g of sample was capable of holding 8 g of protein as a cream with high stability and no sign of syneresisafter 2 weeks (as shown in figure 47). Figure 52 shows an image prototype PAC-008 after homogenization.

- The process of homogenization was carried out with mixers using:
    - **high speed** and **high shear rate**
    - **high pressure**
- The inventors worked with bench equipment that can homogenize up to 4 liters with a blade homogenizer probe working at ~10K rpm. Pilot models can go up to 60 liters and the industrial versions of this kind of equipment can be found up to 6k liters, but with expected changes in processing time. However, better results in terms of micronization and scalability can be achieved using high pressure emulsifiers.

Figure 53 shows images of a typical high-shear homogenization probe for bench and pilot homogenizers at the top; industrial homogenization/emulsifying machine with a speed rotor of ~ 3k rpm in the middle; and emulsifying system using high-pressure mixing at the bottom.

Figure 54 shows the main steps to obtain a plant-based yogurt preparation process using the cellulosic material scaffold proposed by the inventors. Figure 54 shows a process flow diagram to obtain plant-based yogurt using the cellulosic material scaffold.

5.1. Plant-based seafood substitutes: Plant-based raw Tuna

1.1. Objective

The objective was to develop and prototype a vegan alternative to traditional tuna, focusing on creating a plant-based formulation that replicates conventional tuna's sensory (flavour, odour, colour, and texture) attributes.

1.2. Treatments

The inventors created several formulations comprising various combinations of ingredients to obtain a formulation with characteristics similar to traditional tuna. A list of formulations is provided below.

- TMPC - 015 - Liquid tuna flavour
- TMPC - 016 - Liquid fish flavour
- TMPC - 017 - Liquid fish and tuna flavour
- TMPC - 018 - Liquid tuna flavour and natural fish flavour
- TMPC - 019 - Natural fish and natural tuna flavour
- TMPC - 020 - Liquid tuna flavour, natural fish flavour and natural tuna flavour
- TMPC - 021 - 0.65g k-carrageenan
- TMPC - 022 - 0.45g k-carrageenan
- TMPC - 023 - Without k-carrageenan
- TMPC - 024 - Magna ruby and supra red liquid
- TMPC -025 - Red No 40 and supra red liquid
- TMPC - 026 - Supra red, magna ruby, red no 40
- TMPC - 027 - Supra red, magna ruby

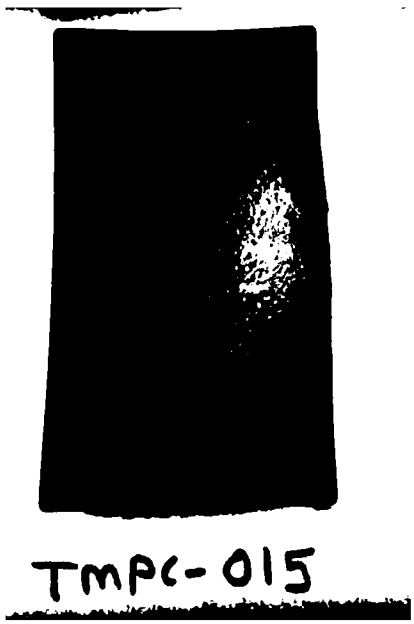
1.3. Equipment and materials

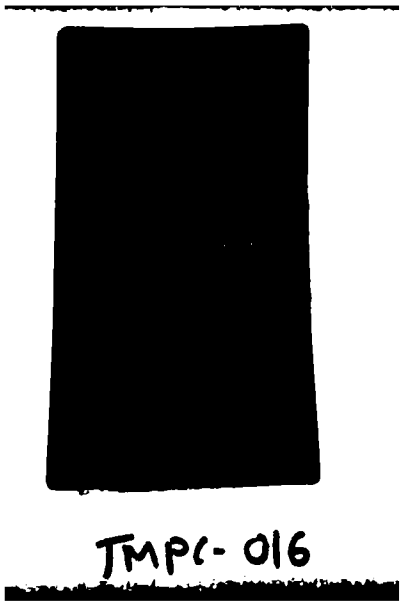
An exemplary list of equipments and materials is provided below.

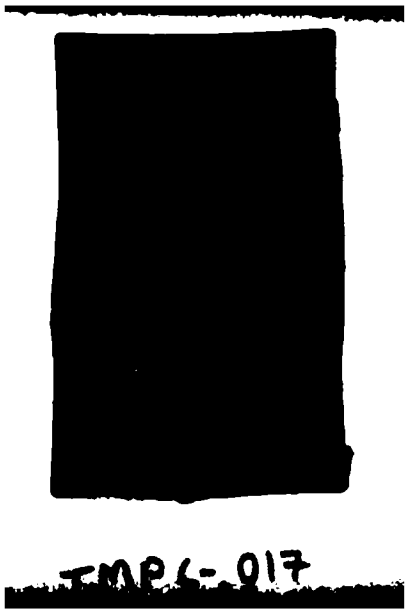
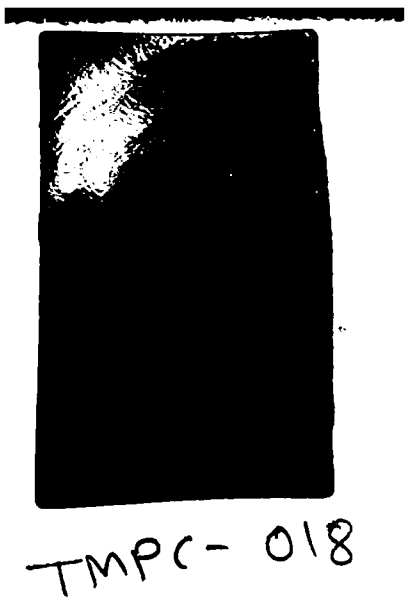
- Plastic containers
- Spoons
- Thermo mix Thermomixer
- Cooking pan
- Betty Crocker Plastic spatula

- Hanna HI pH meter (S/N HI981036)
- ThermoPro TP01A Thermometer
- Thermo Fisher Droppers
- Scale (Sartorius, S/N 0043105184)

1.4. Treatments, formulations and comments

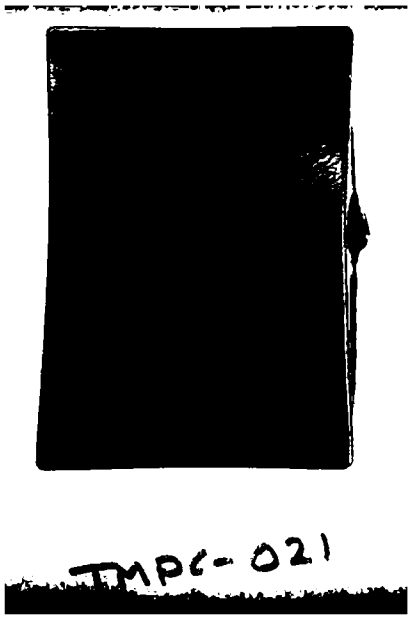
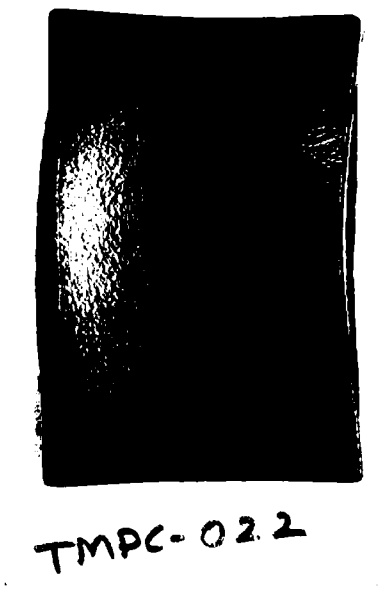
Formulation	Picture	Comments
TMPC-015 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g Dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 3.15g Liquid Fish Flavor ● 0.03g Red no 40 ● 0.29g Supra red ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Firm and too oily texture ● Bitter taste

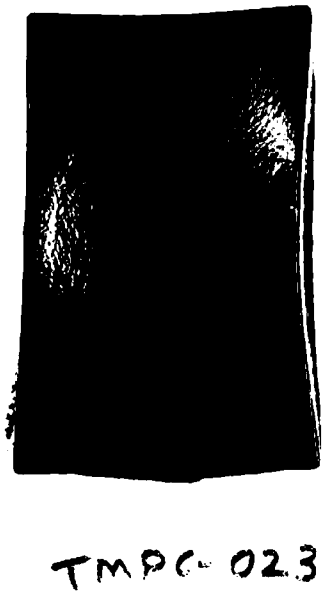
TMPC-016 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 3.15g Liquid Fish Flavor ● 0.05g Red No. 40 ● 0.27g Supra red ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Firm texture ● Mild fishy taste ● Orange in colour

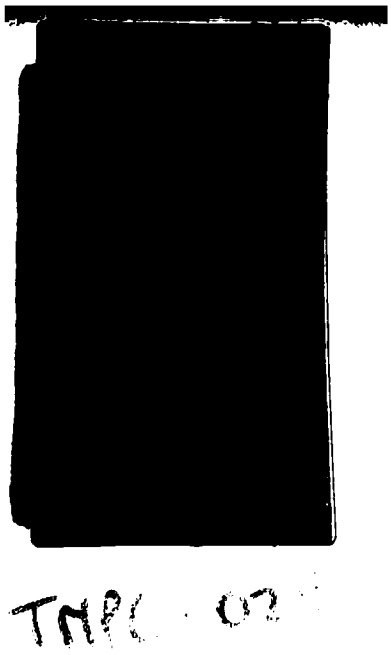
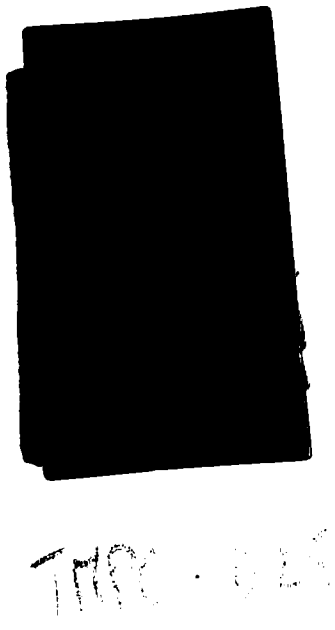
TMPC-017 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 1.57g Liquid Fish Flavor ● 1.57g Liquid Tuna Flavour ● 0.03g Red no 40 ● 0.29g Supra red ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Firm texture ● Bitter taste and strong unpleasant taste
TMPC-018 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast		● Texture has bite ● Tuna like colour ● Mild bitter flavour

• 3.15g Sorbitol • 0.63g Liquid Fish Flavor • 4.72g Natural Fish Flavour • 0.05g Magna ruby • 0.20g Supra red • 1.5g Omega 3 • 20.58g Flaxseed oil		
TMPC-019 • 46.46 g Water • 214.20 g Distilled water • 6.30 g dry cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Tuna Flavor • 4.72g Natural Fish Flavour • 0.03g Magna ruby • 0.29g Supra red • 1.5g Omega 3 • 20.58g Flaxseed oil		• Tough texture with bite • Bit bland flavour • Colour like Yellowfin Tuna

TMPC-020 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 2.36g Liquid Tuna Flavor ● 2.36g Natural Tuna Flavour ● 0.08g Magna ruby ● 0.20g Supra red ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Softer texture ● Mild bitter aftertaste ● Too pink in colour

TMPC-021 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.65 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Tuna Flavor ● 4.72g Natural Fish Flavour ● 0.05g Magna ruby ● 0.18g Supra red ● 1.5g Omega 3 ● 20.58g Flaxseed oil		● Solid and firm bite texture ● Moist appearance ● Not strong fishy/metallic taste
TMPC-022 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.45 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Tuna Flavor		● Soft fish like texture ● Too purple in colour ● Slight metallic taste

• 4.72g Natural Fish Flavour • 0.08g Magna ruby • 0.15g Supra red • 1.5g Omega 3 • 20.58g Flaxseed oil		
TMPC-023 • 46.46 g Water • 214.20 g Distilled water • 6.30 g dry cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Tuna Flavor • 4.72g Natural Fish Flavour • 0.10g Magna ruby • 0.10g Supra red • 1.5g Omega 3 • 20.58g Flaxseed oil	 	• Mushy and slimy texture • Too bright in colour • Grainy and rough overall surface

TMPC-024 • 46.46 g Water • 214.20 g Distilled water • 6.30 g dry cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 0.63g Liquid Fish Flavor • 4.72g Natural Fish Flavour • 0.03 g Magna ruby • 0.15 g Supra red liquid • 1.5g Omega 3 • 20.58g Flaxseed oil		• Solid and firm bite texture • Moist and oily overall • Pinkish appearance
TMPC-025 • 46.46 g Water • 214.20 g Distilled water • 6.30 g dry cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol		• Solid and firm bite texture • Moist and oily overall • Red and vibrant appearance

• 4.72g Natural Tuna Flavor • 4.72g Natural Fish Flavour • 0.03 g Red No 40 • 0.15 g Suprar red • 1.5g Omega 3 • 20.58g Flaxseed oil		
TMPC-026 • 46.46 g Water • 214.20 g Distilled water • 6.30 g dry cellulosic material • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.90 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.00g Flaxseed oil		• Reddish appearance • Firm and oily texture • Tuna like flavour

TMPC-027 ● 46.46 g Water ● 214.20 g Distilled water ● 6.30 g dry cellulosic material ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.90 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Fish Flavor ● 4.72g Natural Tuna flavour ● 0.15g Supra red ● 0.08g Magna Ruby ● 22.00g Flaxseed oil	 TMPC- 027	● Pinkish appearance ● Firm and oily texture ● Mild fishy taste

1.5. Protocol

The protocol for all the samples was quite similar, however, with differing ingredients. A person skilled in the art would understand that the steps recited herein can vary and could be performed in any order. Following is the protocol for the formulations.

1. Weighing of Ingredients:
    a. Dry ingredients were measured, starting with the ingredient having the lowest concentration, and placed into a mixing bowl.
    b. Similarly, all the liquid ingredients were weighed, starting with the lowest concentration, and were placed into a separate mixing bowl.
2. Combining Liquid Ingredients:
    a. The mixture of liquid ingredients was transferred into the designated thermomix bowl.
    b. The lid of the thermomixer was securely closed and a 15-second blending cycle was initiated for the liquid ingredients.
    c. The lid was opened and a spatula was used to ensure that any adhered material on the thermomixer walls was properly scraped off.

3. Gradual Dry Ingredient Addition:
    a. The thermomixer lid was closed and the device was set to a lower speed setting.
    b. The complex powder was gradually introduced into the thermomixer, maintaining a controlled and steady addition rate.
    c. The mixer was stopped once all the dry ingredients were incorporated. The lid was opened and a spatula was used to scrape off the material from the wall.
4. Blending and Mixing:
    a. The thermomixer lid was closed again and the mixture was blended for 30 seconds, ensuring homogeneity and even distribution.
5. Heating and Preparation:
    a. The blended mixture was transferred into a nonstick pan, ensuring careful handling to avoid spillage.
    b. Heat was applied to the pan using a gas stove, gently heating the mixture until its temperature reached 65°C or above.
    c. Once the desired temperature was achieved, the stove was turned off.
6. Transfer and Packaging:
    a. The heated mixture was carefully moved into a suitable plastic container.
    b. The plastic container containing the mixture was placed into a vacuum-seal bag, and securely the bag was sealed using a vacuum sealer device.
7. Settling and Refrigeration:
    a. The vacuum-sealed samples were put aside in a refrigerator, allowing them to settle for a minimum duration of 4 hours.
    b. After this settling period, the formulation was ready for further analysis and evaluation.

1.6. Results

Out of all the formulations completed, the following table provides a comparison among the sensory analysis results of a few formulations.

Table 35. Sensory analysis for different attributes comparison among samples.

Sensory attributes	TMPC-021	TMPC-022	TMPC-023	TMPC-026	TMPC-027
Overall Appearance	7.20 ± 0.84	6.40 ± 0.55	6.50 ± 1.00	7.00 ± 0.82	6.25 ± 2.22
Colour	7.00 ± 100	6.40 ± 0.89	6.60 ± 0.55	6.75 ± 0.96	6.50 ± 2.38
Texture	7.00 ± 1.22	6.60± 0.89	5.80 ± 1.10	7.75 ± 0.50	7.25± 0.96
Tuna Flavour	6.40 ± 0.89	6.00 ± 0.71	6.00 ± 1.87	6.50 ± 1.73	6.50 ± 2.38

Metallic Flavour	5.40 ± 1.82	5.40 ± 1.52	5.60 ± 1.52	6.50± 1.29	5.25 ± 1.26
Odour	6.75 ± 0.50	6.75 ± 0.55	6.80 ± 0.45	7.00 ± 2.00	6.50 ± 2.38

n=6 ± Standard Deviation

Figure 55A and Figure 55B provides a Sensory analysis graph for Tuna formulations TMPC-021 (55A), TMPC-022 (55A), TMPC-023 (55A), TMPC-026 (55B) and TMPC-027 (55B).

1.7. Highlights

The sensory analysis provided valuable insights into the sensory characteristics of the different treatments, which can be crucial for product development and quality improvement. TMPC-021 demonstrated a high score for the overall sensory performance in overall appearance, color, and texture attributes. Tuna and metallic flavour attributes remained consistent across all treatments, suggesting that these attributes are not strongly influenced by formulation differences. TMPC-026 demonstrated superior qualities in key attributes. It exhibited a more appealing overall appearance, colour, and texture, along with a milder metallic flavour and a more favourable odour profile when compared to TMPC-027. While TMPC-026 and TMPC-027 samples had similar ratings for tuna flavour, TMPC-026 demonstrated a better score for overall appearance when compared to TMPC-027, indicating its potential for a more satisfactory sensory experience.

1.8. Further Objective

The primary objective was to develop and prototype a vegan alternative to traditional tuna, focusing on creating a plant-based formulation that replicates conventional tuna's sensory (flavour, odour, colour, and texture) attributes. A further objective was to determine the range of the most important additives/ingredients (K-carrageenan, fava protein, and cellulosic material (also referred to as WBF cellulose), to create plant-based tuna with an acceptable sensory profile.

1.9. Treatments

The inventors created several formulations comprising various combinations of ingredients to obtain a formulation with characteristics similar to traditional tuna. A list of formulations is provided below.

- TMPC - 028 - 1.00g k-carrageenan
- TMPC - 029 - 0.80g k-carrageenan
- TMPC - 030 - 0.65g k-carrageenan
- TMPC - 031 - 0.55g k-carrageenan
- TMPC - 032 - 0.45g k-carrageenan
- TMPC - 033 - 1.96g fava protein
- TMPC - 034 - 4.72g fava protein
- TMPC - 035 - 7.78g fava protein

- TMPC - 036 - 11.02g fava protein
- TMPC - 037 - 16.0g fava protein
- TMPC - 039 - 3.15g cellulose
- TMPC - 040 - 6.3g cellulose
- TMPC - 041 - 12.6g cellulose
- TMPC - 042 - 18.9g cellulose

1.10. Equipment and materials

An exemplary list of equipments and materials is provided below.

- Plastic containers
- Spoons
- Thermo mix Thermomixer
- Cooking pan
- Betty Crocker Plastic spatula
- Hanna HI pH meter (S/N HI981036)
- ThermoPro TP01A Thermometer
- Thermo Fisher Droppers
- Scale (Sartorius, S/N 0043105184)

1.11. Treatments, formulations and comments

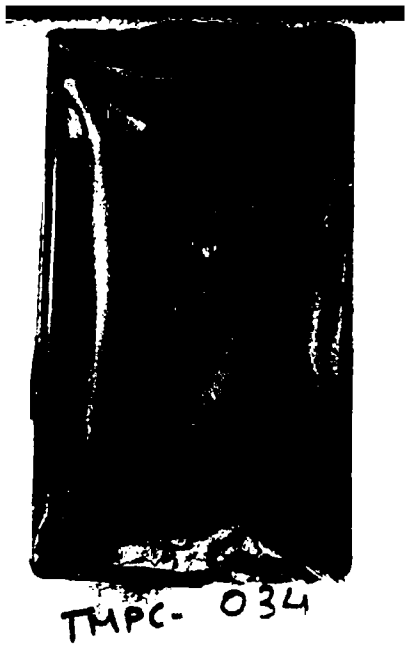
TMPC-028 ● 261.4g Water ● 6.30 g dry cellulose ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 1.00 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Fish Flavor ● 4.72g Natural Tuna flavour		● All attributes are the same as the control sample

• 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		
TMPC-029 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.80 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• All attributes same as the control sample

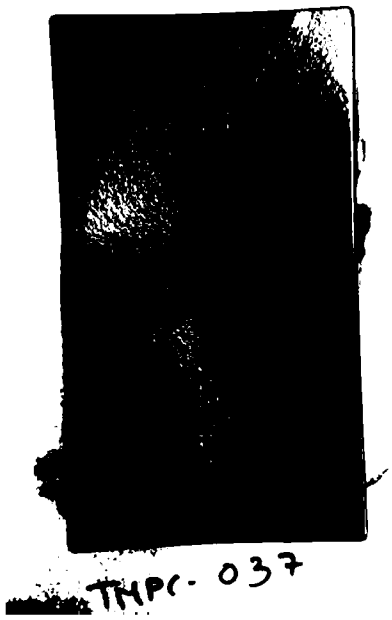
TMPC-030 ● 261.4g Water ● 6.30 g dry cellulose ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.65 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Fish Flavor ● 4.72g Natural Tuna flavour ● 0.04g Red no 40 ● 0.15g Supra red ● 0.04g Magna Ruby ● 22.08g Flaxseed oil		● All attributes same as the control sample

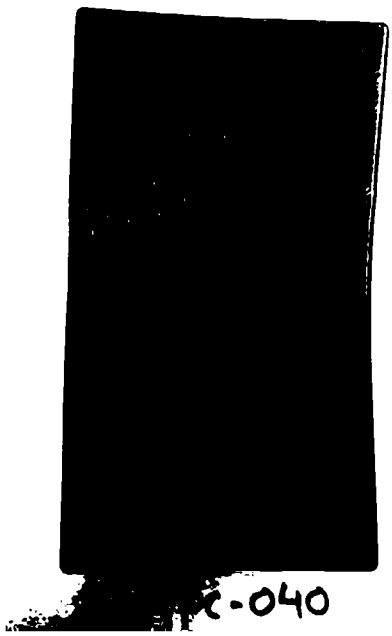
TMPC-031 ● 261.4g Water ● 6.30 g dry cellulose ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.55 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Fish Flavor ● 4.72g Natural Tuna flavour ● 0.04g Red no 40 ● 0.15g Supra red ● 0.04g Magna Ruby ● 22.08g Flaxseed oil		● Softer texture ● All other attributes same as the control sample
TMPC-032 ● 261.4g Water ● 6.30 g dry cellulose ● 2.20g Konjac gum ● 2.20g Xanthan Gum ● 0.45 g k-carrageenan ● 2.20g Salt ● 1.96g Fava Protein ● 3.0g Yeast ● 3.15g Sorbitol ● 4.72g Natural Fish Flavor ● 4.72g Natural Tuna flavour		● Softer texture ● All other attributes same as the control sample

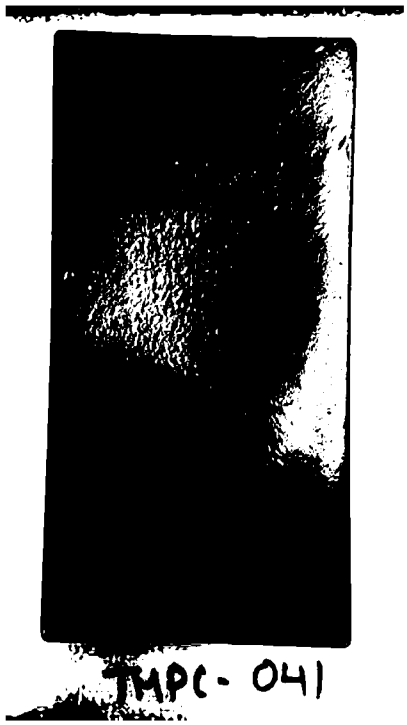
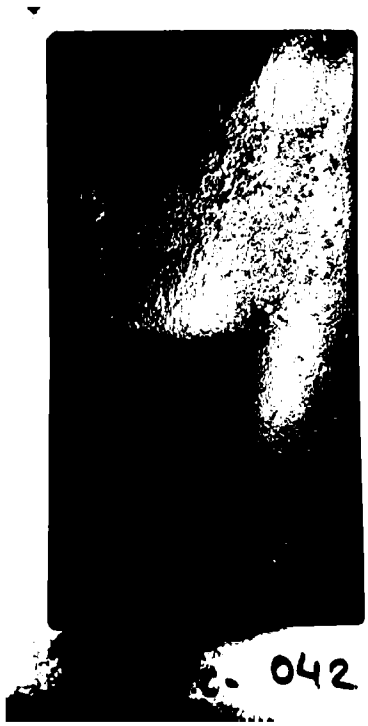
• 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		
TMPC-033 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• All attributes same as the control sample

TMPC-034 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 2.20g Salt • 4.72g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• Less fishy flavour • All other attributes same as the control sample
TMPC-035 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 2.20g Salt • 7.78g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour		• Less fishy flavour • All other attributes same as the control sample

• 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		
TMPC-036 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 2.20g Salt • 11.02g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• Less fishy flavour • All other attributes same as the control sample

TMPC-037 • 261.4g Water • 6.30 g dry cellulose • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 2.20g Salt • 16.0g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• Less fishy flavour • All other attributes same as control sample
TMPC-039 • 261.4g Water • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 3.15g cellulose • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour		• Slimy appearance • All other attributes same as the control sample

• 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		
TMPC-040 • 261.4g Water • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 6.3g cellulose • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• All attributes same as the control sample

TMPC-042 • 261.4g Water • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 12.6g cellulose • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour • 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		• Stiff and hard texture • All other attributes same as the control sample
TMPC-042 • 261.4g Water • 2.20g Konjac gum • 2.20g Xanthan Gum • 0.65 g k-carrageenan • 18.9g cellulose • 2.20g Salt • 1.96g Fava Protein • 3.0g Yeast • 3.15g Sorbitol • 4.72g Natural Fish Flavor • 4.72g Natural Tuna flavour		• Stiff and hard texture • All other attributes same as the control sample

• 0.04g Red no 40 • 0.15g Supra red • 0.04g Magna Ruby • 22.08g Flaxseed oil		

1.12. Treatments

The protocol for all the samples was similar just differing in some of the ingredients. It was observed that some of the formulations had a colour resembling real Tuna e.g. TMPC-0026. In an exemplary embodiment, the following protocol was used to develop the formulations. A person skilled in the art would understand that the sequence of steps is not pertinent, and other variations of this methodology are encompassed within the scope of this application.

1. **Weighing of Ingredients:**
    a. All dry ingredients were carefully measured, starting with the ingredient having the lowest concentration, and placed into a mixing bowl.
    b. Similarly, all liquid ingredients were weighed, starting with the one with the lowest concentration, and placed them into a separate mixing bowl.
2. **Combining Liquid Ingredients:**
    a. The mixture of liquid ingredients was transferred into the designated thermomix bowl.
    b. The lids of the thermomixer were securely closed and a 15-second blending cycle was initiated for the liquid ingredients.
    c. The lid was opened and a spatula was used to ensure that any adhered material on the thermomixer walls was properly scraped off.
3. **Gradual Dry Ingredient Addition:**
    a. The thermomixer lid was closed and the device was set to a lower speed setting.
    b. Gradually the complex powder was introduced into the thermomixer, maintaining a controlled and steady addition rate.
    c. The mixer was stopped once all the dry ingredients were incorporated. The lid was opened and by using a spatula the material from the wall was scraped out.

4. **Blending and Mixing:**
    a. The thermomixer lid was closed again and the mixture was blended for 30 seconds, ensuring homogeneity and even distribution.
5. **Heating and Preparation:**
    a. The blended mixture was transferred into a nonstick pan, ensuring careful handling to avoid spillage.
    b. Heat was applied to the pan using a gas stove, gently heating the mixture until its temperature reaches 65°C or above.
    c. Once the desired temperature was achieved, the stove was turned off.
6. **Transfer and Packaging:**
    a. The heated mixture was carefully moved into a suitable plastic container.
    b. The plastic container containing the mixture was placed into a vacuum-seal bag, and the bag was securely sealed using a vacuum sealer device.
7. **Settling and Refrigeration:**
    a. The vacuum-sealed samples were placed in a refrigerator, allowing them to settle for a minimum duration of 4 hours.
    b. After this settling period, the formulation was ready for further analysis and evaluation.

1.13. Results

The inventors prepared five different formulations using different concentrations of k-carrageenan to define the acceptable range of k-carrageenan in the plant-based tuna. The following table provides a comparison among the sensory parameters of formulations TMPC- 028, TMPC - 029, TMPC-030, TMPC -031 and TMPC - 032.

Table 36. Comparison among the sensory parameters from samples TMPC-028 to TMPC-032.

Sensory attributes	TMPC-028	TMPC-029	TMPC-030	TMPC-031	TMPC-032
Overall Appearance	7.00 ± 0.82	7.25 ± 0.50	7.25 ± 0.50	7.00 ± 0.82	7.00 ± 0.82
Colour	7.25 ± 0.50	7.25 ± 0.50	7.00 ± 0.82	7.00 ± 0.82	7.00 ± 0.82
Texture	6.75 ± 0.96	6.50± 0.58	5.75 ± 1.26	7.25 ± 0.50	6.25± 0.96
Tuna Flavour	7.25 ± 0.96	7.25 ± 0.96	7.25 ± 0.96	7.25 ± 0.96	6.50 ± 2.38
Metallic Flavour	7.00 ± 1.00	7.00 ± 1.00	7.00 ± 1.00	7.00± 1.00	6.25 ± 1.71
Odour	6.50 ± 1.73	7.00 ± 1.41	7.00 ± 1.41	7.25 ± 0.96	7.25 ± 0.96

n=4 ± Standard Deviation

A comparison among the sensory parameters from samples TMPC-028 to TMPC-032 is shown in Figure 55C.

Five different formulations were prepared using different concentrations of fava protein to define the acceptable range of fava protein in the plant-based tuna. The following table provides a comparison among the sensory parameters of formulations TMPC- 033, TMPC - 034, TMPC-035, TMPC -036 and TMPC - 037.

Table 24 . Comparison among the sensory parameters from samples TMPC-033 to TMPC-037.

Sensory attributes	TMPC-033	TMPC-034	TMPC-035	TMPC-036	TMPC-037
Overall Appearance	6.75 ± 1.89	6.50 ± 1.73	6.50 ± 1.73	6.25 ± 2.22	6.50 ± 1.29
Colour	7.00 ± 2.00	6.75 ± 1.89	6.50 ± 2.38	6.00 ± 2.16	6.00 ± 2.16
Texture	7.50 ± 1.00	7.00± 1.41	6.75 ± 1.26	6.50 ± 0.58	5.50± 1.73
Tuna Flavour	6.75 ± 1.89	6.75 ± 1.89	6.25 ± 1.71	6.00 ± 1.41	5.50 ± 1.29
Metallic Flavour	6.50 ± 1.29	6.50 ± 1.29	6.50 ± 1.29	6.50± 1.29	6.25 ± 1.50
Odour	6.50 ± 1.73	6.50 ± 1.73	6.50 ± 1.29	6.50 ± 1.29	5.75 ± 1.50

n=4 ± Standard Deviation

Figure 55D provides a comparison among the sensory parameters from samples TMPC-033 to TMPC-037.

Five different formulations were prepared using different concentrations of cellulose to define the acceptable range of cellulose in the plant-based tuna. The following table provides a comparison among the sensory parameters of formulations TMPC- 038, TMPC - 039, TMPC-040, TMPC -041 and TMPC - 042.

Table 25 . Comparison among the sensory parameters from samples TMPC-039 to TMPC-042.

Sensory attributes	TMPC-039	TMPC-040	TMPC-041	TMPC-042
Overall Appearance	7.00 ± 0.82	6.75 ± 1.26	6.50 ± 1.00	5.75 ± 0.96
Colour	6.75 ± 0.50	6.25 ± 1.50	6.50 ± 0.58	5.50 ± 0.58
Texture	6.75 ± 0.96	6.75 ± 0.50	6.50 ± 0.58	4.25± 1.50
Tuna Flavour	7.00 ± 0.82	7.00 ± 0.82	6.50 ± 0.58	5.25 ± 1.71

Metallic Flavour	6.00 ± 0.82	6.00 ± 0.82	5.75± 0.96	5.25 ± 1.71
Odour	7.00 ± 0.82	7.00 ± 0.82	6.50 ± 0.58	6.00 ± 1.41

n=4 ± Standard Deviation

Figure 55E provides a comparison among the sensory parameters from samples TMPC-039 to TMPC-042.

1.14. Highlights

- The K-carrageenan trial using sensory analysis demonstrated that aside from texture, most attributes remain consistent across the formulations. For texture, a concentration of 0.55 g of k-carrageenan gave better results.
- Variations were observed primarily in texture, referable to the differing concentrations of k-carrageenan.
- However, none of the results fell below an acceptable range.
- It can be concluded that the working limit for k-carrageenan lies within the range of 0.45 g to 1.0 g.
- The fava protein trial using sensory analysis demonstrated that aside from texture and flavour, most attributes remain consistent across the formulations. The best texture and flavour parameters were from the formulations 033 and 034, ranging the concentration from 1.96g to 4.72g of fava protein
- Variations were observed in texture and flavour, due to the differing concentrations of fava protein.
- However, none of the results fell below an acceptable range. Therefore, it can be concluded that the working limit for fava protein is within the range of 1.96g to 16.0g.
- The cellulosic material trial using sensory analysis, demonstrated that all the sensory parameters exhibited differences across the formulations. The best formulations were the 038 and 039, with the cellulosic material ranging from 3.15g to 6.3g of cellulosic material.
- Variations were observed in texture due to the differing concentrations of Cellulose.
- However, none of the results fell below an acceptable range.
- It can be concluded that the working limit for cellulose is within the range of 0.5% to 6%.

5.2. **Plant-based Dairy Substitutes: Plant-based Vegan Ice cream**

2.1. Experiment

2.1.1. Objective

The main objective was to recreate a plant-based Ice cream using cellulosic material, i.e. cellulose-based scaffolds. Another objective was to evaluate the capacity of the cellulosic material or scaffolds to substitute the egg and compare the vegan ice cream formulation with the ones available in the market.

2.1.2. Treatments

The following formulations were developed and tested by the inventors.

- Regular in-house-made ice cream with egg, regular milk, and no cellulose
- Ice cream with cellulosic material and no egg (Egg substitution) - cellulosic material (preferably 2%)
- Vegan Ice cream made with cashew milk - cellulosic material (preferably 2%)
- Vegan Ice cream made with oat milk - cellulosic material (preferably 2%)
- Vegan Ice cream Methocel made with cashew milk – Methylcellulose (preferably 2%)
- Vegan Ice cream Avicel made with cashew milk – Avicel (preferably 2%)
- Regular ice cream from the market
- Vegan ice cream from the market

2.1.3. Equipment and materials

An exemplary list of equipment's and materials is provided below. A person skilled in the art would understand that any suitable replacements of these materials are contemplated within the scope of this invention.

- Plastic containers
- Spoons
- Musso Lussino Ice cream Machine
- Cooking pan
- Betty Crocker Plastic spatula
- ThermoPro TP01A Thermometer
- Scale (Sartorius, S/N 0043105184)

2.1.4. Ingredients

An exemplary list of ingredients is provided below. A person skilled in the art would understand that any suitable replacements of these ingredients are contemplated within the scope of this invention.

- cellulosic material
- Cashew Milk
- Oat Milk
- Chocolates
- Coffee Powder
- Sugar
- Glucose
- Egg yolks

2.1.5. Protocol

A person skilled in the art would understand that the steps recited herein can vary and could be performed in any order. Following is the protocol that was used to prepare the formulations.

- Weighed the designated quantities of chocolate, glucose, sugar, and instant coffee in a single container.
- Heated the desired amount of milk in a saucepan until it reaches a hot temperature.
- Once the milk was hot, added the chocolate mixture created in Step 1 to the hot milk. In the case of non-vegan ice cream formulation, included eggs as well.
- Simultaneously stirred the mixture during the heating process. Switched off the stove when the mixture reached a creamy consistency.
- Measured the desired quantity of cellulosic material and combined it with water. Used a homogenizer to achieve a uniform homogenous blend and set the mixture aside.
- Added the milk and chocolate mixture into an ice cream machine. Incorporated the homogenized cellulosic material mixture into the ice cream machine as well.
- Allowed the mixture to churn for the predetermined duration, ensuring proper homogenization and desired texture development.
- Transferred the prepared mixture into a freezer-safe container. Allowed the mixture to settle and cool within the freezer for 2 hours, until desired consistency and optimal taste development.

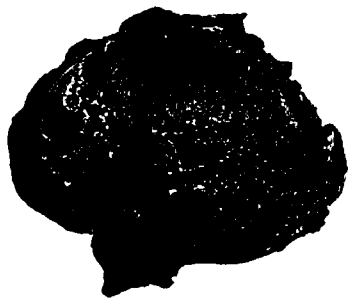
2.1.6. Results

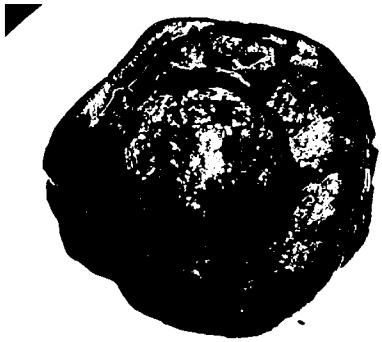
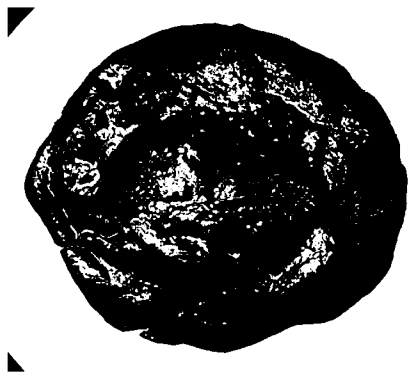
2.1.6.1. Melting Analysis

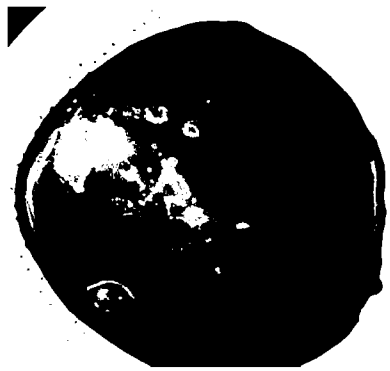
The following table provides melting analysis and observations for each formulation.

Table 26 . Pictures and observations for each formulation.

cellulosic material with regular milk ice cream 5 min at Room temperature	cellulosic material ice cream regular milk 30 min at Room temperature	cellulosic material ice cream regular milk 60 minutes at Room temperature
		

		
cellulosic material with cashew milk ice cream 5 min at Room temperature 	cellulosic material ice cream cashew milk 30 min at Room temperature 	cellulosic material ice cream cashew milk 60 minutes at Room temperature 
cellulosic material with oat milk ice cream 5 min at Room temperature	cellulosic material ice cream oat milk ice cream 30 min at Room temperature	cellulosic material ice cream oat milk ice cream 60 minutes at Room temperature

		
Regular in-house milk ice cream 5 min at Room temperature 	Regular in-house milk ice cream 30 min at Room temperature 	Regular in-house milk ice cream 60 minutes at Room temperature 
Regular market milk ice cream 5 min at Room temperature 	Regular market milk ice cream 30 min at Room temperature 	Regular market milk ice cream 60 minutes at Room temperature 

Avicel Ice cream 5 min at Room temperature 	Avicel Ice cream 30 min at Room temperature 	Avicel Ice cream 60 minutes at Room temperature 
Methocel Ice cream 5 min at Room temperature 	Methocel Ice cream 30 min at Room temperature 	Methocel Ice cream 60 minutes at Room temperature 

2.1.6.2. Sensory Analysis

A comparison between regular Ice cream and ice cream made with cellulosic material and cellulose competitors is shown in Figure 56. Additionally. Table 27 provides a comparison among different ice cream samples.

Table 27 . Comparison among different ice creams.

Treatments	Overall Appearance	Meltiness	Flavour	Overall Creaminess

Avicel with cashew milk	7.33 ± 0.82	5.67± 1.03	5.83 ± 2.40	5.67 ± 1.51
cellulosic material with regular milk	7.00 ± 1.26	7.00 ± 1.67	7.45 ± 1.21	6.18 ± 2.36
cellulosic material with cashew milk	6.73 ± 1.19	7.82 ± 1.72	6.27 ± 1.83	6.09 ± 1.67
Methocel A4C with cashew milk	5.82 ± 1.66	7.18 ± 1.72	6.09 ± 1.45	5.73 ± 1.56
Regular in-house ice cream	4.36 ± 3.07	3.73 ± 2.69	7.91 ± 1.30	6.36 ± 2.84

n=6 ± Standard Deviation

Further, a comparison among Regular Ice cream and Ice cream made with cellulosic material without egg (Egg substitution) and Vegan (cashew milk) - T-test, is provided in Table 28 .

Table 28 provides a tabular comparison of different formulations and their sensory attributes.

Treatment	Sensory attributes			
	Overall Appearance	Meltiness	Flavour	Overall Creaminess
Regular in-house Ice Cream X cellulosic material without egg	0.03	0.00	0.38	0.89
Regular in house Ice Cream X cellulosic material vegan	0.05	0.00	0.01	0.80
cellulosic material without egg X cellulosic material vegan	0.61	0.27	0.04	0.92

A comparison between milk ice cream (left) and regular ice cream fabricated in-house (right) - 5 min at room temperature is shown in Figure 57. A comparison between regular ice cream and ice cream made with cellulosic material without egg (Egg substitution) is provided in Figure 58.

Table 29 provides a comparison between regular ice cream and Ice cream made with cellulosic material without egg (Egg substitution) - Average scores.

Treatment	Sensory attributes			
	Overall Appearance	Meltiness	Flavour	Overall Creaminess
Regular in house Ice Cream	4.36 ± 3.07	3.73 ± 2.69	7.91 ± 1.30	6.36 ± 2.84
Ice cream with cellulosic material and without egg	7.00 ± 1.26	7.00 ± 1.67	7.45 ± 1.21	6.18 ± 2.36

n=6 ± Standard Deviation

Table 30 provides a comparison between Regular Ice cream and Ice cream made with cellulose and without egg (Egg substitution) - T-test.

Treatment	Sensory attributes			
	Overall Appearance	Meltiness	Flavour	Overall Creaminess
Regular in-house Ice Cream X cellulosic material without egg	0.03	0.00	0.38	0.89

Figure 59 provides a comparison between ice cream fabricated with Avicel (left) + vegan formulation with cellulosic material (middle) + Methocel (right) after 1 h at room temperature. Figure 60 provides a comparison of the churning time among vegan cellulosic material , vegan Avicel, vegan methocel, and regular ice creams.

2.1.7. Highlights

In order to understand the meltiness at room temperature pictures were taken at the 5 min, 30 min, and 60 min mark. On the 5 min, as well as 30 min mark the +milk and vegan demonstrated comparable meltiness patterns as the regular Ice cream from the market (containing different additives such as gums and cellulose).'

After 60 min at room temperature, comparing the vegan formulations, the one with cellulosic material was the only one that held the shape and didn't totally melt down. The vegan formulations with cellulosic material exhibited lower meltiness when compared to avicel ($P < 0.05$). Numerically, the vegan formulations demonstrated better flavour, meltiness, and overall creaminess than the competitors.

When comparing the regular ice cream produced in-house to the one with cellulosic material without egg and the vegan formulations, the sensory analysis demonstrated lower meltiness and higher overall appearance ($P < 0.05$) for both produced with cellulosic material ones compared to the regular counterpart. On the other hand, the regular ice cream demonstrated superior ($P < 0.05$) flavour, followed by the treatment fabricated with cellulosic material without egg ($P < 0.05$), and then the vegan formulation. In summary, it was observed that cellulosic material clearly improved the meltiness attribute of the ice cream formulation and at the same time didn't compromise the creaminess and overall appearance.

2.2. Experiment

2.2.1. Objective

The main objective was to understand the effect of cellulosic material on the melting rate and viscosity of ice cream.

2.2.2. Treatments

The following formulations were tested in this experiment.

- Plant-based Ice cream formulation utilizing 1% of cellulosic material
- Plant-based Ice cream formulation utilizing 0.5% of cellulosic material
- In-house standard plant-based Ice cream formulation without cellulosic material

2.2.3. Equipment and materials

The following non-exhausting list of equipments and materials were used in this experiment.

- Plastic containers
  Spoons
- Musso Lussino Ice cream Machine
- Cooking pan
- Betty Crocker Plastic spatula
- ThermoPro TP01A Thermometer
- Scale (Sartorius, S/N 0043105184)

2.2.4. Ingredients

The following non-exhaustive list of ingredients were used to prepare the formulations.

- 10 g arrowroot
- 65 g coconut oil
- 297.4-300 g water
- 5 g fava
- 2.5 g locust bean
- 5 g of cornstarch
- 100 g glucose
- 30 g sugar
- 6 g of cashew
- 1 g instant coffee
- 5.5 g hazelnut paste
- 0-2.65 g with or without cellulosic material

2.2.5. Protocol

A person skilled in the art would understand that the steps recited herein can vary and could be performed in any order. Following is the protocol that was used to prepare the formulations.

1. The water, cashew, protein powder, and cellulosic material (if it is not the control sample), were mixed and heated to 70 ℃. The Vitamix was then mixed, and filtered (in the case of the cellulosic material added after the filtering step).
2. The remaining ingredients are then added in the thermomix for 5 min 30 sec at 65 ℃, except the coconut oil.
3. The coconut oil is added 2 min before the end of the mixing process in the thermomixer.
4. The ice cream was churned for around 25 min.
5. The ice cream was then allocated in a plastic container, labelled with the treatment and the date of fabrication, and stored in the freezer.

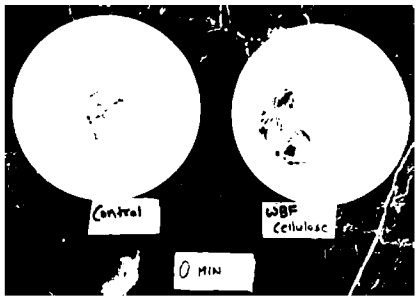
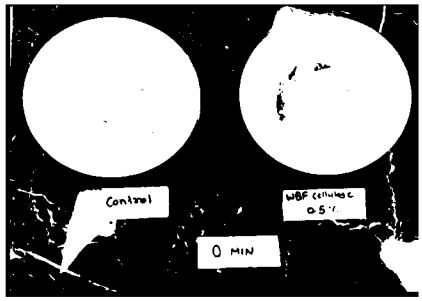
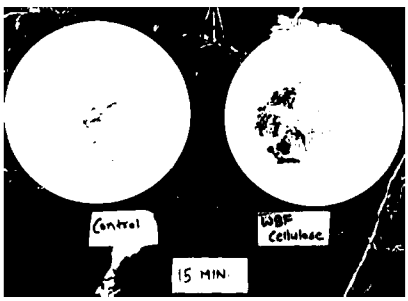
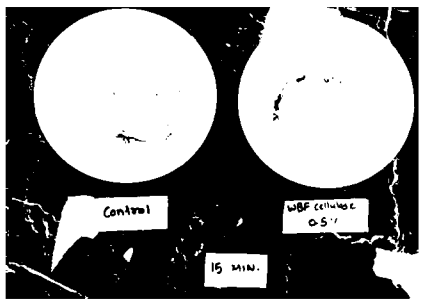
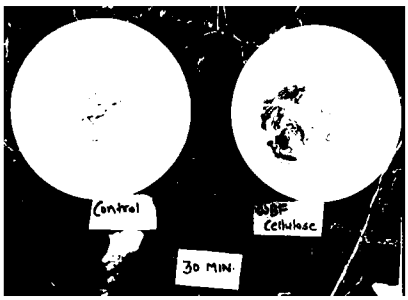
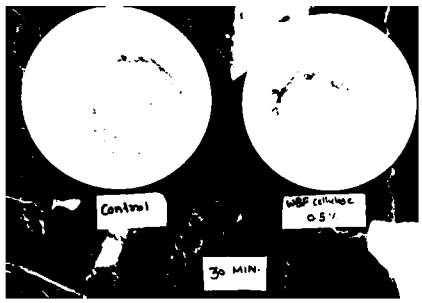
2.2.6. Results

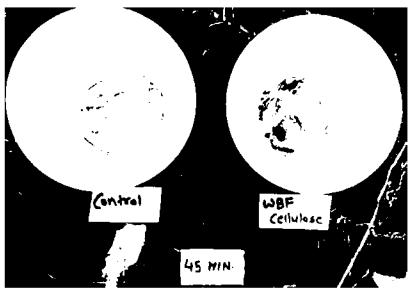
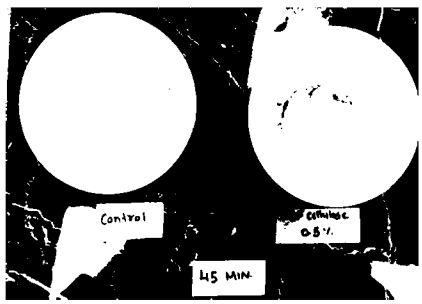
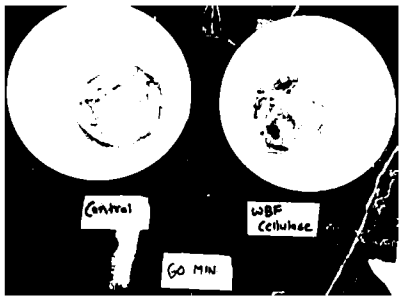
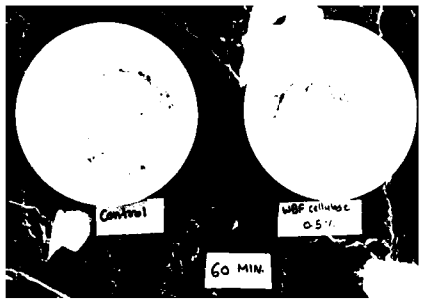
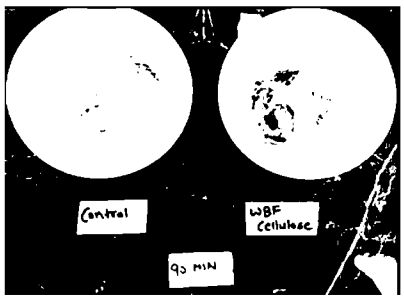
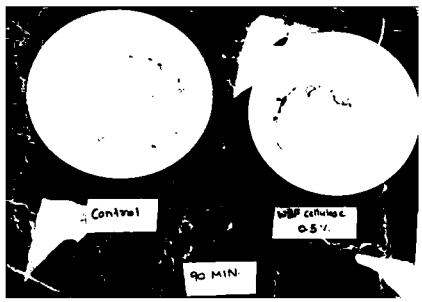
2.2.6.1. Visual melting rate

An exemplary protocol for the visual melting rate experiment is provided below.

- 100g samples were placed in bowls for both test and reference.
- The visual inspection for melting was performed and pictures were taken of each sample at T=0 minutes and every 15 minutes up to 90 minutes.
- The melting behaviour of the ice cream formulations was based on the visual inspection by observing water/liquid release from the sides.

Table 31. Visual melting analysis test pictures.

Timeframe	Pictures (1% cellulosic material vs In house control)	Pictures for (0.5% cellulosic material vs In house control)
0 Min		
15 Min		
30 Min		

45 Min		
60 Min		
90 Min		

2.2.6.2. Viscosity Analysis

The main objective was to understand the effect of the cellulosic material on the viscosity of the ice cream formulation. It was observed that higher viscosity contributed to the denser structure with less watery mouthfeel.

- Materials

The following materials were used to conduct this analysis.

  - Plant-based Ice cream formulation utilizing 0.5% cellulosic material
  - In house, Standard plant-based Ice cream formulation without cellulosic material
  - 10 mL syringe
  - ViscoQC™ 300 Rotational Viscometer

- Protocol

A person skilled in the art would understand that these steps can be performed in any order and that there could be other steps that are not explicitly defined here. An exemplary protocol for the analysis is provided below.

- Use a 10 mL syringe to add 5 mL of the room-temperature sample to the cylindrical holder of the viscometer.
- Run the viscometer on setting “stop at time SW” 3 times.
- Dispose the material and fill up another 5 mL of solution. Repeat.
- Dispose the material and fill up another 5 mL of solution for the third time.
- Repeat all steps for all samples.
- Stop at SW time.
- Run for 45 seconds at 0.54 rpm.

Table 32 . Viscosity analysis of the sample

Sample	Viscosity in(cps) mPa
0.5% cellulosic material	80,000
Control	4,444

2.2.7. Highlights

Formulations containing cellulosic material demonstrated dense texture in preliminary tasting, however, the one with 0.5% cellulosic material was slightly more dense than the one with 1% cellulosic material . It was observed that cellulosic material , which acts as a water-binding agent, reduced the visual melting rate of the ice cream melting by binding water molecules. cellulosic material incorporation in the ice cream maintained smooth consistency and decreased ice crystal formation. cellulosic material created thicker, and denser formulations when compared to the control sample (without the cellulosic material . The higher viscosity observed in the ice cream containing cellulosic material ensured a stable texture and prevented water separation.

5.3. **Plant-based Dairy Substitute: Plant-based Cream Cheese**

3.1. Effect of cellulosic material

3.1.1. Objective

The objective was to understand the effect of the cellulosic material in the cream cheese formulation. Due to the higher moisture retention capacity, the cellulosic material can potentially improve the texture of cream cheese by giving a thick and creamy texture. It can also help retain water during the freeze-thaw process.

3.1.2. Treatments

The following formulations were prepared and tested in this experiment.

- Cream cheese 11 - 1% cellulosic material and water
- Cream cheese 12 - 0% cellulosic material and water
- Cream cheese 13 - 0.5% cellulosic material l and cashew milk
- Cream cheese 14 - 0.25% cellulosic material and cashew milk
- Cream cheese 15 - 0.5% cellulosic material and water
- Cream cheese 16 - 0.25% cellulosic material and water

3.1.3. Equipment and materials

The following non-exhaustive list of materials and equipment were used in this experiment.

- Plastic containers
- Spoons
- Vitamix blender (Vitamix, S/N 065971240221017008)
- Sous Vide (Atmovac-Eurodic Inc., S/N 60BAJI0444)
- Scale (Sartorius, S/N 0043105184)

3.1.4. Ingredients

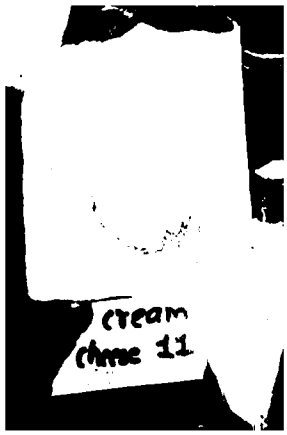
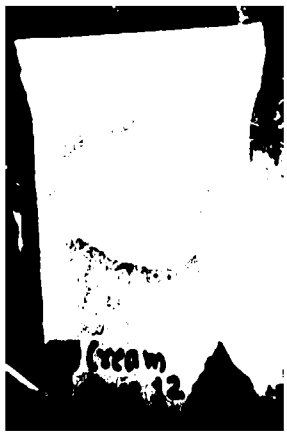
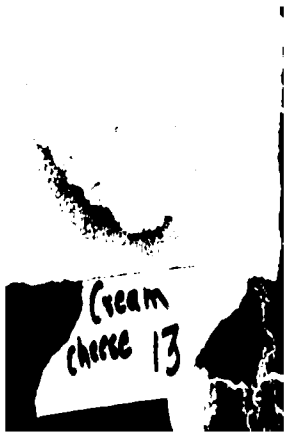
The following non-exhaustive list of ingredients was used in this experiment.

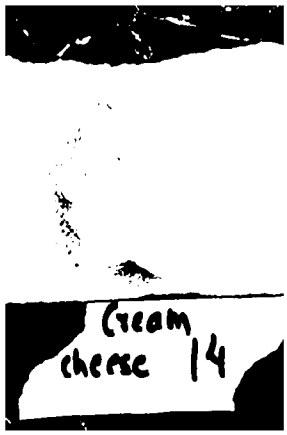
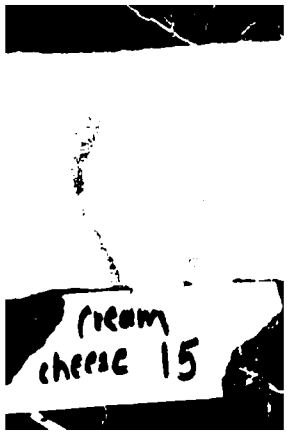
- 164.3-166.8 g Water
- 20 g Perfactosol
- 2 g Salt
- 60 g Coconut oil
- 0.25 g Citric acid
- 1 g Nutritional Yeast
- 0-2.5 g cellulosic material

3.1.5. Treatments, formulations and highlights

A list of exemplary formulations is provided below.

Formulations	Pictures	Highlights

Cream cheese 11 • 164.25g Water • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast • 2.50g cellulosic material		• Less thicker appearance • Creamy texture • Mild granular
Cream cheese 12 • 166.75g Water • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast		• Easily spreadable • Cream cheese-like appearance
Cream cheese 13 • 165.50g Cashew Milk • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast • 1.25g cellulosic material		• Smooth, creamy texture • Dense appearance

Cream cheese 14 • 166.13g Cashew Milk • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast • 0.62g cellulosic material		• Smooth, creamy texture • Moderately dense appearance
Cream cheese 15 • 165.50g Water • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast • 1.25g cellulosic material		• Smooth mouthfeel • Easily spreadable • Dense cream cheese like texture
Cream cheese 16 • 166.13g Water • 20g Perfectasol • 2g Salt • 60g Coconut Oil • 0.25g Citric acid • 1g Nutritional Yeast • 0.62g cellulosic material		• Smooth mouthfeel • Easily spreadable • Less dense texture

3.1.6. Protocol

A person skilled in the art would understand that the steps provided below can be performed in any order. However, an exemplary protocol is provided below.

1. Weighed all the dry ingredients in the bowl.
2. Weighed water/milk in a separate bowl.
3. Added both those mentioned above dry and liquid ingredients into the Vitamix bowl.
4. Turned on the Vitamix at speed 3 in a low setting.
5. Weighed coconut fat and start pouring it slowly into the Vitamix from the top.
6. Turned the speed to 10 with a high variable setting for 4 minutes.
7. Transferred the mixture to the plastic container.
8. Performed the Sousvide process in the mixture at 72℃ for 20 minutes.
9. Stored it in the refrigerator for 12 hours.

3.1.6.1. Bodying texture test for Cream cheese

A person skilled in the art would understand that the steps provided below can be performed in any order. However, an exemplary protocol is provided below.

- For the cream cheese spreading test, 10 grams of cream cheese was spread on toasted bread slices.
- Each cream cheese was observed in the body and texture characteristics in general.
- Observations were taken on how easily the cream cheese could be spread onto the bread surface and assessed its overall texture during the process.

3.1.6.1. Freeze-thaw test for cream cheese

A person skilled in the art would understand that the steps provided below can be performed in any order. However, an exemplary protocol is provided below.

- For the freeze-thaw test, 50 g of each sample was allocated in the freezer at -20°C for 12 hours.
- Subsequently, the samples were removed from the freezer and left at room temperature thawing for 1 hour.
- The visual ice crystals were observed right after take from the freezer.
- After the thawing period, the texture and water release of each sample were carefully observed.
- This methodology demonstrated the samples' ability to survive freezing and thawing processes. It also showed how cellulosic material helps with texture stability and water retention properties.

3.1.7. Results

3.1.7.1. Bodying texture of the cream cheese

The cellulosic material improved the body of plant-based cream cheese, providing a less runny texture when spread on the toast. Figure 61 shows the texture of the plant-based cream cheese control ((a) on the left) and fabricated with cellulosic material ((b) on the right) spread in a toast.

3.1.7.2. Reduced Ice Crystal Formation

It was also observed that the incorporation of cellulosic material decreased the formation of visual ice crystals during the freezing process. In addition, it enhanced the stability of the plant-based cream cheese, preventing separation and maintaining its quality over time. Figure 62 shows the plant-based cream cheese control ((b) on the right) and fabricated with cellulosic material ((a) on the left) right after the freezing process.

3.1.7.3. Water Separation Prevention after Thawing

In the exemplary experiment, cellulosic material at 1 % and 0.75% prevented water separation post-thawing by trapping water molecules within the cream cheese formulation, maintaining the desired texture and consistency. In the exemplary experiment, the cellulosic material concentrations of 0.25% (lost 1.23 g of water) and 0.50% (lost 1.05 g of water) were also tested. At both concentrations, cellulosic material decreased water separation and loss in comparison to the control (lost 5.70 g of water) however, did not avoid it as observed in the higher concentrations tested. Figure 63 shows the plant-based cream cheese from the market (left), control fabricated in-house (middle), and fabricated with the cellulosic material (right) after the thawing process at Room temperature.

3.1.8. Highlights

The cellulosic material improved the body of plant-based cream cheese, demonstrating a thicker texture during the spreadability test. Incorporating cellulosic material decreased on a visual inspection, the formation of ice crystals during the freezing process. cellulosic material enhanced the stability of plant-based cream cheese by preventing water separation after the thawing test. cellulosic material prevented water separation post-thawing potentially by trapping water molecules within the cream cheese formulation.

3.1.9. Further Objective

It was a further objective to test the effect of the cellulosic material in different concentrations (0% to 3%) to f the cream cheese formulation.

3.1.9.1. Treatments

The following treatments were tested by the inventors.

- TMPC - 029 - 0.5% of cellulose
- TMPC - 030 - 1.0% of cellulose
- TMPC - 031 - 1.5% of cellulose
- TMPC - 032 - 2.0% of cellulose

- TMPC - 033 - 2.5% of cellulose
- TMPC - 034 - 3.0% of cellulose
- TMPC - 035 - 0% of cellulose

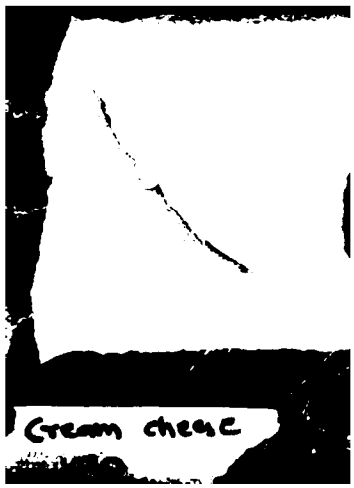
3.1.9.2. Equipment and materials

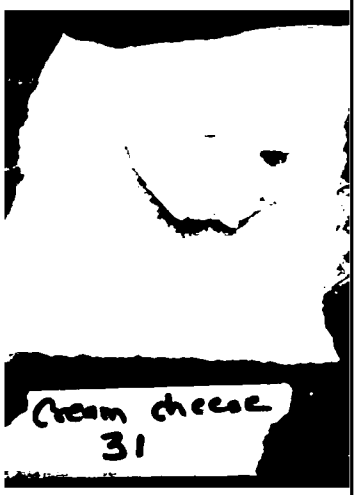
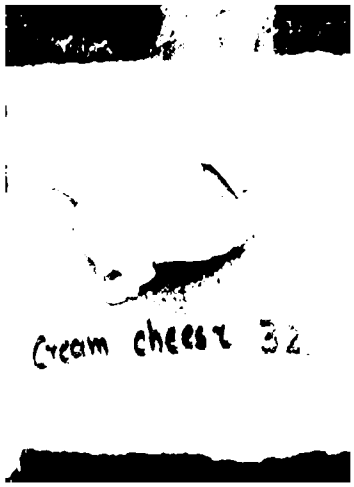
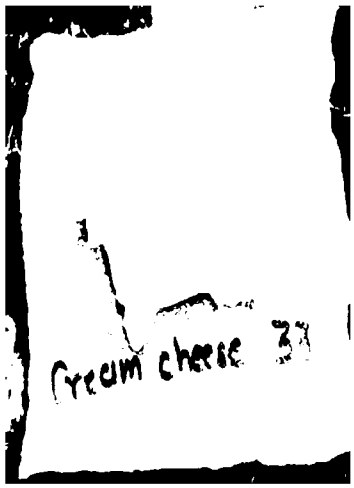
An exemplary list of equipment and materials that were used for this experiment are provided below.

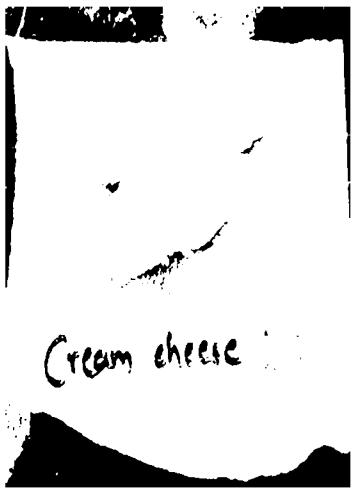
- Plastic containers
- Spoons
- Vitamix blender (Vitamix, S/N 065971240221017008)
- Sous Vide (Atmovac-Eurodic Inc., S/N 60BAJI0444)
- Scale (Sartorius, S/N 0043105184)

3.1.9.3. Treatments, formulations and Highlights

The following table provides an overview of formulations that were tested by the inventors.

Cream Cheese - 029 • 163g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 1.25g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Easily spreadable and smooth texture
Cream Cheese - 030 • 161.75g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 2.50g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Easily spreadable and smooth texture

Cream Cheese - 031 • 160.50g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 3.75g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Less smooth texture • Not easily spreadable
Cream Cheese - 032 • 129.25g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 5.0g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Less smooth texture • Not easily spreadable
Cream Cheese - 033 • 158.0g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 6.25g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Less smooth texture • Not easily spreadable

Cream Cheese - 034 • 156.75g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 7.50g cellulose • 1g Nutritional Yeast • 0.25g Citric acid		• Stiff texture • Not easily spreadable
Cream Cheese - 035 • 164.25g Water • 20g Perfectasol • 60g Coconut Oil • 2.5g Oat flour • 2g Salt • 1g Nutritional Yeast • 0.25g Citric acid		• Runny texture • Not easily spreadable

3.1.9.4. Protocol

An exemplary method of preparing the formulation is provided below.

1. All the dry ingredients were weighed except cellulose in the bowl.
2. Water and cellulose were weighed in a separate bowl.
3. A Vitamix bowl was used to mix both for 1 minute at high speed.
4. Above dry and liquid ingredients were then added into the same Vitamix bowl.
5. The Vitamix was run at speed 3 in a low setting.
6. Coconut fat was weighed and heated in the microwave for 30 seconds.
7. Pouring it slowly into the Vitamix from the top.
8. Turning the speed to 10 with a high variable setting for 4 minutes.
9. The mixture was then transferred to the plastic container.
10. The sample was placed in the Sousvide at 72℃ for 20 minutes.
11. Storing it in the refrigerator for 12 hours.

3.1.9.5. Viscosity test for Cream cheese

The viscosity values were determined before the Sous Vide process using the following Viscosity Analysis

- 5 ml of the solution was taken via a syringe and placed in the viscometer to analyze the viscosity
- The analysis was performed 9 times to obtain accurate results
- The viscometer was used to analyze the viscosity of the 5 ml of solution
- Steps 4-6 were repeated two more times for triplicate results
- Settings on the Viscosimeter:
- ViscoQc 300H: https://www.anton-paar.com/us-en/products/details/viscoqc/?sku=105024
- Spindle SC4-21 with a circumference of 5.27 cm
- A 10 mL syringe was used to add 5 mL of the room-temperature solution to the cylindrical holder of the viscometer
- The viscometer was run on setting “stop at time Stop at time (Runs for 45 seconds at 0.54 rpm) 3 times
- The material was disposed off and then another 5 mL of solution was filled up. This process was repeated.
- The material was disposed off and then another 5 mL of solution was filled up for the third time.
- All steps were repeated for all samples.

3.1.9.6. Freeze-Thaw test for Cream cheese

- For the freeze-thaw test, 50 g of each sample was allocated in the freezer at -20°C for 12 hours.
- Subsequently, the samples were removed from the freezer and left at room temperature thawing for 3 hours.
- After the thawing period, the texture and water release of each sample were carefully observed.
- This methodology demonstrated the samples' ability to survive freezing and thawing processes. It also showed how cellulose helps with texture stability and water retention properties.

3.1.9.7. Results

Figure 64 shows the comparison of the viscosity from cream cheeses containing cellulosic material concentration ranging from 0 to 3% and Tables 33 and 34 provide additional comparative data.

Table 33 . Pictures comparing the freezing-thawing test of cream cheeses containing cellulosic material ranging from 0-3%

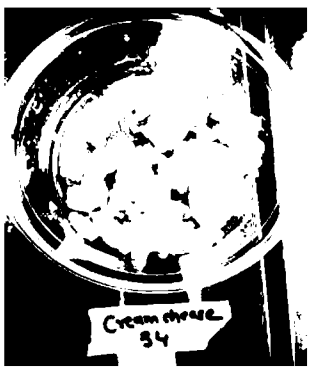
Cream Cheese -029 (0.5% Cellulose) 	Cream Cheese -030 (1% cellulose) 	Cream Cheese -031 (1.5% cellulose) 	Cream Cheese -032 (2.0% cellulose) 
Cream Cheese -033 (2.5% cellulose) 	Cream Cheese -034 (3% cellulose) 	Cream Cheese -035 (0.0% cellulose) 	

Table 34 **.** Comparison of the water release in g from cream cheeses containing cellulosic material concentration ranging from 0 to 3%.

Formulations	**Water released (g)**
Cream Cheese 29	0.48
Cream Cheese 30	0.45
Cream Cheese 31	0.30
Cream Cheese 32	No water release observed
Cream Cheese 33	No water release observed
Cream Cheese 34	No water release observed

Cream Cheese 35	3.02

3.1.9.8. Highlights

It was observed by the inventors that the cellulosic material can be used in the cream cheese formulation ranging from 0.5% to 3%. The control sample demonstrated a low viscosity and high water release after the freezing-thawing test. The cellulosic material incorporated into the cream cheese using any level tested starting by 0.5% increased the product's viscosity while exponentially decreasing the water release. The higher the cellulose concentration, the stiffer and less easy to spread was the formulation. Although higher cellulose concentration decreases the water release.

6. Conclusion

The cellulosic material can be used to prepare highly stable emulsions by adding emulsifiers, and mixing the materials at a high shear rate given at 10k rpm, a process called homogenization. In this study, a solution of ~98% of cellulosic material and ~2% Xhanthan gum was enough to produce cream with the same viscosity as regular yogurt. The same mixture after adding 8% of protein gave highly dense creams. Homogenized cellulosic material, 50%, enriched with a similar content in protein, sugar, and fat, added with vitamins from yeast extract was fermented with a strain of *Bacillus bulgaricus*, giving a modified product with viscosity and adhesivity similar to the regular yogurt. After these preliminary experiments, it is safe to conclude that the homogenized cellulosic material can act as a scaffold to nide bacteria and metabolize media compounds, holding its structure as cream. The cellulosic material can also be used as a platform for dairy products and other applications related to scaffolding bacterial cells.

The optimum concentration of κ-carrageenan, fava protein, and cellulosic material to produce a plant-based tuna with better sensory scores is 0.45-0.60 g (preferably 0.55 g), 1.96g to 4.72g, and 3.15g to 6.3g respectively. However, all the ranges tested were able to produce a viable product.

Cooked salmon prototype

The cooked salmon prototype represents a promising product demonstrating similarities to the conventional salmon for several nutritional and physical attributes.

Smoked salmon prototype

The smoked salmon prototype has the main focus to provide similar organoleptic characteristics when compared to the conventional smoked salmon. The product also demonstrated similar sensory attributes.

White lines

The white lines from the conventional fish are composed of connective tissue and fat, so in order to mimic the mouthfeel, a vegan mayonnaise with a high concentration of fat was produced with the objective to connect the slabs, represented by the red- muscle. The cellulosic material enhanced the white lines attributes and thus provides a promising avenue for large-scale production of white lines.

Plant-based Tuna

The cooked salmon prototype represents a promising product demonstrating similarities to the conventional salmon for several nutritional and physical attributes.

Plant-based ice cream

The cellulosic material enhanced ice cream attributes by substantially decreasing the visual meltiness while increasing creaminess and overall appearance. The preliminary results exhibited a promising avenue for further enhancement of plant-based ice cream production.

Plant-based yogurt

The cellulosic material enhanced the yogurt attributes and thus provides a promising avenue for large-scale production of plant-based yogurt.

Plant-based Cream Cheese

The cellulosic material proved to be a solution for the plant-based cream cheese, increasing the viscosity and decreasing the water release which could be very useful in the preparation of frozen cream cheese.

While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. It is not intended that the invention be limited by the specific examples provided within the specification. While the invention has been described with reference to the aforementioned specification, the descriptions and illustrations of the embodiments herein are not meant to be construed in a limiting sense. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. Furthermore, it shall be understood that all aspects of the invention are not limited to the specific depictions, configurations or relative proportions set forth herein which depend upon a variety of conditions and variables. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is therefore contemplated that the invention shall also cover any such alternatives, modifications, variations or equivalents. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

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Links

1. 2021 Alternative Seafood Industry Update: https://gfi.org/wp-content/uploads/2022/04/2021-Alternative-Seafood-Industry-Update.pdf

2. USDA - FoodData Central: https://gfi.org/seafood/

3. Inline Emulsifier Mixer: High speed, high shear emulsifying mixer: https://www.quadroliquids.com/products/inline-emulsifier-mixer/?hsCtaTracking=c82fe932-3183-4c74-b54f-6496629ad87f%7Cced128bd-adae-46bf-92bc-a7b4903a579c

4. CFR - Code of Federal Regulations Title 21 - FDA. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=131.111

CLAIMS

What is claimed is:

1. A plant-based food product comprising the following ingredients:
    a) a bleached cellulose-based plant material;
    b) at least one texturized vegetable protein, isolate protein, or both;
    c) at least one thickening/gelling agent; and
    d) one or more food additives.

2. The plant-based food product of claim 1, wherein the product additionally comprises at least one cellulose material, at least one oil or both.

3. The plant-based food product of claim 1, wherein the bleached cellulose-based plant material is derived from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, potato, grape skin, or a combination thereof.

4. The plant-based food product of claim 1, wherein the at least one texturized vegetable protein is derived from mung bean, fava bean, brown rice, pea, wheat, zein or a combination thereof.

5. The plant-based food product of claim 1, wherein the at least one isolate protein is whey isolate, whey concentrate, whey hydrolysate, milk protein, mung bean, fava bean, brown rice, pea, wheat, zein, or a combination thereof.

6. The plant-based food product of claim 1, wherein the at least one thickening/gelling agent is konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cornstarch, potato starch, modified starch, cellulose ethers (Methocel), xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar) or a combination thereof.

7. The plant-based food product of claim 1, wherein the one or more food additives are selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

8. The plant-based food product of claim 2, wherein the at least one cellulose material is bamboo fibre, woven bamboo fibre, potato fibre or any combination thereof.

9. The plant-based food product of claim 2, wherein the at least one oil is a vegetable oil.

10. The plant-based food product of any one of claims 1-9, wherein the concentration of the bleached cellulose-based plant material is in the range of 20% to 70%.

11. The plant-based food product of any one of claims 1-10, wherein the concentration of the at least one texturized vegetable protein, isolate protein or both is in the range of 5% to 50%.

12. The plant-based food product of any one of claims 1 to 11, for manufacturing a plant-based meat mimic.

13. The plant-based food product of any one of claims 1 to 11, for manufacturing a plant-based salmon mimic, a plant-based fish-fillet mimic, or a salmon like product.

14. The plant-based food product of any one of the claims 1 to 11, wherein the mouthfeel, sensory feel and texture of the plant-based meat mimic are similar to a meat-based product.

15. The plant-based food product of any one of the claims 1 to 11, wherein the proximate composition, protein content, or chemical properties of the plant-based meat mimic are similar to a meat-based product.

16. The plant-based food product of claim 1, wherein the bleached cellulose-based plant material is replaced by microcrystalline cellulose or any other commercially available cellulose.

17. A plant-based food product, wherein the food product comprises:
Water, Mung bean protein crisp, Isolate protein, Sunflower oil, Konjac gum ,Ca(OH)2, Salt, Plant-derived cellulosic material, bleached plant material, Tapioca Starch, Wheat TVP, Brilliant Orange, Astaxanthin, Watermelon Pink, Flavorcan Masker, New Salmon Flavor, Glucone delta lactone, and Kappa Carrageenan.

18. A pant-based food product, wherein the food product comprises:
Water, Isolate mung bean protein, Sunflower oil, Algae Oil, Methyl cellulose, Plant-derived cellulosic material, bleached plant material, Pea Protein, Watermelon Pink, Baked Salmon Flavour, Natural Salmon Flavour Type, or Yeast extract

19. A plant-based food product comprising the following ingredients:
a) a bleached cellulose-based plant material;
b) at least one cellulose material;
c) at least one fatty acid group;
d) at least one thickening/gelling agent; and
e) one or more food additives.

20. The plant-based food product of claim 19, wherein the product additionally comprises at least one oil.

21. The plant-based food product of claim 19, wherein the product additionally comprises at least one texturized vegetable protein, isolate protein, or both.

22. The plant-based food product of claim 19, wherein the bleached cellulose-based plant material is derived from apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, potato, grape skin, or a combination thereof.

23. The plant-based food product of claim 21, wherein the at least one texturized vegetable protein is derived from mung bean, fava bean, brown rice, pea, wheat, zein or a combination thereof.

24. The plant-based food product of claim 21, wherein the at least one isolate protein is whey isolate, whey concentrate, whey hydrolysate, milk protein, mung bean, fava bean, brown rice, pea, wheat, zein, or a combination thereof.

25. The plant-based food product of claim 19, wherein the at least one thickening/gelling agent is konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cornstarch, potato starch, modified starch, cellulose ethers (Methocel), xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar) or a combination thereof .

26. The plant-based food product of claim 19, wherein the one or more food additives are selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, , preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

27. The plant-based food product of claim 19, wherein the at least one fatty acid group is Omega 3 or Omega 6.

28. The plant-based food product of claim 19, wherein the at least one cellulose material is bamboo fibre, woven bamboo fibre, potato fibre or any combination thereof.

29. The plant-based food product of any one of claims 19-28, wherein the concentration of the bleached cellulose-based plant material is in the range of 20% to 70%.

30. The plant-based food product of any one of claims 19-29, for manufacturing a plant-based meat mimic.

31. The plant-based food product of any one of claims 19 to 30, for manufacturing a plant-based salmon mimic, a plant-based fish-fillet mimic, or a salmon like product.

32. The plant-based food product of any one of the claims 19 to 31, wherein the mouthfeel, sensory feel and texture of the plant-based meat mimic are similar to a meat-based product.

33. The plant-based food product of any one of the claims 19 to 32, wherein the proximate composition, protein content, or chemical properties of the plant-based meat mimic are similar to a meat-based product.

34. The plant-based food product of claim 19, wherein the bleached cellulose-based plant material is replaced by microcrystalline cellulose or any other commercially available cellulose.

35. A plant based food-product, wherein the food-product comprises:
Water, Mercerized or bleached apple, Bamboo fiber, Konjac gum, K-carrageenan, Calcium hydroxid, Citric acid, Salt, Smoked salmon flavour, Paprika, Fiesta pink, Omega 3, and Flaxseed oil.

36. A plant-based white lines mimic comprising:
a) an egg-white substitute, a gelatin substitute, or both;
b) a vegetable oil; and
c) a cellulose source.

37. The plant-based mimic of claim 36, wherein the mimic additionally comprises one or more food additives, one or more thickeners, one or more emulsifiers, salts, sugars, artificial sweeteners, water, or a combination thereof.

38. The plant-based mimic of claim 36, wherein the egg-white substitute is aquafaba.

39. The plant-based mimic of claim 36, wherein the gelatin substitute is agar agar.

40. The plant-based mimic of claim 36, wherein the vegetable oil is sunflower oil.

41. The plant-based mimic of claim 36, wherein the cellulose source is plant-derived cellulosic material, bleached plant material or methyl cellulose (methocel).

42. The plant-based mimic of any one of claims 36-41, wherein the mimic additionally comprises xanthan gum.

43. A plant-based yogurt comprising a cellulosic material and/or at least one nanocellulose and one or more food additives.

44. The plant-based yogurt of claim 43, wherein the yogurt additionally comprises a protein source, a fat source, a sugar source, a bacterial source, a nitrogen source, at least one growth factor, or a combination thereof.

45. The plant-based yogurt of claim 43, wherein the at least one nanocellulose source is cellulose nanofibres in a composition or slurry form.

46. The plant-based yogurt of claim 43, wherein the at least one or more food additives selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or in combination thereof.

47. The plant-based yogurt of claim 43, wherein the at least one or more food additive is xanthan gum, carrageenan, guar gum, pectin, modified starches, starch acetate, hydroxypropyl starch, cationic starch, carboxymethylated starch and other modified starches, Alginates, or carboxymethylcellulose (CMC).

48. The plant-based yogurt of claim 43, wherein the protein source is a vegetable protein or a protein isolate.

49. The plant-based yogurt of claim 43, wherein the protein source is mung bean isolate, fava bean isolate, brown rice isolate, soybean isolate, or a hydrolyzed protein from any of these sources.

50. The plant-based yogurt of any one of claims 43-49, wherein the viscosity of the yogurt ranges from 8 Pa.s to 80 Pa.s.

51. The plant-based yogurt of claim 43, wherein the at least one bacterial source is Bacillus bulgaricus.

52. Use of a bleached cellulose-based plant material for production of a plant-based seafood or meat product.

53. Use of a combination of a cellulosic material and/or a nanocellulose to manufacture a plant-based yogurt formulation.

54. Use of aquafaba to mimic white lines in a plant-based meat mimic.

55. A method of manufacturing a plant-based product, comprising the steps of:

a) preparing a mixture comprising a bleached cellulose-based plant material, at least one thickening/gelling agent, one or more food additives except Calcium Hydroxide, at least one oil, or a combination thereof;

b) heating the mixture until a pre-determined temperature is reached or until a pre-determined time;

c) adding Calcium Hydroxide to the mixture;

d) adding at least one texturized vegetable protein, isolate protein, or both to the mixture; and mixing manually to prepare a dough; and

e) wrapping the final mixture and vacuum sealing it to prepare the plant-based food product.

56. The method of claim 55, wherein the method further comprises freezing the vacuum sealed food product and placing it in a sous-vide machine.

57. The method of claim 56, wherein the vacuum sealed food product is frozen for a period of 1-4 hours.

58. The method of claim 55, wherein the method further comprises:

a) unwrapping the vacuum sealed food product;

b) cutting the food product at an angle to create layers; and

c) spreading white lines between the layers and resealing the food product.

59. The method of claim 55, wherein the method further comprises storing the vacuum sealed food product in a fridge or a freezer until the food product is consumed.

60. The method of claim 55, wherein the at least one texturized vegetable protein, isolate protein or both are pre-soaked in water prior to adding to the mixture.

61. The method of claim 60, wherein the pre-soaked proteins are shredded prior to adding to the mixture.

62. The method of claim 55, wherein the bleached cellulose-based plant material is mixed with the at least one texturized vegetable protein, the isolate protein, or both and added to the mixture at step d).

63. The method of claim 56, wherein the vacuum sealed food product is placed in the sous-vide machine at a temperature of 50°C – 80°C for a period of 10 minutes – 180 minutes.

64. The method of claim 55, wherein the final mixture is allowed to stand for a predetermined period prior to wrapping and vacuum sealing it.

65. The method of claim 55, wherein step a) is carried out by mixing by hand, a robotic coupe, a mixer or by a dispersive mixing technique to mix the ingredients uniformly.

66. The method of any one of claims 55-65, wherein the method is for preparing the plant-based food product of claims 1-18.

67. A method of manufacturing a plant-based food product [cooked salmon] comprising the steps of:

a) preparing a dry mixture comprising at least one cellulose material, at least one thickening/gelling agent, one or more food additives, at least one texturized vegetable protein, at least one isolate protein or a combination thereof;

b) preparing a wet mixture comprising a bleached cellulose-based plant material, at least one oil, at least one fatty acid group, water, or a combination thereof;

c) mixing the wet mixture continuously with intermittent breaks to add any additional food additives;

d) pouring the dry mixture slowly in the wet mixture to prepare a final mixture;

e) heating the final mixture for a predetermined period until a desired temperature is reached;

f) adding one or more preservatives to the final mixture; and

g) wrapping the final mixture and vacuum sealing it to prepare the plant-based food product.

68. The method of claim 67, wherein calcium hydroxide is optionally added to the dry mixture.

69. The method of claim 67, wherein the step of mixing is carried out by mixing by hand, a robotic coupe, a mixer or by a dispersive mixing technique to mix the ingredients uniformly.

70. The method of claim 67, wherein the final mixture is heated until the desired temperature of 70ºC – 100ºC is reached.

71. The method of claim 67, wherein the method further comprises:

a) freezing the vacuum sealed mixture and placing it in a sous-vide machine; and

b) storing the vacuum sealed mixture in a fridge or a freezer until the food product is consumed.

72. The method of claim 71, wherein the vacuum sealed food product is placed in the sous-vide machine at a temperature of 50ºC – 80ºC for a period of 0.5 minute – 5 minutes.

73. The method of claim 71, wherein the freezing step is carried out using a blast freezer to prevent formation of ice crystals.

74. The method of claim 67, wherein the method further comprises:

a) unwrapping the vacuum sealed food product;

b) cutting the food product at an angle to create layers; and

c) spreading white lines between the layers and resealing the food product.

75. The method of claims 67, wherein the one or more preservative is citric acid.

76. The method of claims 67-75, wherein the method is for preparing the plant-based food product of claims 19-35.

77. A method of manufacturing a plant-based/vegan yogurt formulation comprising:

a) homogenizing a cellulosic material and/or at least one nanocellulose to prepare a homogenized cellulose mixture;

b) adding one or more food additives, a protein source, a fat source, a sugar source, a bacterial source, a nitrogen source, at least one growth factor, or a combination thereof, to the homogenized cellulose mixture; and

c) allowing the mixture to ferment for a predetermined time to prepare the plant-based yogurt formulation.

78. The method of 77, further comprising any of the steps:

a) adding at least one growth factor, vitamin or both to the homogenized cellulose mixture;

b) performing homogenization in a mixer at a high speed and/or high shear rate;

c) optionally centrifuging the homogenized cellulose mixture to adjust the viscosity of the formulation;

d) optionally letting the homogenized cellulose mixture to sit for a predetermined time prior to the mixing step;

e) optionally adding flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof, to the homogenized cellulose mixture; or

f) packing and storing the plant-based/vegan yogurt formulation.

79. A plant-based food product comprising the following ingredients:

a) a dry cellulosic material;

b) at least one texturized vegetable protein;

c) at least one thickening/gelling agent; and

d) one or more food additives.

80. The plant-based food product of claim 79, wherein the product additionally comprises at least one oil, at east one fatty acid, or both.

81. The plant-based food product of claim 79, wherein the dry cellulosic material is derived from a plant material.

82. The plant-based food product of claim 81, wherein the plant cellulosic material is from apple, onions, pear, banana, mango, corn cob, fruit pomace, carrots, palm heart, watermelon, melon, kale residues, produces residues, fava residue, oat residue, potato, potato residue, grape skin, or a combination thereof.

83. The plant-based food product of claim 82, wherein the concentration of the plant cellulosic material is in the range of 0.5 % - 10%.

84. The plant-based food product of claim 79, wherein at least one texturized vegetable protein is derived from mung bean, fava bean, soy, brown rice, pea, wheat, zein or a combination thereof.

85. The plant-based food product of claim 84, wherein the concentration of at least one texturized vegetable protein such as fava bean is in the range of 1.5 g – 20.0 g.

86. The plant-based food product of claim 79, wherein the at least one thickening/gelling agent is konjac gum, tapioca starch, kappa-carrageenan, methylcellulose, cornstarch, potato starch, modified starch, cellulose ethers, xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar) or a combination thereof.

87. The plant-based food product of claim 86, wherein the concentration of at least one thickening / gelling agent such as kappa-carrageenan is in the range of 0.25 g – 1.25 g.

88. The plant-based food product of claim 79, wherein one or more food additives are selected from the group of flavouring agents, colouring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, sugars, salts, vitamins, supplements, growth factors, stabilizers, preservatives, stabilizers, spices, texture modifying agents, pH adjusting agents, yeast extract, water or a combination thereof.

89. The plant-based food product of claim 88, wherein the flavouring agent may be from a plant-based fish flavour, a tuna flavour, or any similar fish flavour or a combination thereof.

90. The plant-based food product of claim 88, wherein the colouring agent may be from Magna Ruby, Supra Red, Red No. 40, or any similar colouring agent or a combination thereof.

91. The plant-based food product of claim 80, wherein at least one oil is a vegetable oil.

92. The plant-based food product of claim 80, wherein at least one fatty acid is Omega 3 and Omega 6.

93. The plant-based food product of any one of claims 79-92, wherein the concentration of the dry cellulosic material is in the range of 1% to 3%.

94. The plant-based food product of any one of claims 79-92, wherein the concentration of the at least one texturized vegetable protein is in the range of 0.3% to 1%.

95. The plant-based food product of any one of claims 79 to 94, for manufacturing a plant-based tuna mimic.

96. The plant-based food product of any one of claims 79-95, wherein the mouthfeel, sensory feel and texture of the plant-based tuna mimic is similar to a regular tuna product.

97. A plant-based food product, wherein the food product comprises:
water; a dry cellulosic material ; a thickening/gelling agent from Konjac gum, Xanthan Gum, k-carrageenan, or a combination thereof; a texturized protein such as Fava Protein; a flavoring agent from a Fish Flavor, a Tuna flavour, or both; a coloring agent from Supra red, Magna Ruby, Red No. 40, or a combination thereof; a vegetable oil such as Flaxseed oil; a yeast extract; a food additive such as Salt, Sorbitol, or both; and a fatty acid such as Omega 3.

98. A plant-based ice cream comprising a cellulosic material, at least one thickening/gelling agent, at least one starch, at least one milk alternative and one or more food additives.

99. The plant-based ice-cream of claim 98, wherein the ice-cream additionally comprises at least one vegetable oil, a texturized vegetable protein, a sugar source, or a combination thereof.

100. The plant-based ice-cream of claim 98, wherein the at least one or more food additives selected from the group of flavoring agent, coloring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or in combination thereof.

101. The plant-based ice cream of claim 98, wherein the cellulosic material is derived from a plant material.

102. The plant-based ice cream of claim 98, wherein the plant material is apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, kale residue, watermelon, melon, produces residue, potato, potato residue, grape skin, or a combination thereof.

103. The plant-based ice cream of claim 99, wherein the texturized vegetable protein is derived from mung bean, fava bean, brown rice, pea, wheat, soy, zein or a combination thereof.

104. The plant-based ice cream of claim 98, wherein the at least one thickening/gelling agent is locust bean, konjac gum, tapioca starch, kappa-carrageenan, methyl cellulose, cellulose ethers , xanthan gum, iota-carrageenan, Gellan, Calcium alginate, Sodium alginate, plant-based gelatin (agar agar), cashew, or a combination thereof.

105. The plant-based ice cream of claim 98, wherein the at least one starch is arrowroot, cornstarch, potato starch, modified starch, or a combination thereof.

106. The plant-based ice cream of claim 99, wherein the at least one vegetable oil is coconut oil and the at least one milk alternative is cashew milk or oat milk.

107. The plant-based ice cream of any one of claims 98-106, wherein the concentration of the cellulosic material is in the range of 0.3 – 1.5%.

108. The plant-based ice cream of any one of claims 98-107, wherein the viscosity of the ice cream is in the range of 70000 – 90000 cps.

109. The plant-based ice cream of any one of claims 98-108, wherein the meltiness, mouthfeel, creaminess, texture and other attributes of the ice cream are similar to regular dairy-based ice cream.

110. A plant-based ice cream comprising:
a cellulosic material plant-based material; a texturized vegetable protein such as fava protein, at least one thickening/gelling agent such as locust bean, cashew, or both; at least one starch such as arrowroot, cornstarch, or both; one or more food additives such as water; at least one flavoring agent such as coffee, hazelnut paste or both; at least one oil such as coconut oil, at least one milk alternative from cashew milk or oat milk, and at least one sugar source such as dry sugar, glucose or both.

111. A plant-based cheese comprising a cellulosic material, a plant-based texturizer, a vegetable oil and one or more food additives.

112. The plant-based cheese of claim 111, wherein one or more food additives are selected from the group of flavouring agents, colouring agents, taste maskers, taste enhancers, emulsifiers, artificial sweeteners, food acids, antioxidants, humectants, minerals, salts, vitamins, supplements, stabilizers, raising agents, preservatives, spices, texture modifying agents, pH adjusting agents, yeast extract, water or in combination thereof.

113. The plant-based cheese of claim 111, wherein the cellulosic material is derived from a plant material.

114. The plant-based cheese of claim 113, wherein the plant material is apple, onions, pear, banana, mango, corn cob, apple pomace, carrots, palm heart, watermelon, melon, kale residue, produce residue, potato, potato residue grape skin, or a combination thereof.

115. The plant-based cheese of claim 113, wherein the concentration of the cellulosic material is in the range of 0.5% to 5%.

116. The plant-based cheese of claim 111, wherein the plant-based texturizer is derived from potato, banana, or a similar vegetable.

117. The plant-based cheese of claim 111, wherein the plant-based texturizer is Perfectasol.

118. The plant-based cheese of claim 111, wherein the vegetable oil is coconut oil, sunflower oil, peanut oil, or any other vegetable oil.

119. The plant-based cheese of any one of claims 111-118, wherein the cheese additionally comprises a milk alternative.

120. The plant-based cheese of claim 119, wherein the milk alternative is cashew milk or oat milk or oat flour.

121. Use of plant-based cellulosic material to prevent or decrease the formation of ice crystals in the plant-based cheese according to any one of claims 111-120.

122. Use of plant-based cellulosic material to improve texture and water retention capacity of the plant-based cheese according to any one of claims 111-120.

123. Use of plant-based cellulosic material to prepare plant-based tuna formulation and plant-based dairy formulation.

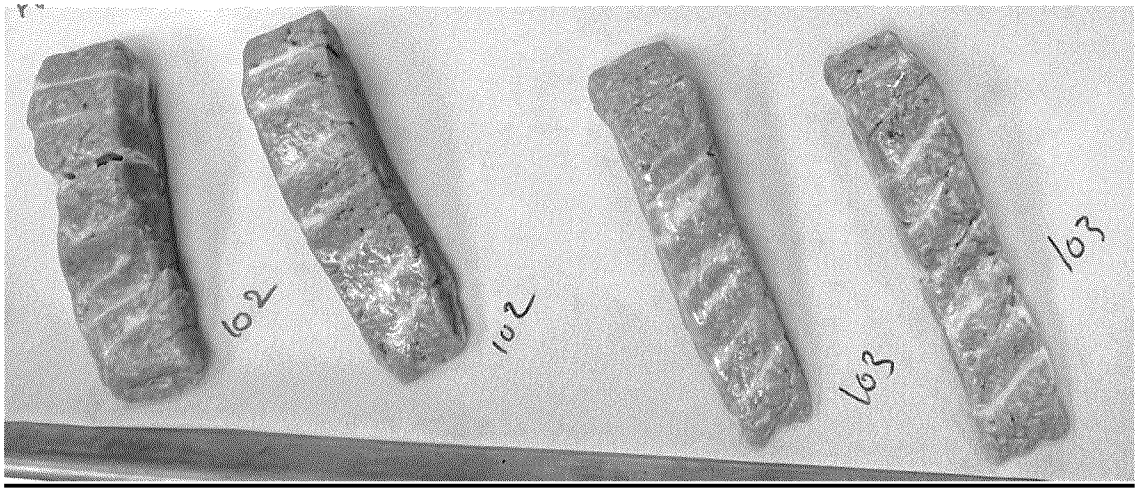


FIGURE 1

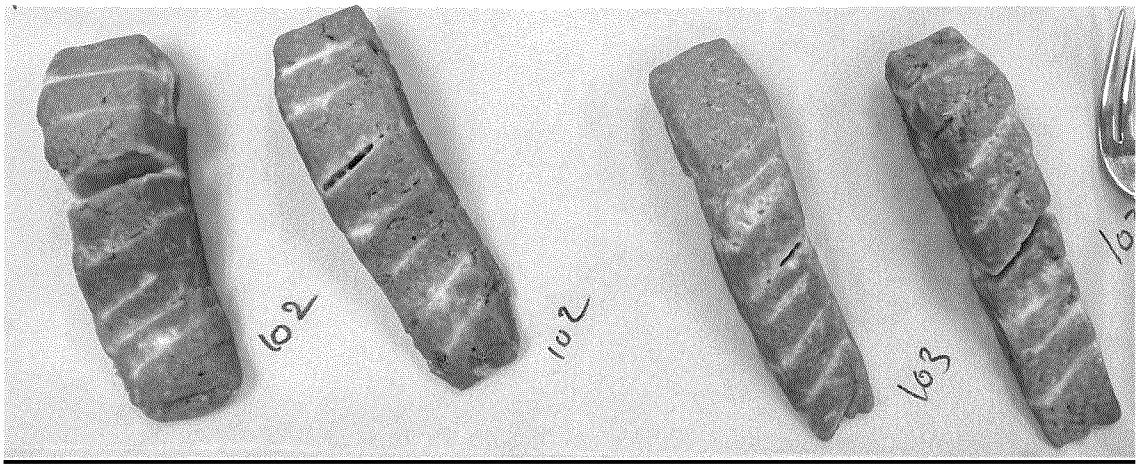


FIGURE 2

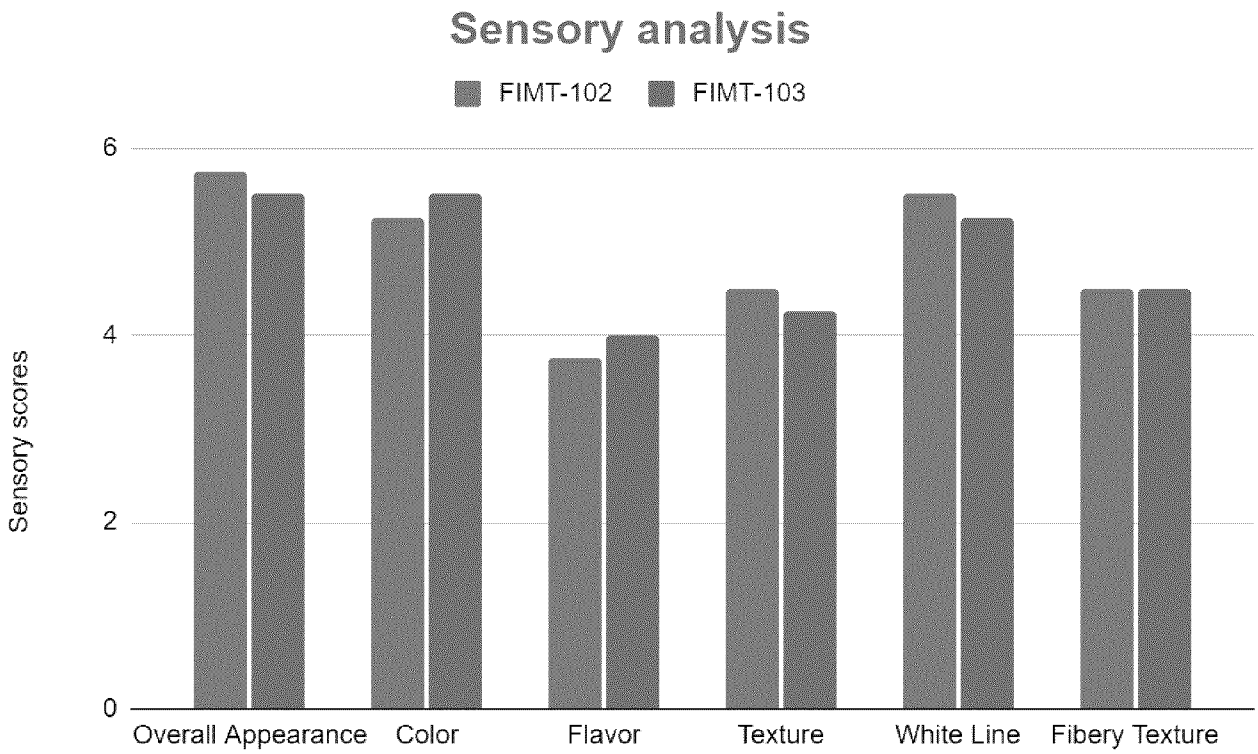

Sensory analysis
FIMT-102
FIMT-103
Sensory scores
6
4
2
0
Overall Appearance
Color
Flavor
Texture
White Line
Fibery Texture

FIGURE 3

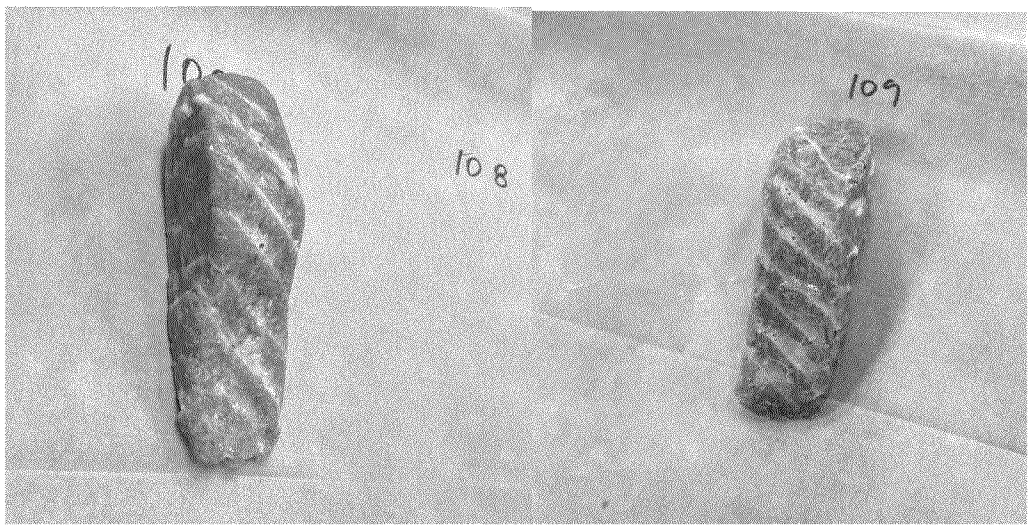


FIGURE 4

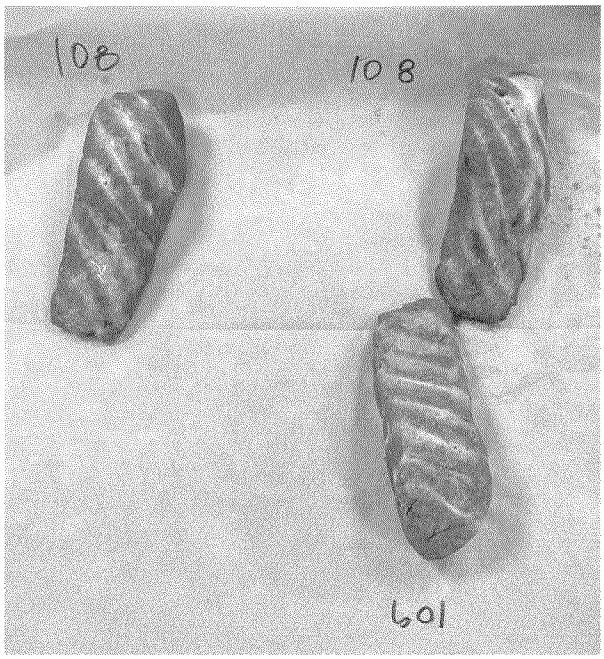


FIGURE 5

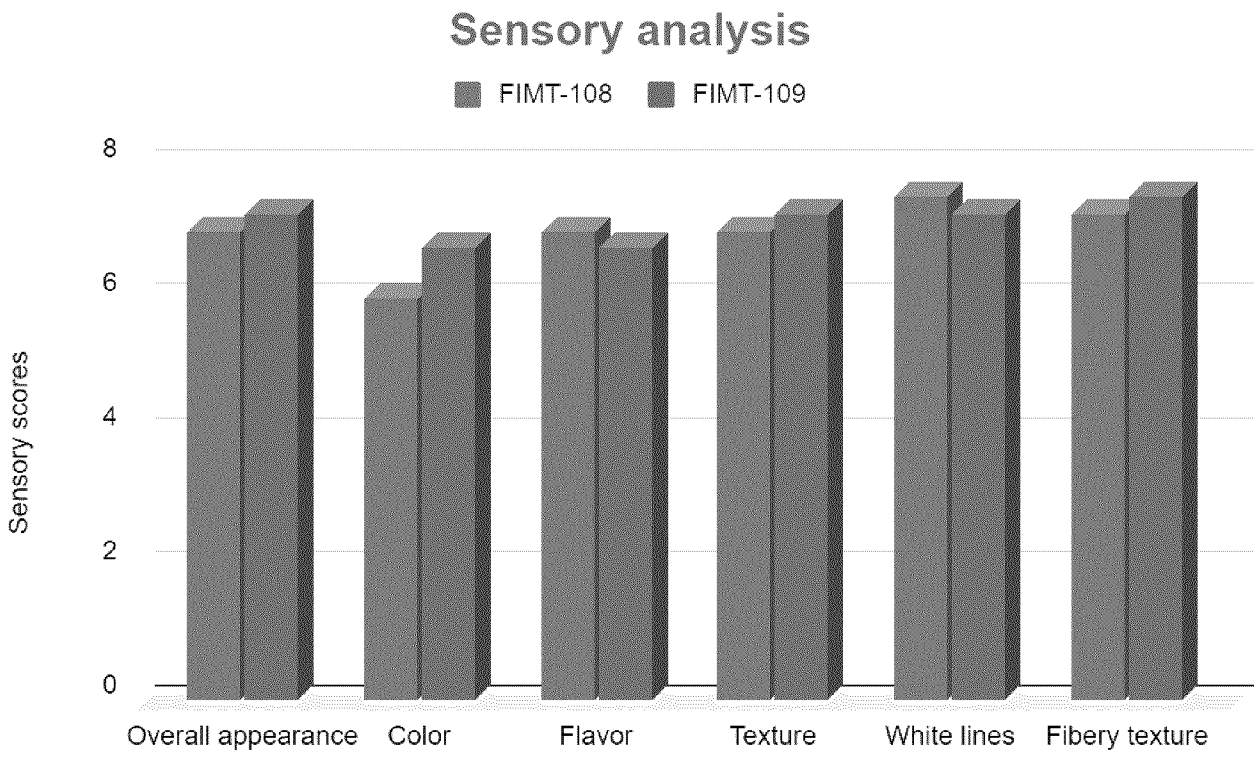


FIGURE 6

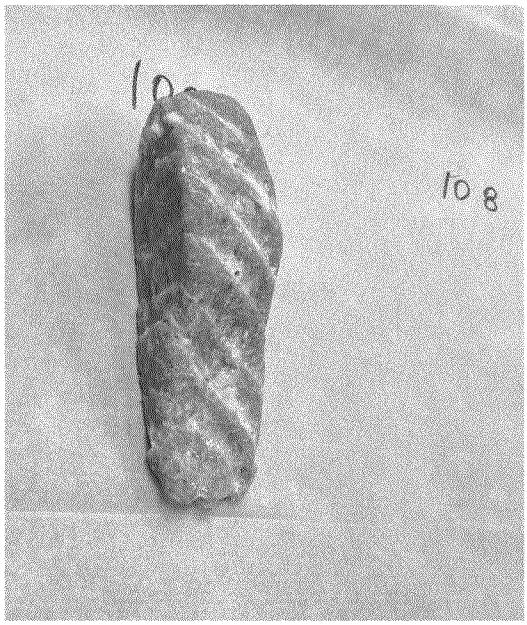


Figure 7

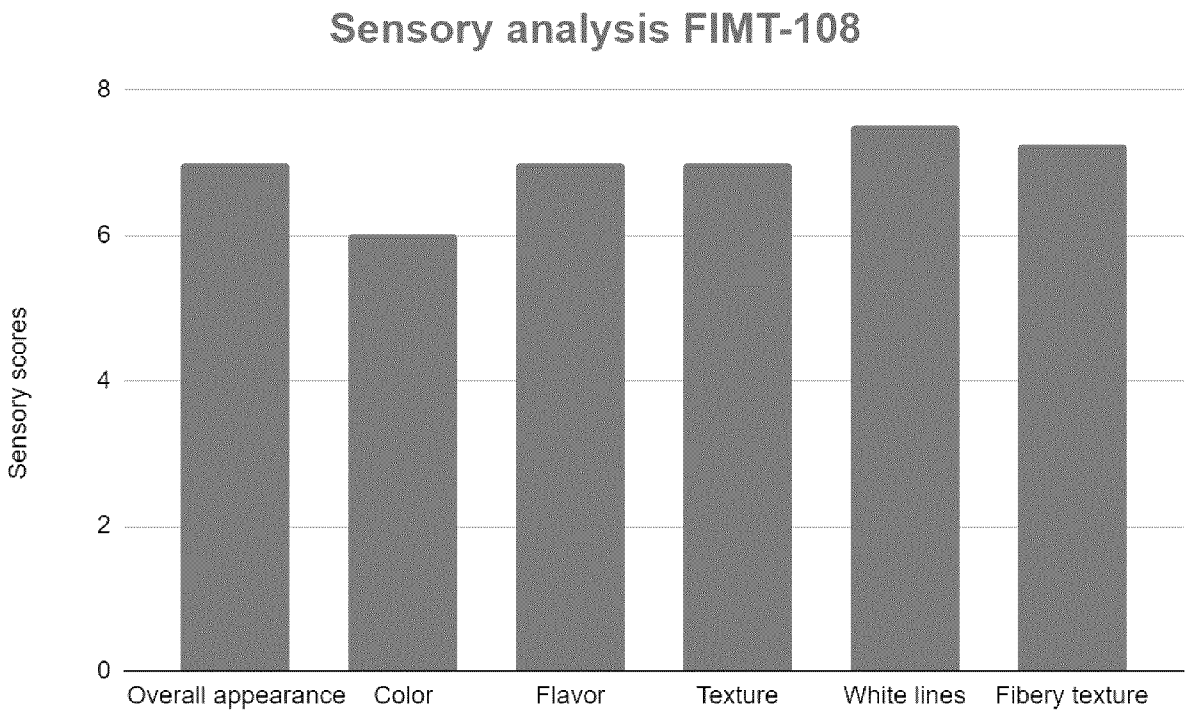

Sensory analysis FIMT-108
Sensory scores
8
6
4
2
0
Overall appearance
Color
Flavor
Texture
White lines
Fibery texture

Figure 8

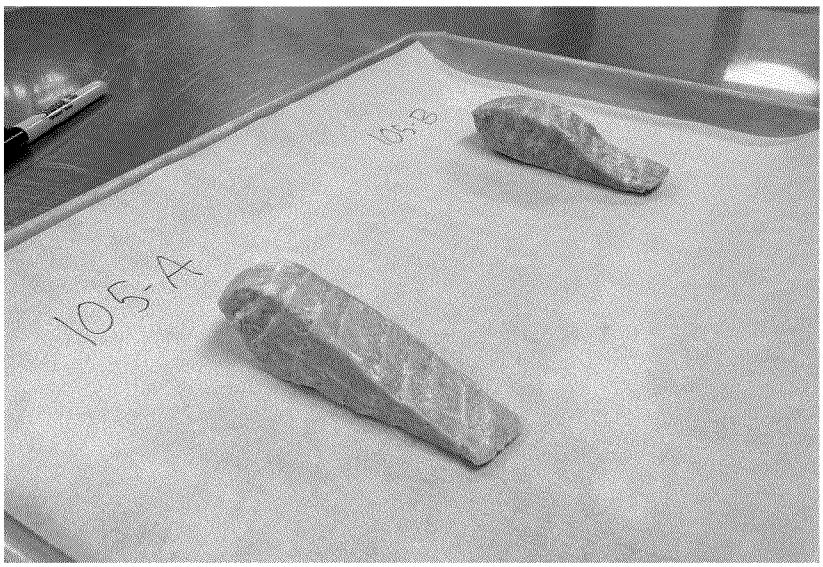


Figure 9

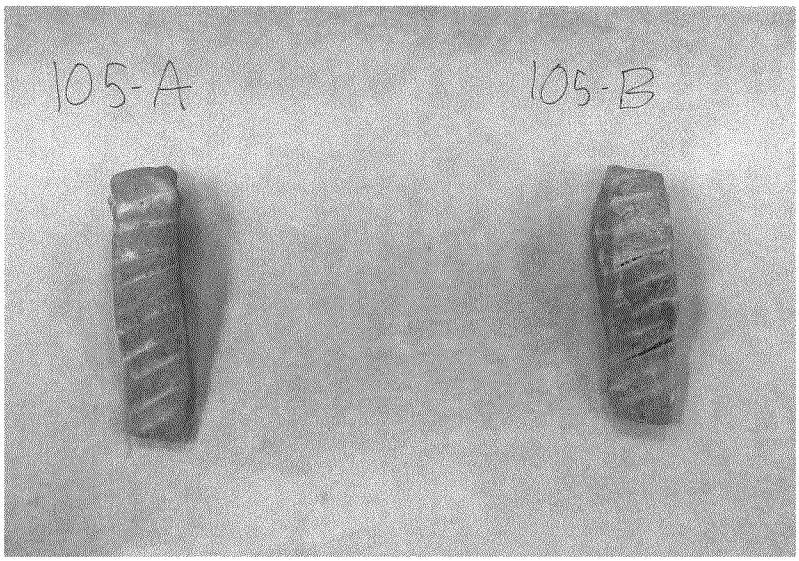


Figure 10

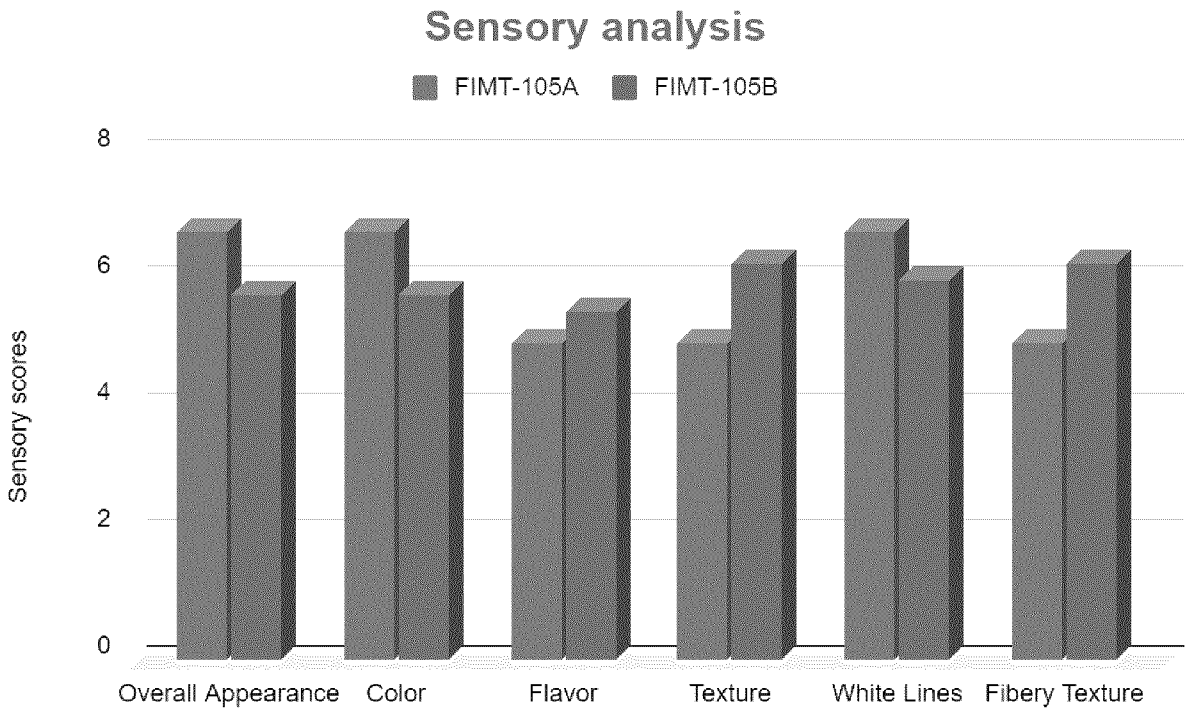


Figure 11

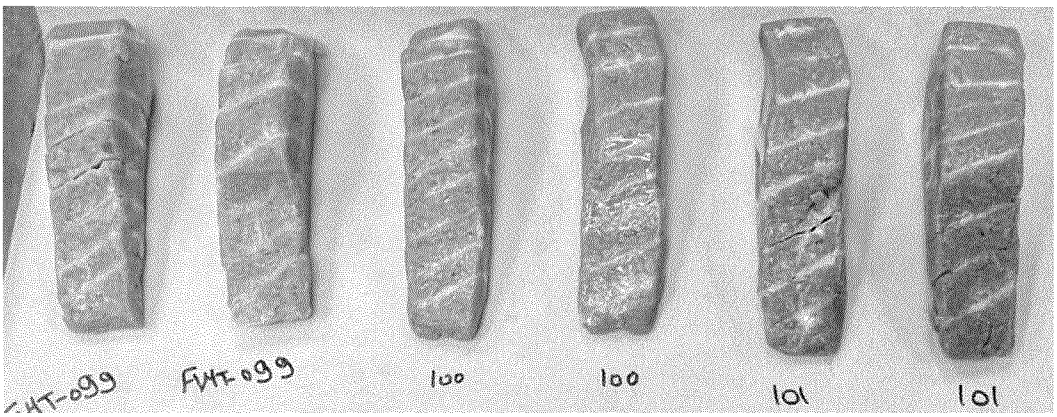


Figure 12

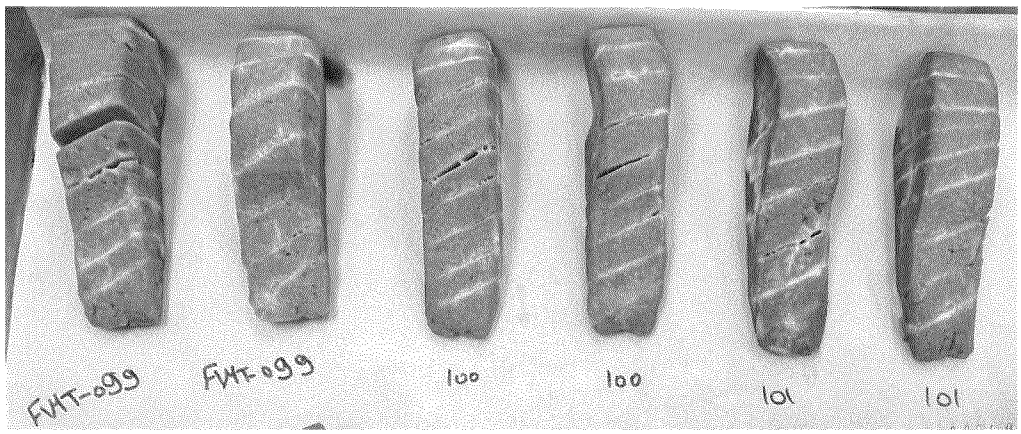


Figure 13

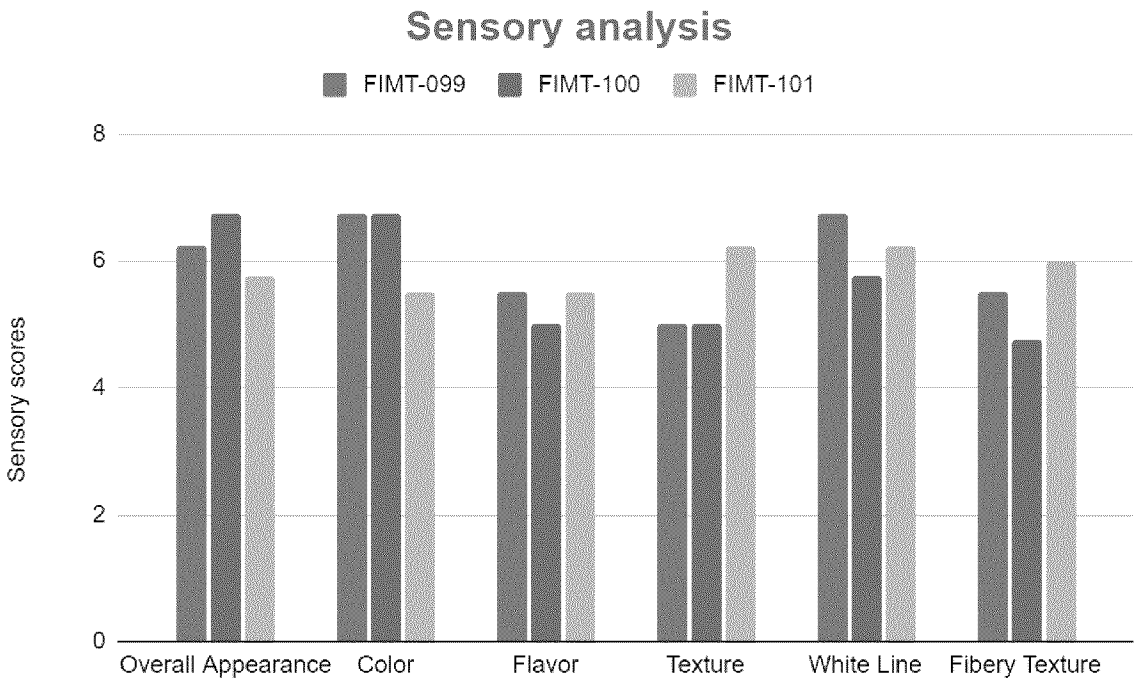


Figure 14

FIMT- 172	FIMT- 173
	

Figure 15



Figure 16

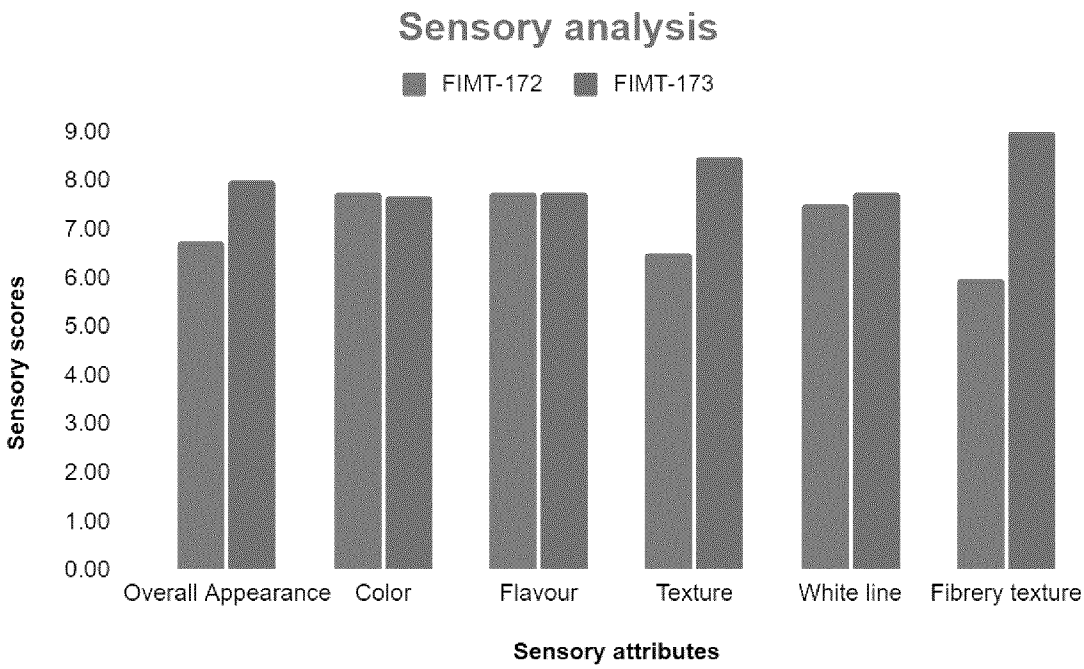

Sensory analysis
FIMT-172
FIMT-173
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Sensory scores
Overall Appearance
Color
Flavour
Texture
White line
Fibrery texture
Sensory attributes

Figure 17

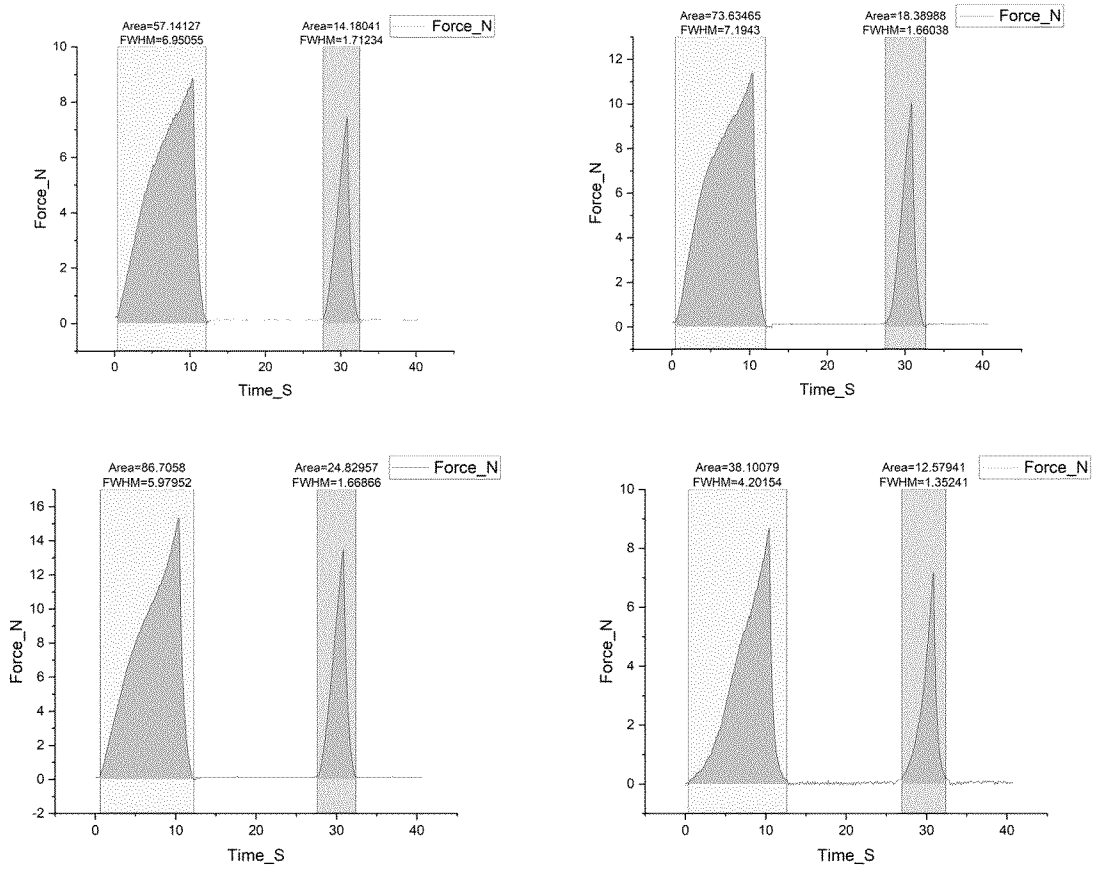

Area=57.14127
FWHM=6.95055
Area=14.18041
FWHM=1.71234
Force_N
Force_N
Time_S
Area=73.63465
FWHM=7.1943
Area=18.38988
FWHM=1.66038
Force_N
Force_N
Time_S
Area=86.7058
FWHM=5.97952
Area=24.82957
FWHM=1.66866
Force_N
Force_N
Time_S
Area=38.10079
FWHM=4.20154
Area=12.57941
FWHM=1.35241
Force_N
Force_N
Time_S

Figure 18A

]

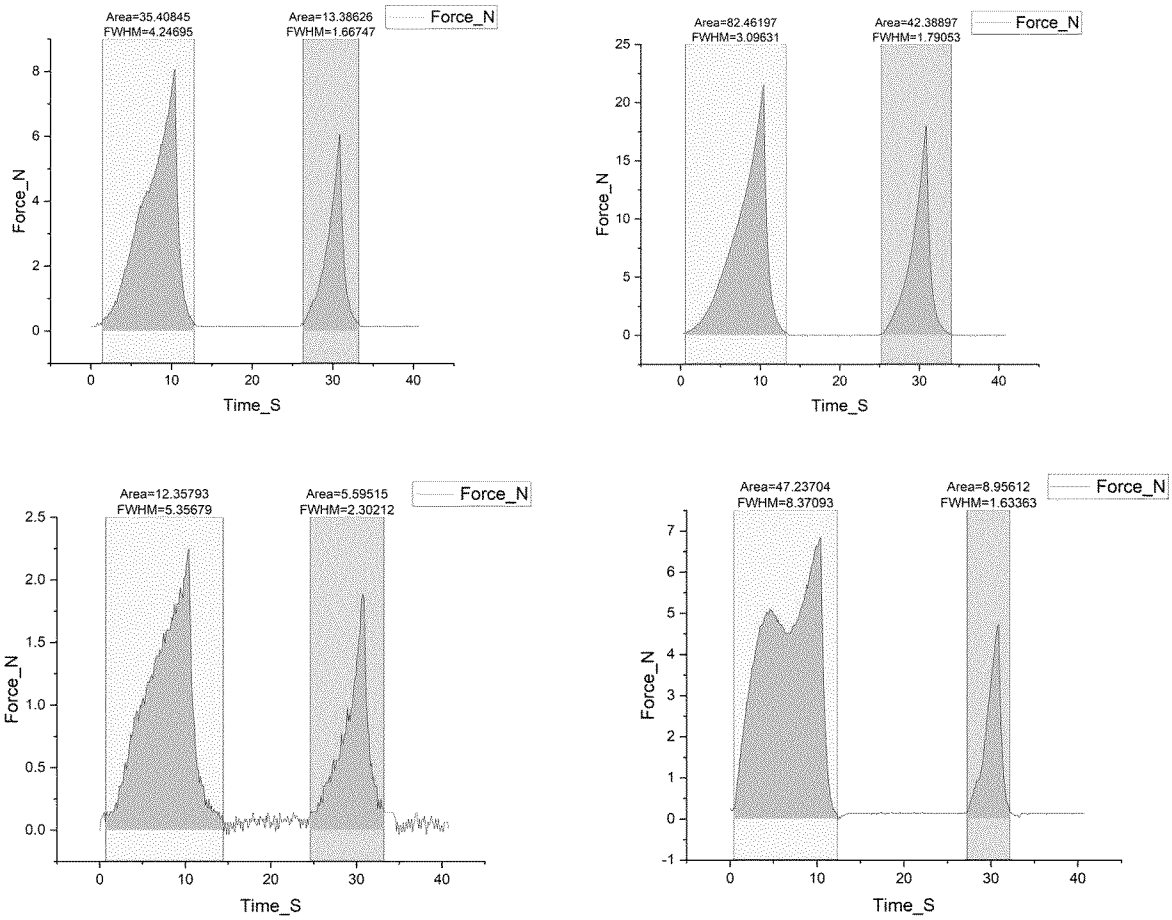

Area=35.40845
FWHM=4.24695
Area=13.38626
FWHM=1.66747
Force_N
Force_N
Time_S
Area=82.46197
FWHM=3.09631
Area=42.38897
FWHM=1.79053
Force_N
Force_N
Time_S
Area=12.35793
FWHM=5.35679
Area=5.59515
FWHM=2.30212
Force_N
Force_N
Time_S
Area=47.23704
FWHM=8.37093
Area=8.95612
FWHM=1.63363
Force_N
Force_N
Time_S

Figure 18B

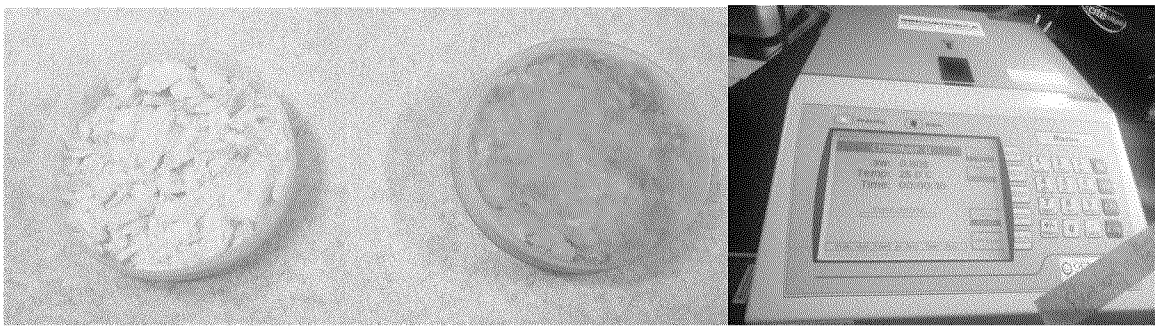


Figure 19



Figure 20



Figure 21



Figure 22

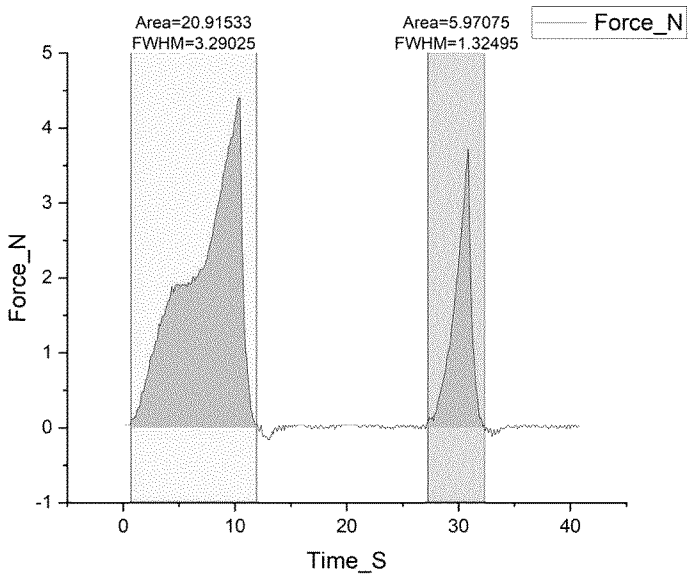


Figure 23

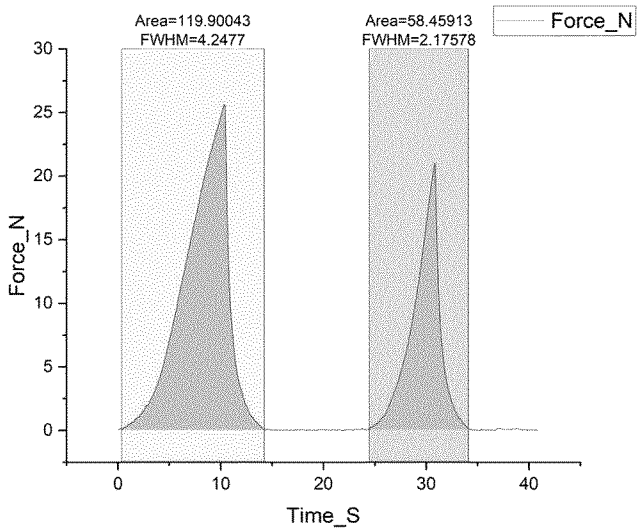


Figure 24

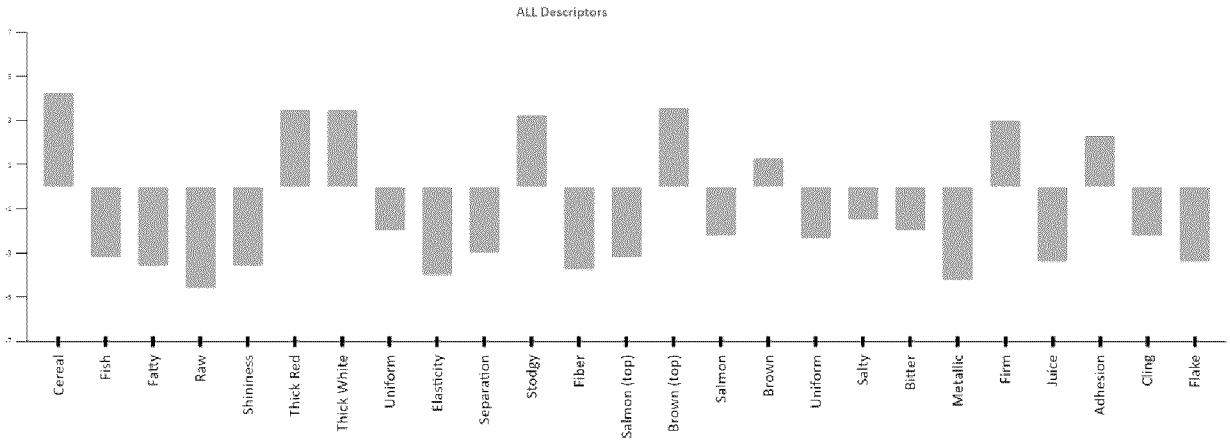


Figure 25

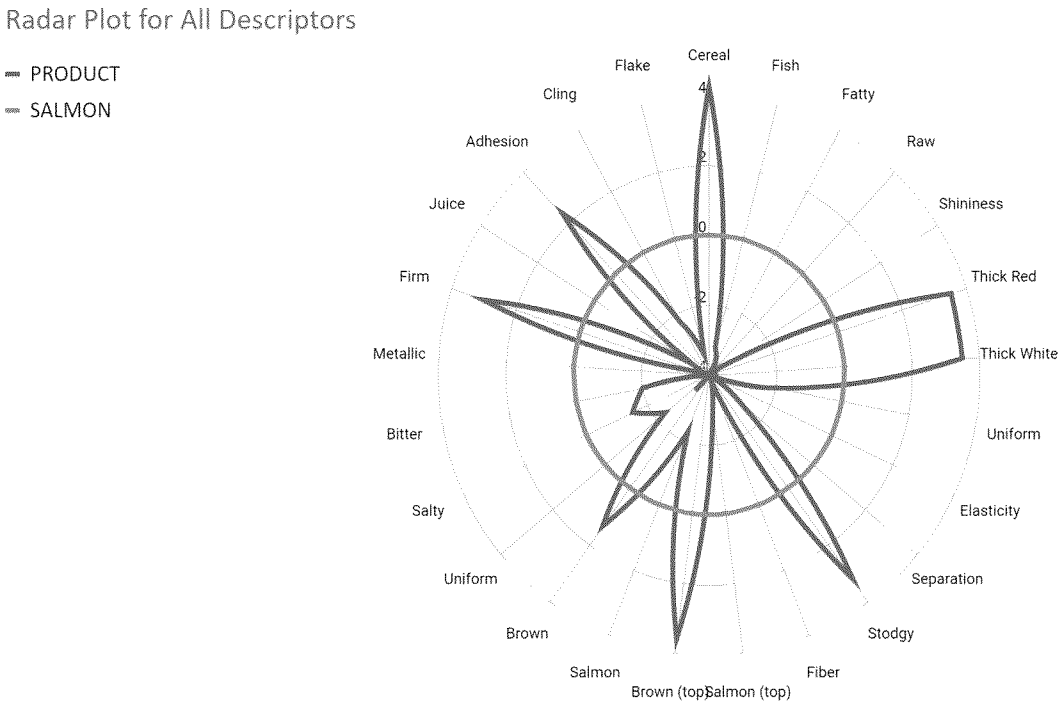


Figure 26



Figure 27



Figure 28



Figure 29

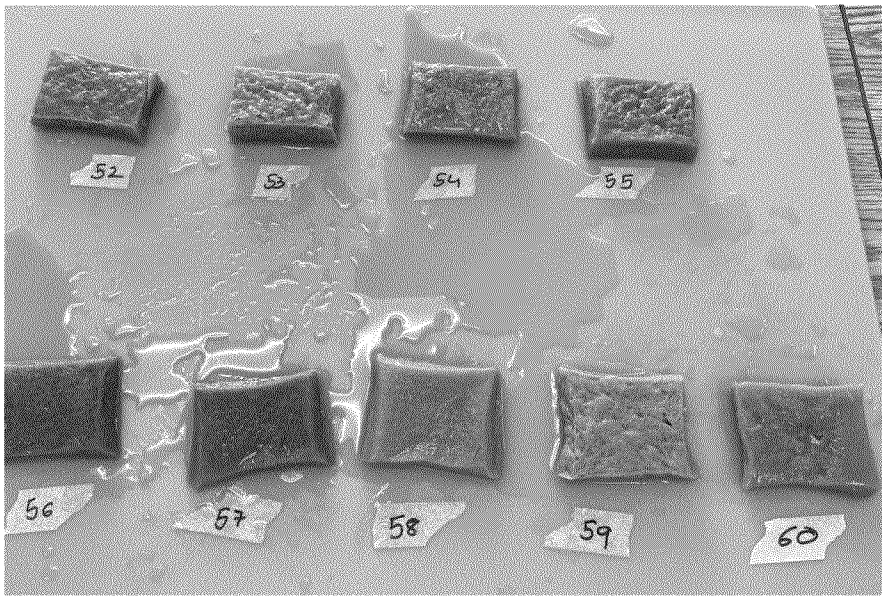


Figure 30.1

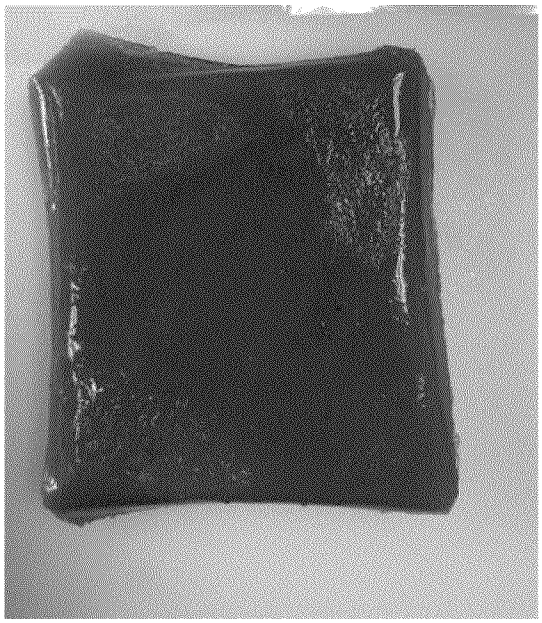


Figure 30.2



Figure 30.3



Figure 30.4

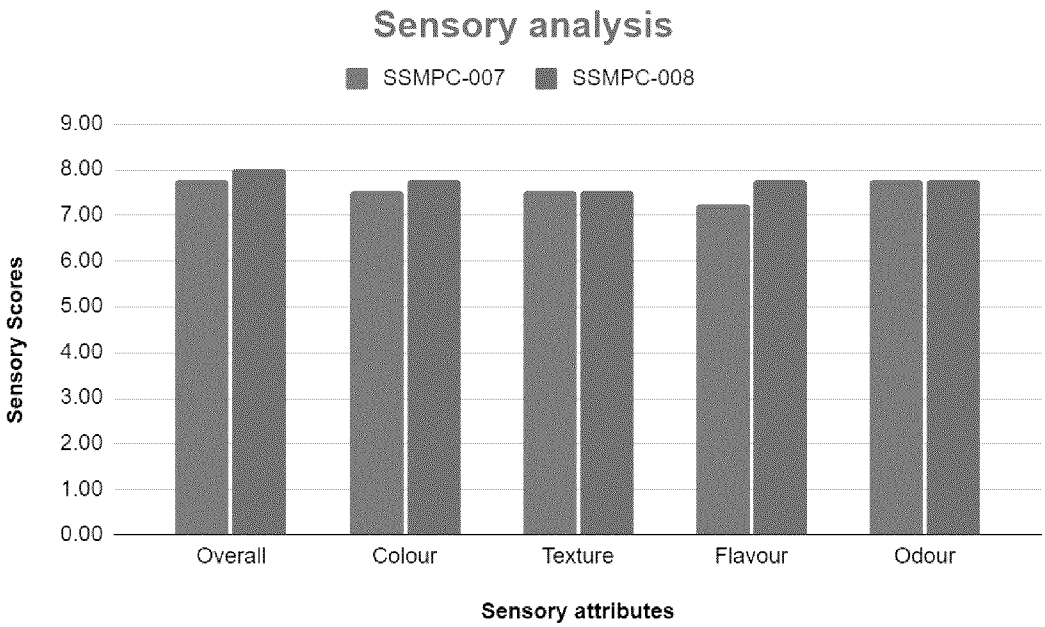


Figure 31

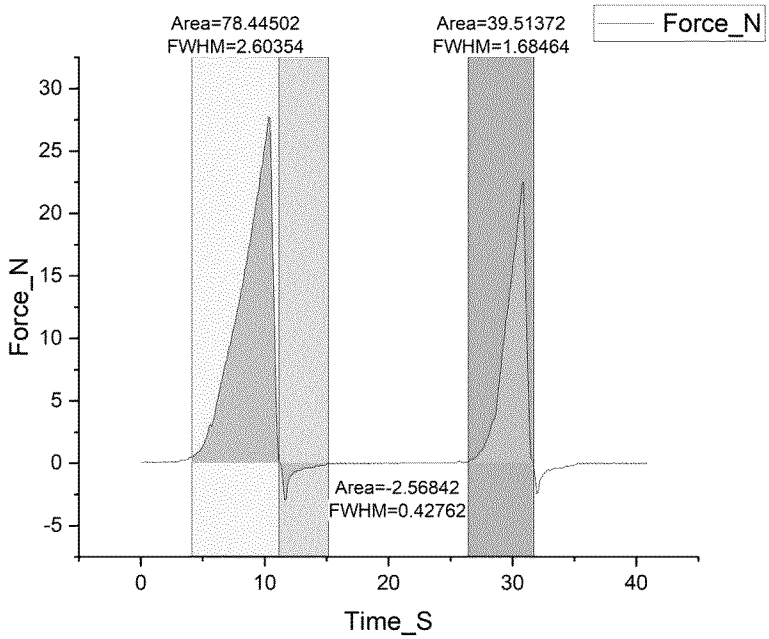

Area=78.44502
FWHM=2.60354
Area=39.51372
FWHM=1.68464
Force_N
Area=-2.56842
FWHM=0.42762
Force_N
Time_S
30
25
20
15
10
5
0
-5
0
10
20
30
40

Figure 32

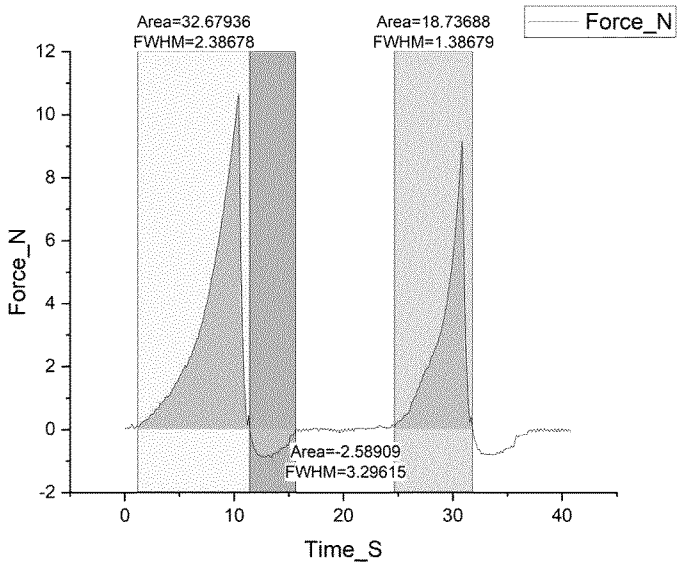


Figure 33

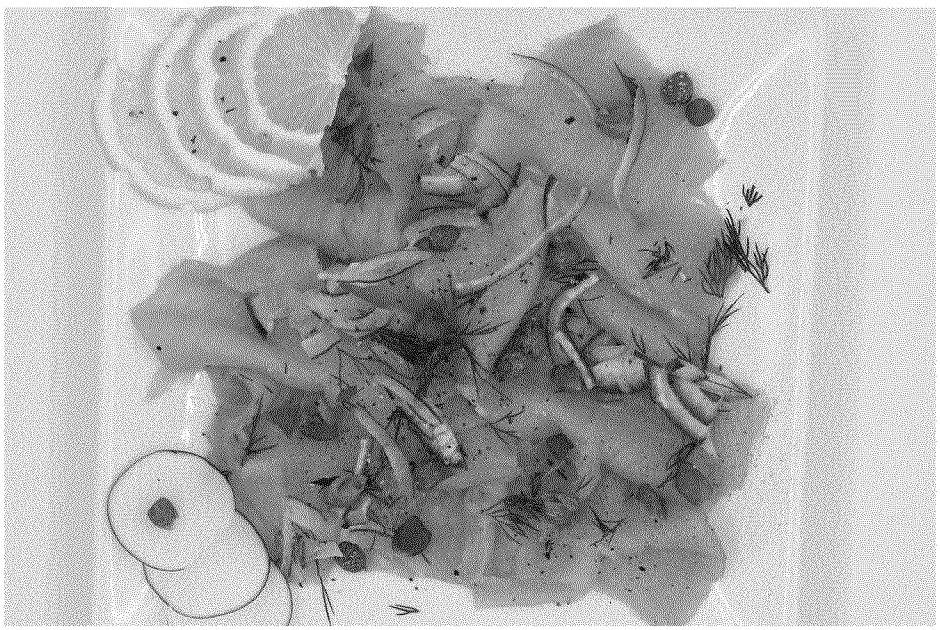


Figure 34

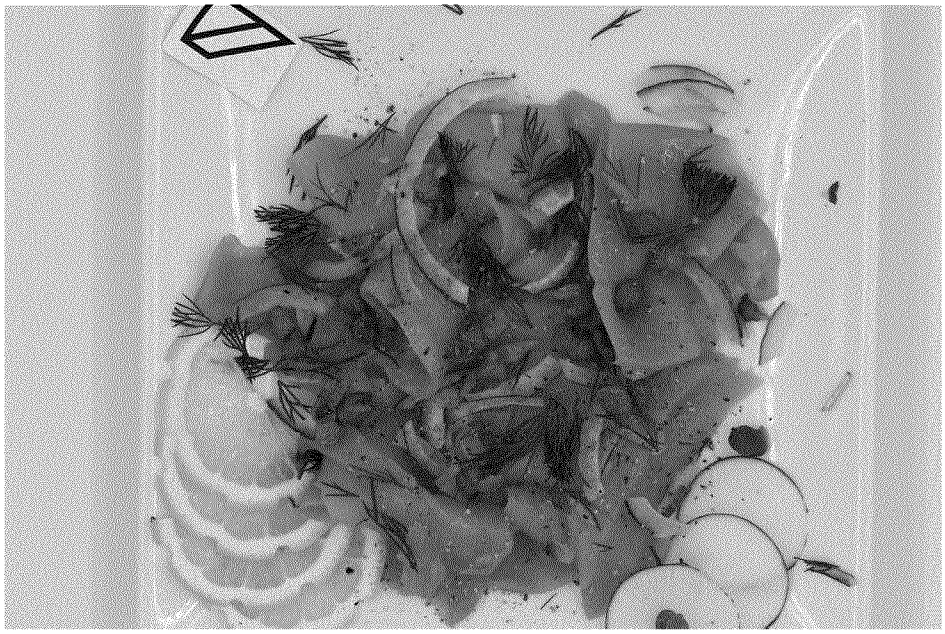


Figure 35

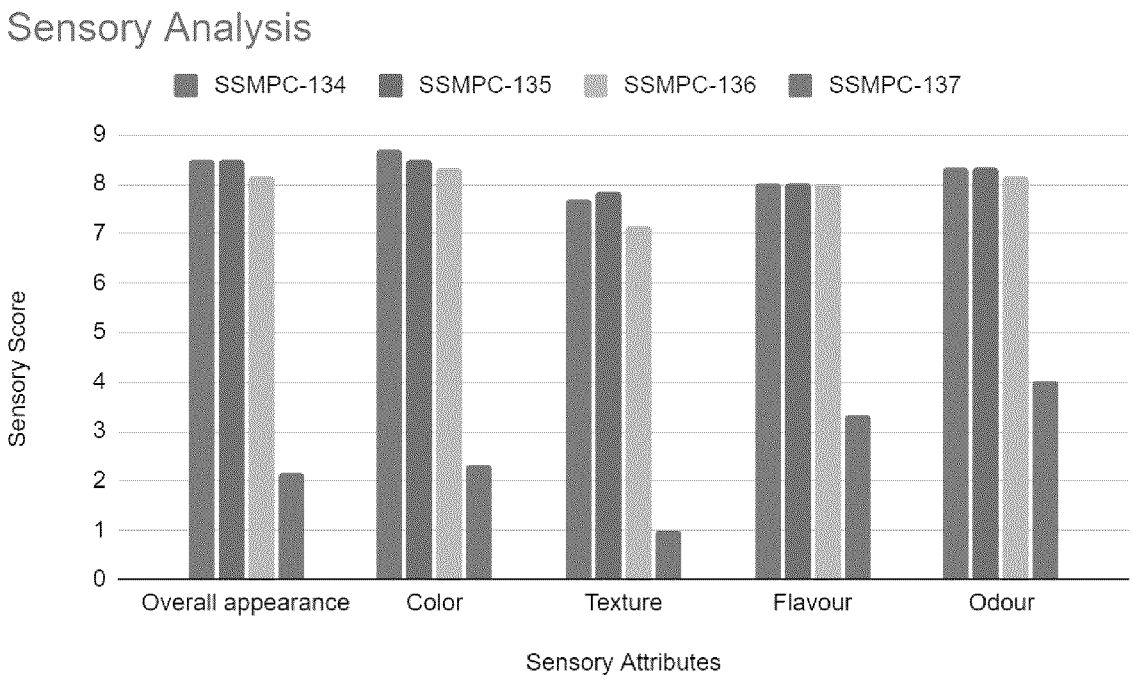

Sensory Analysis
SSMPC-134
SSMPC-135
SSMPC-136
SSMPC-137
Sensory Score
9
8
7
6
5
4
3
2
1
0
Overall appearance
Color
Texture
Flavour
Odour
Sensory Attributes

Figure 36

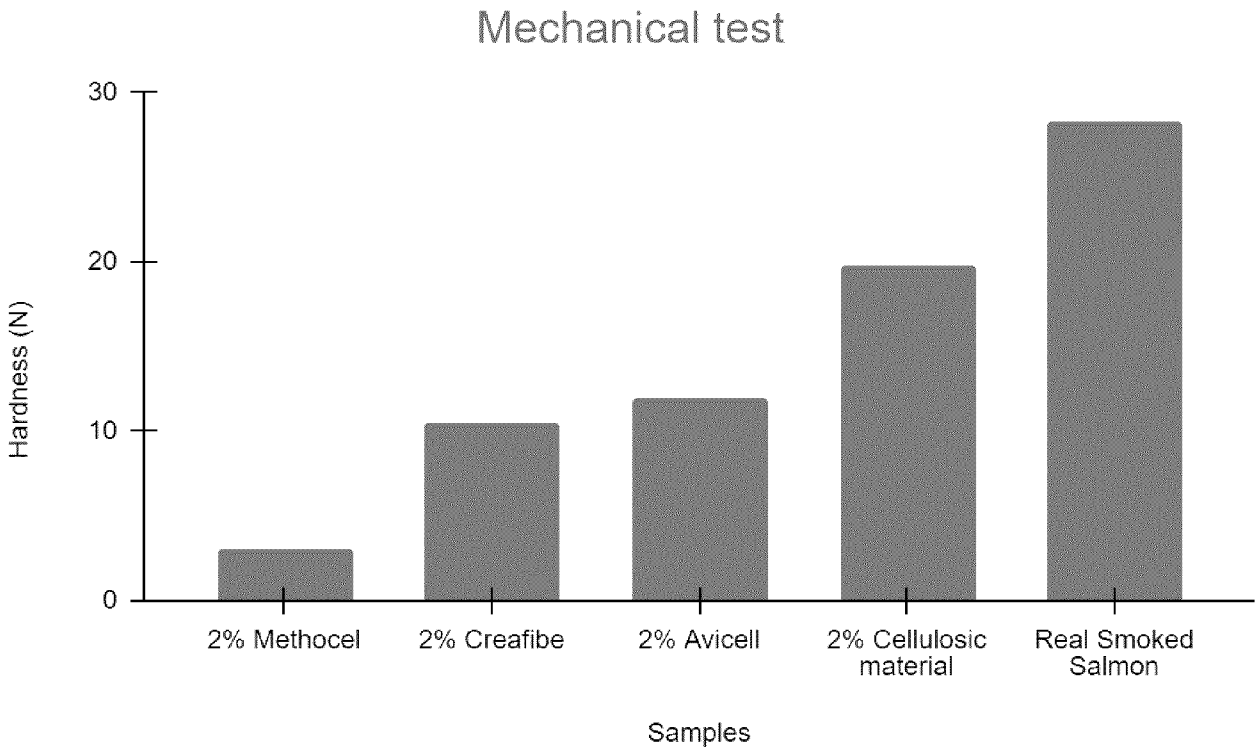

Mechanical test
30
20
10
0
Hardness (N)
2% Methocel
2% Creafibe
2% Avicell
2% Cellulosic material
Real Smoked Salmon
Samples

Figure 37

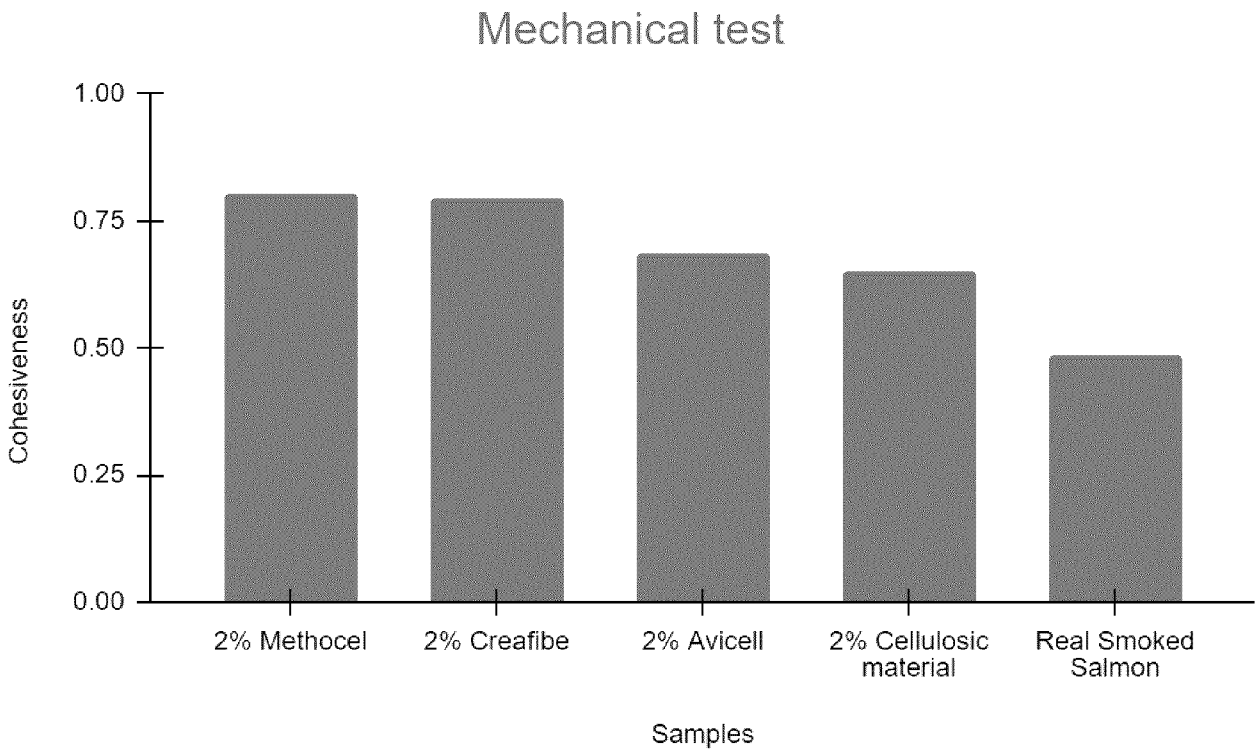

Mechanical test
1.00
0.75
0.50
0.25
0.00
Cohesiveness
2% Methocel
2% Creafibe
2% Avicell
2% Cellulosic material
Real Smoked Salmon
Samples

Figure 38

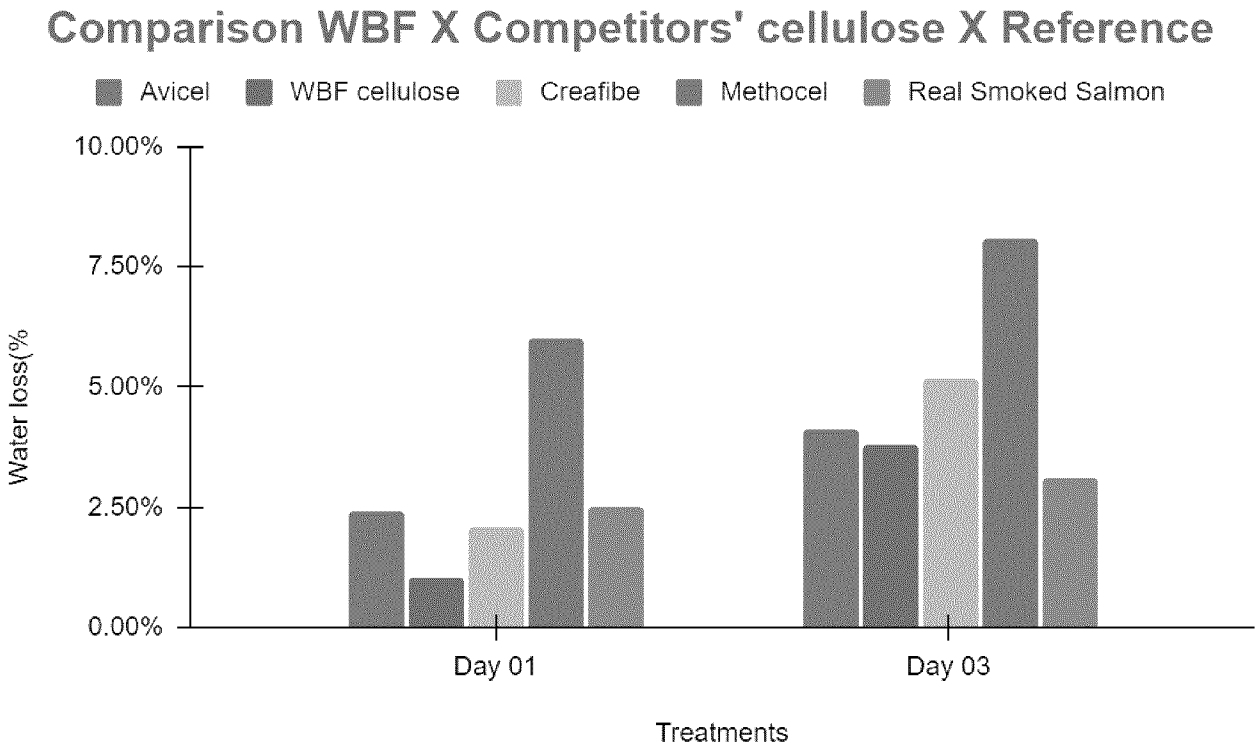

Comparison WBF X Competitors' cellulose X Reference
Avicel
WBF cellulose
Creafibe
Methocel
Real Smoked Salmon
10.00%
7.50%
5.00%
2.50%
0.00%
Water loss(%
Day 01
Day 03
Treatments

Figure 39



Figure 40



Figure 41

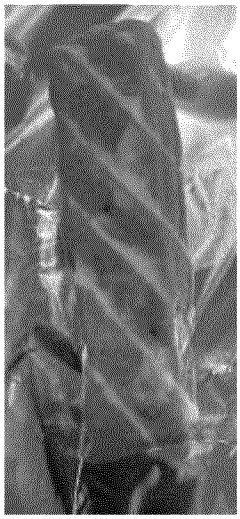
White lines using MAC -042	White lines using MAC-043
	

Figure 42



Figure 43

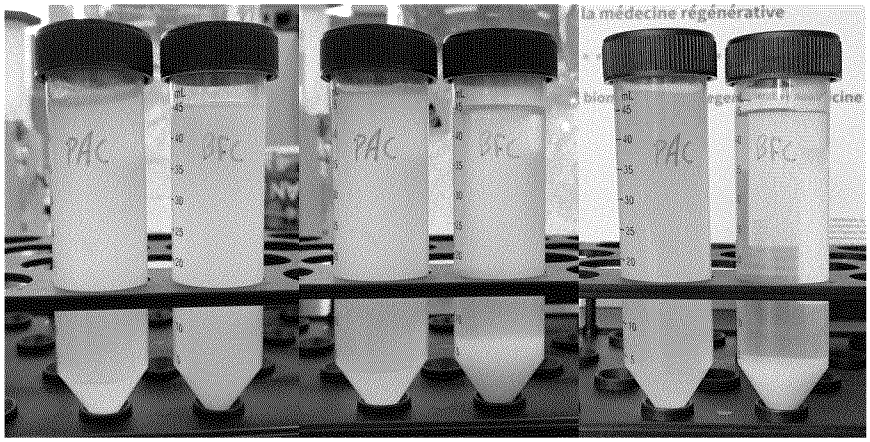


Figure 44

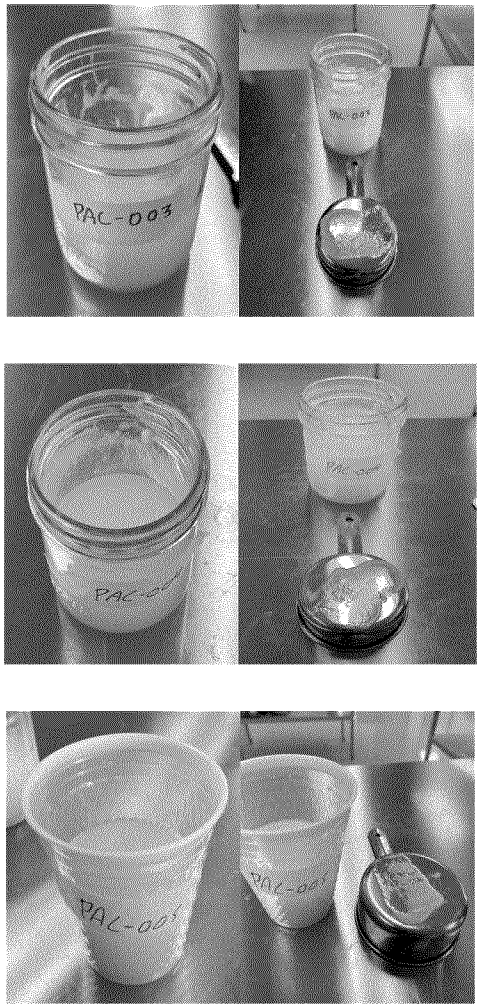


Figure 45

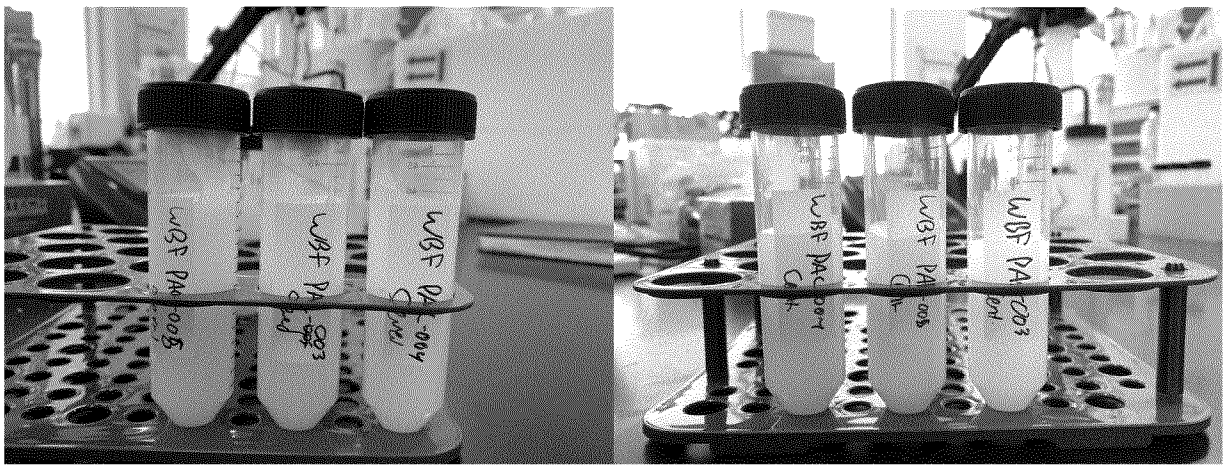


Figure 46

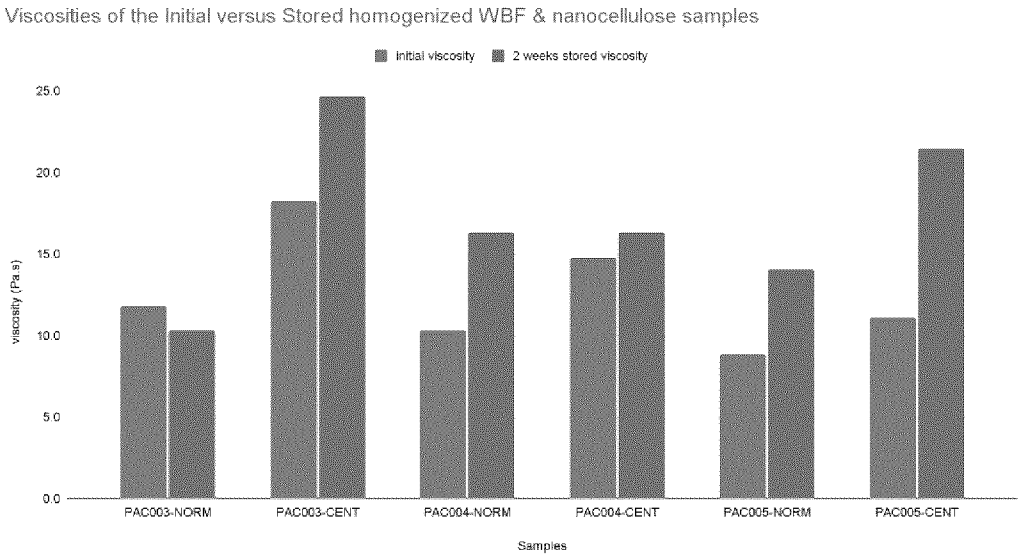


Figure 47

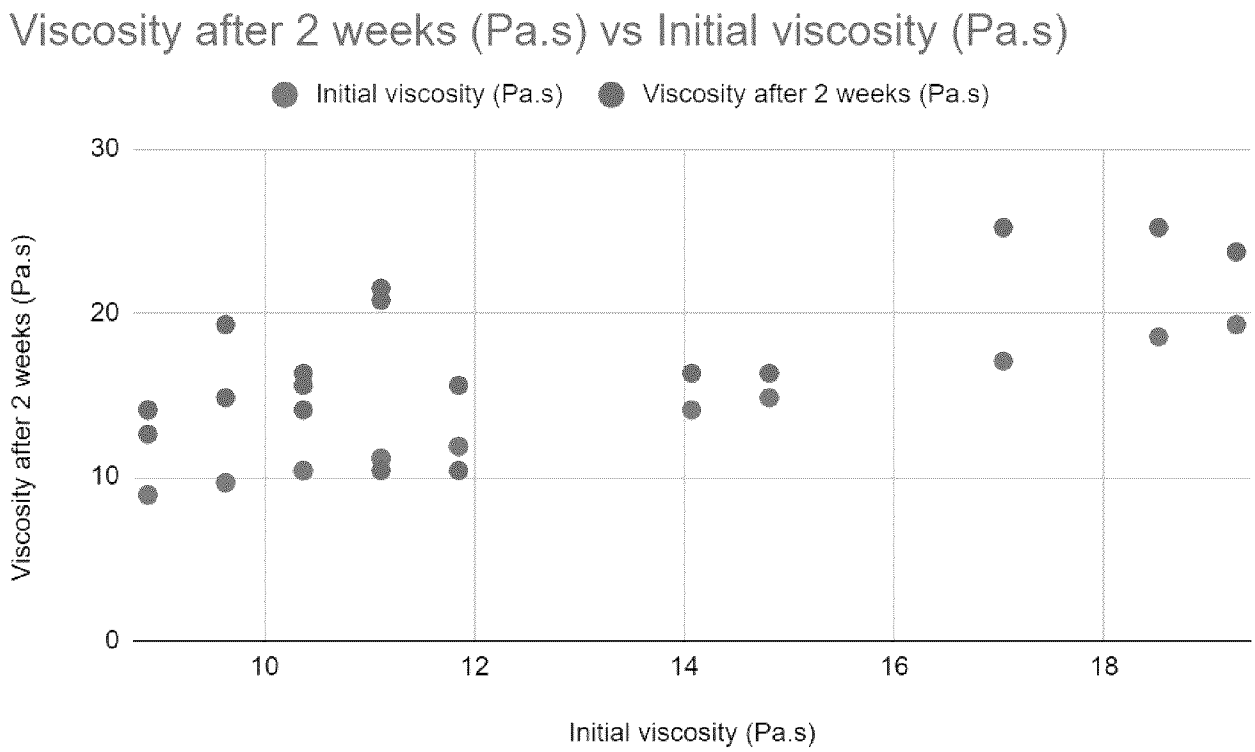


Figure 48

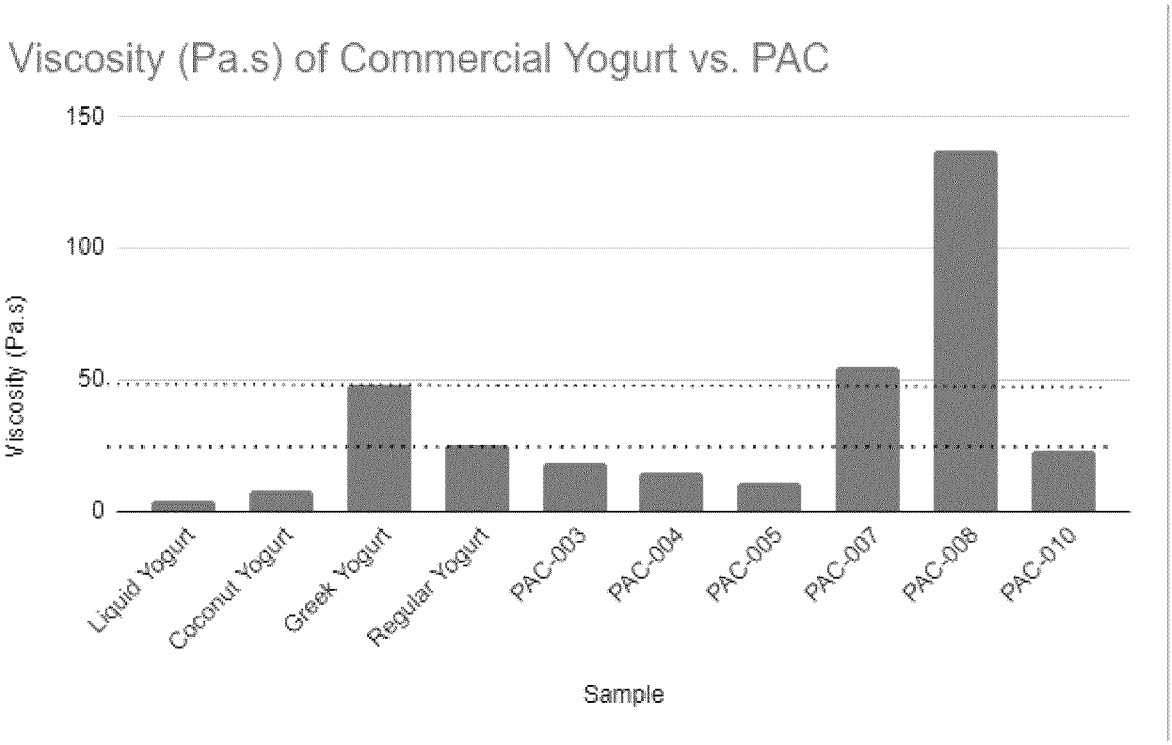


Figure 49



Figure 50



Figure 51

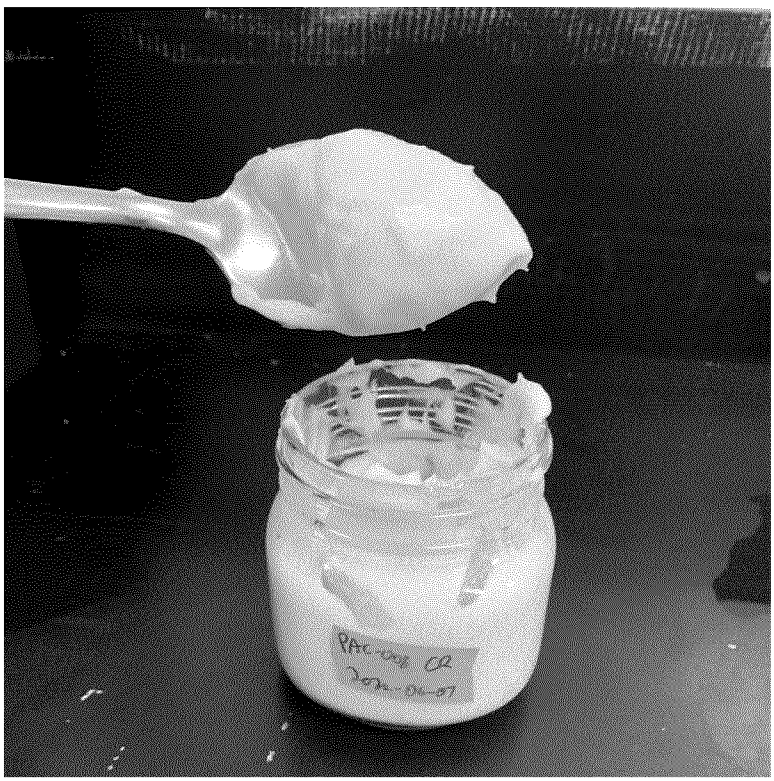


Figure 52

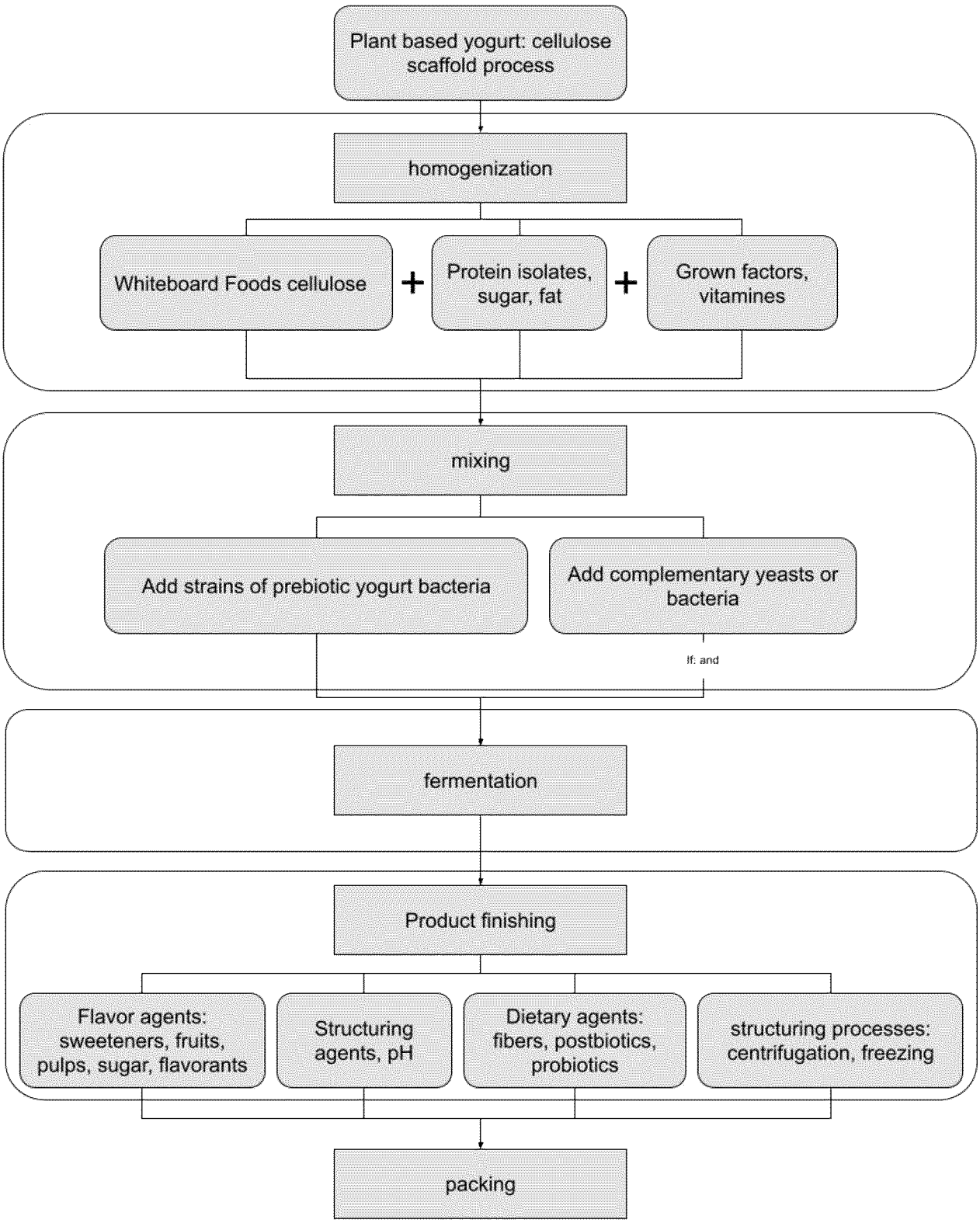

Plant based yogurt: cellulose scaffold process
homogenization
Whiteboard Foods cellulose
+
Protein isolates, sugar, fat
+
Grown factors, vitamines
mixing
Add strains of prebiotic yogurt bacteria
Add complementary yeasts or bacteria
If: and
fermentation
Product finishing
Flavor agents: sweeteners, fruits, pulps, sugar, flavorants
Structuring agents, pH
Dietary agents: fibers, postbiotics, probiotics
structuring processes: centrifugation, freezing
packing

Figure 53

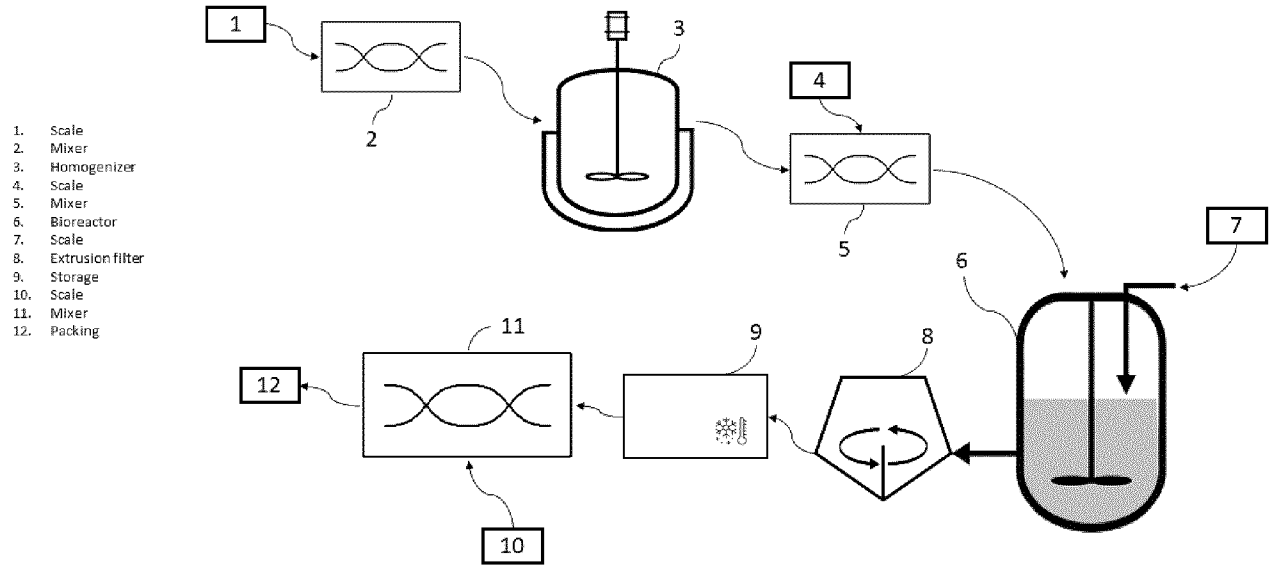

1. Scale
2. Mixer
3. Homogenizer
4. Scale
5. Mixer
6. Bioreactor
7. Scale
8. Extrusion filter
9. Storage
10. Scale
11. Mixer
12. Packing
1
2
3
4
5
6
7
8
9
10
11
12

Figure 54

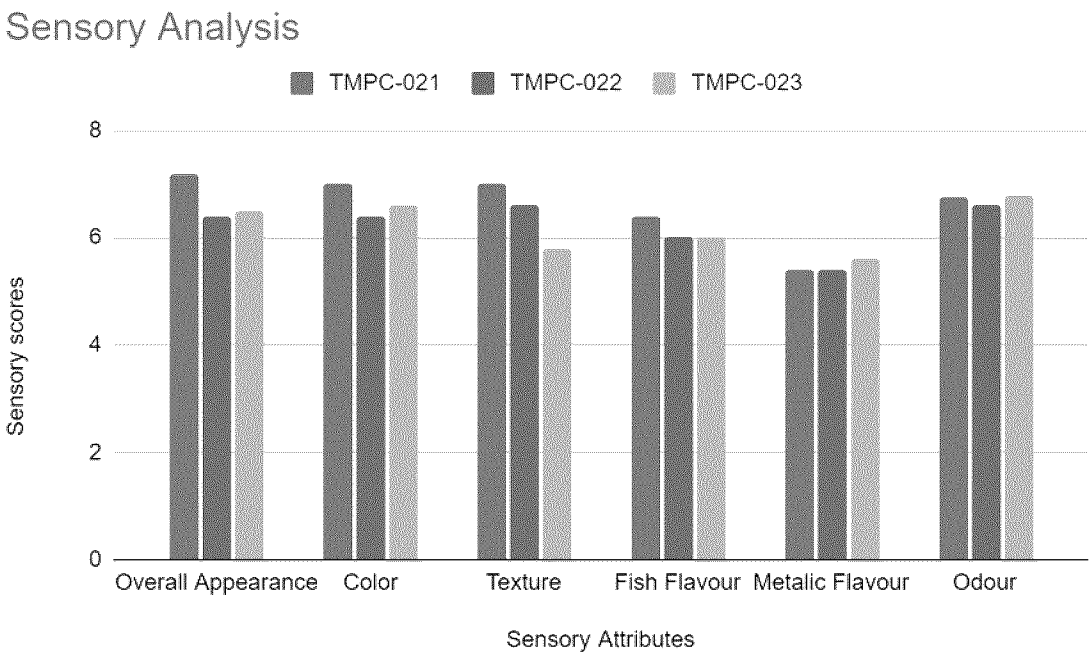


Figure 55A

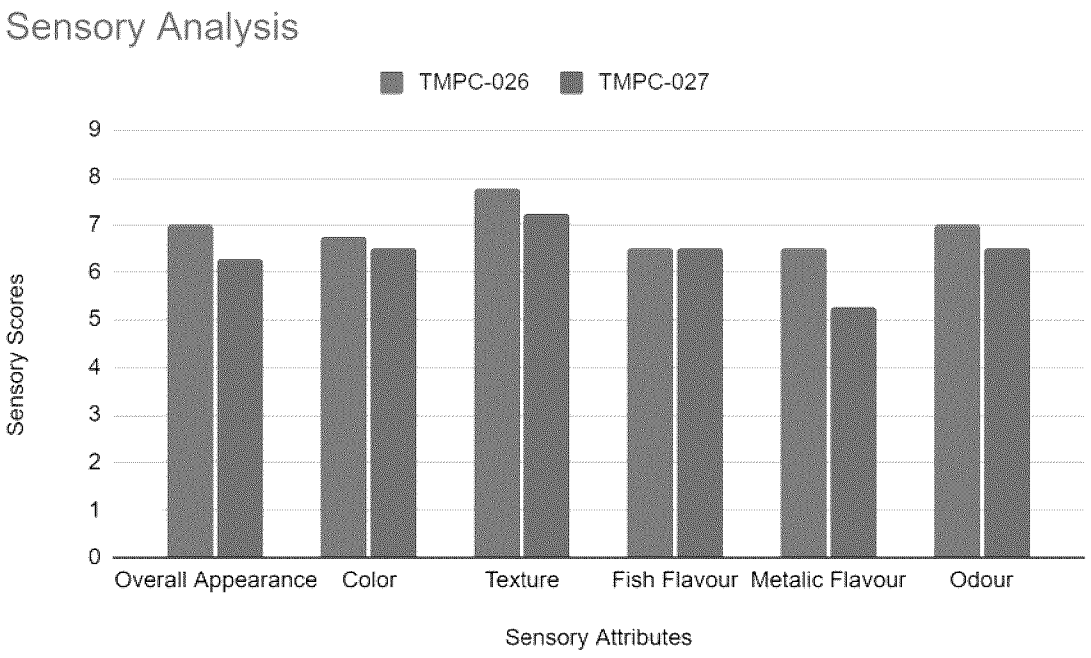


Figure 55B

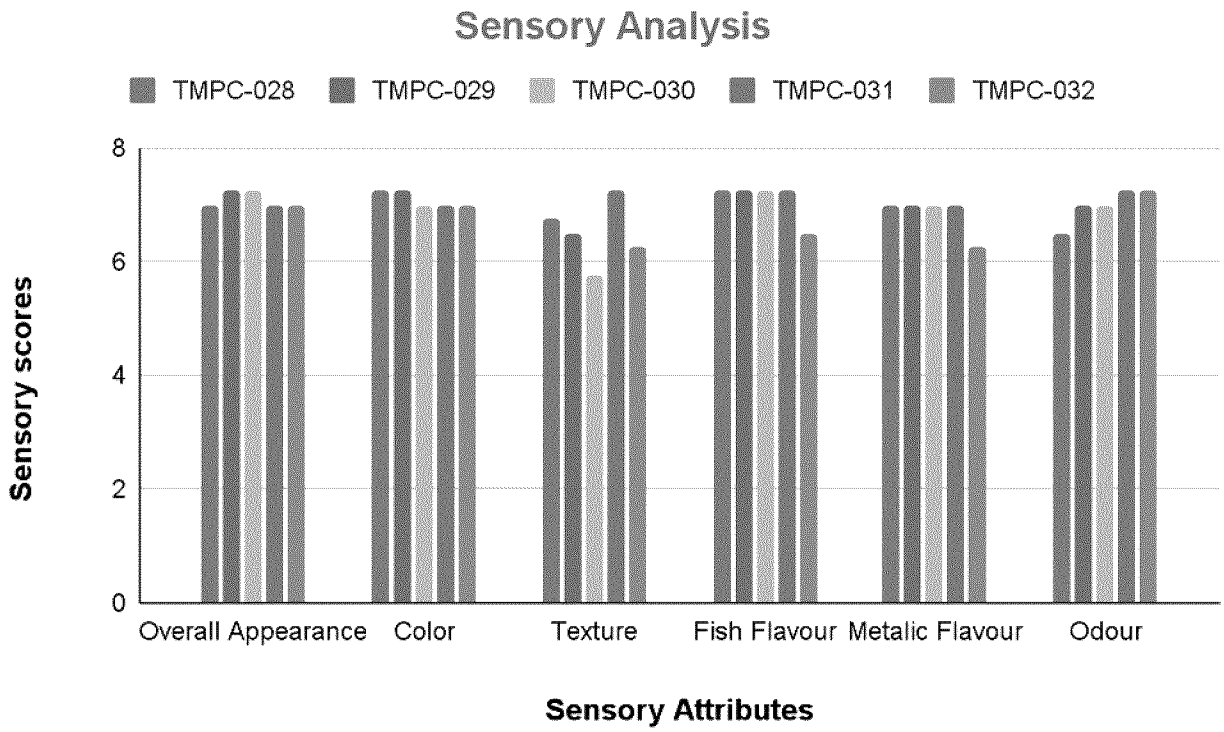


Figure 55C

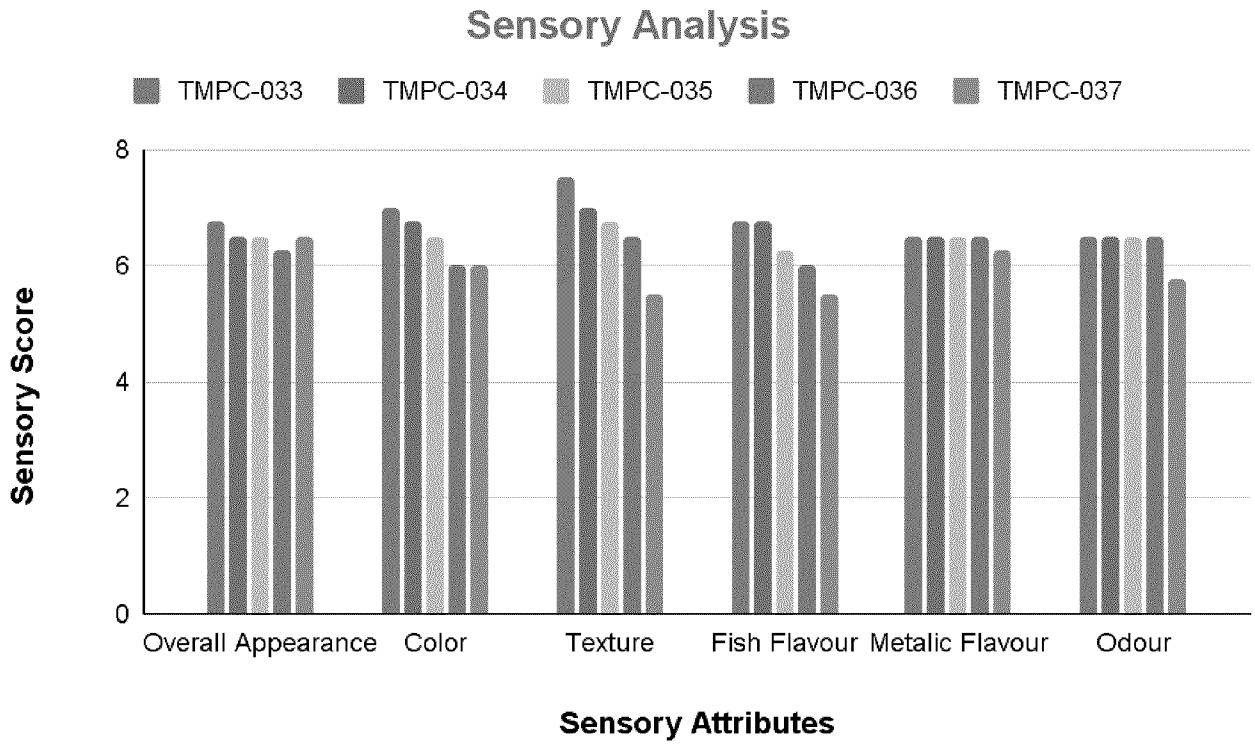


Figure 55D

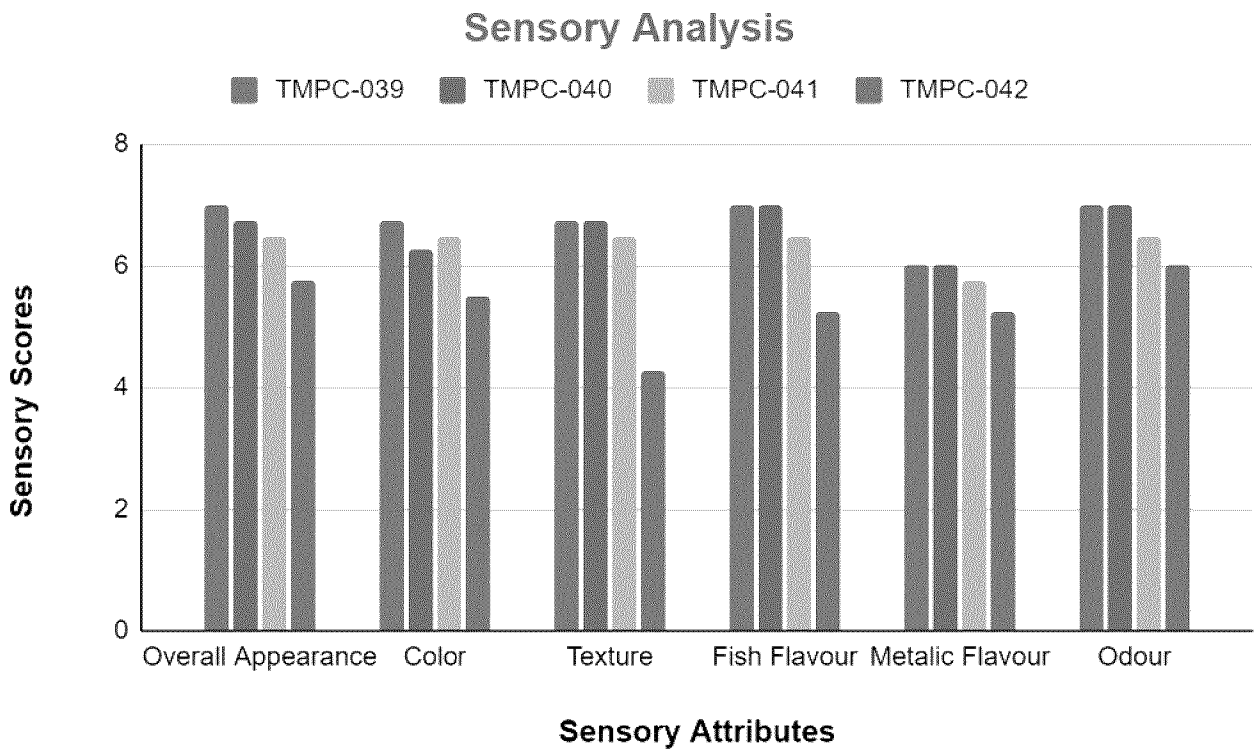

Sensory Analysis
TMPC-039
TMPC-040
TMPC-041
TMPC-042
Sensory Scores
8
6
4
2
0
Overall Appearance
Color
Texture
Fish Flavour
Metalic Flavour
Odour
Sensory Attributes

Figure 55E

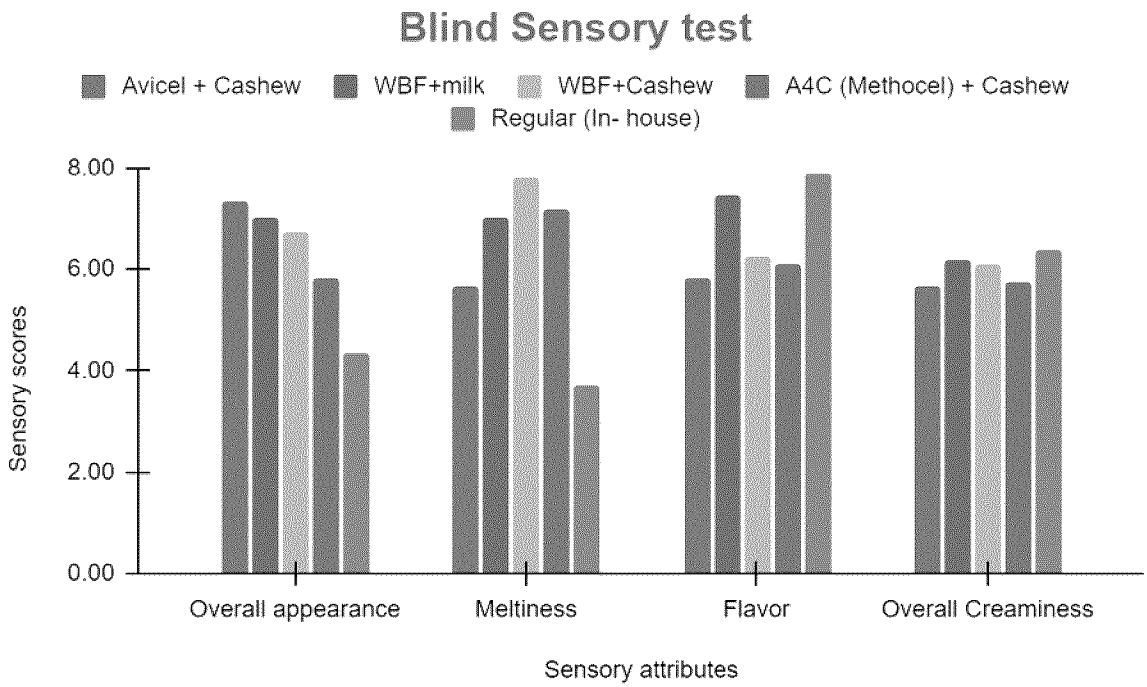

Blind Sensory test
Avicel + Cashew
WBF+milk
WBF+Cashew
A4C (Methocel) + Cashew
Regular (In- house)
8.00
6.00
4.00
2.00
0.00
Sensory scores
Overall appearance
Meltiness
Flavor
Overall Creaminess
Sensory attributes

Figure 56



Figure 57

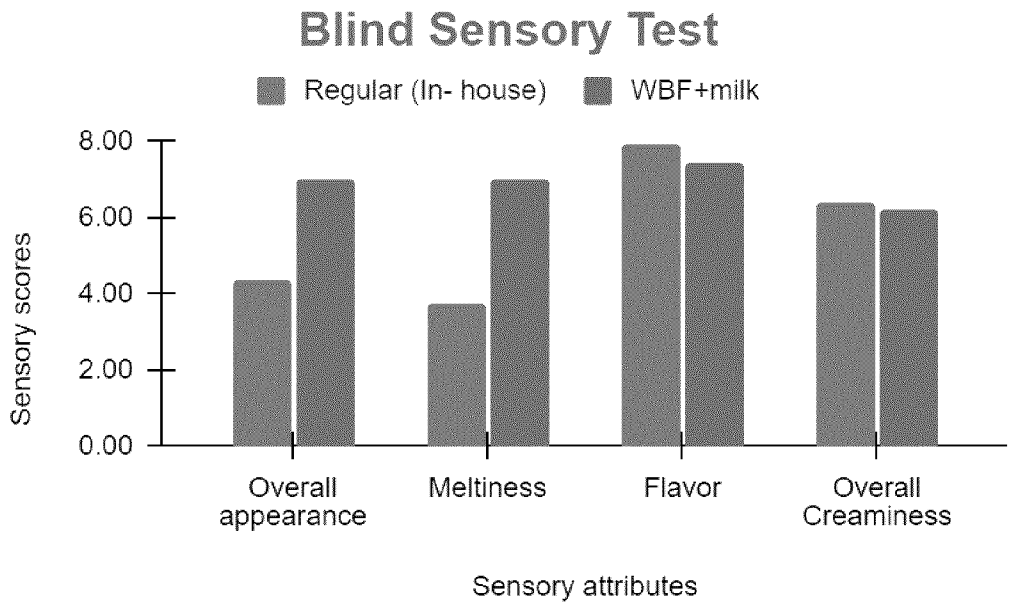

Blind Sensory Test
Regular (In- house)
WBF+milk
8.00
6.00
4.00
2.00
0.00
Sensory scores
Overall appearance
Meltiness
Flavor
Overall Creaminess
Sensory attributes

Figure 58



Figure 59

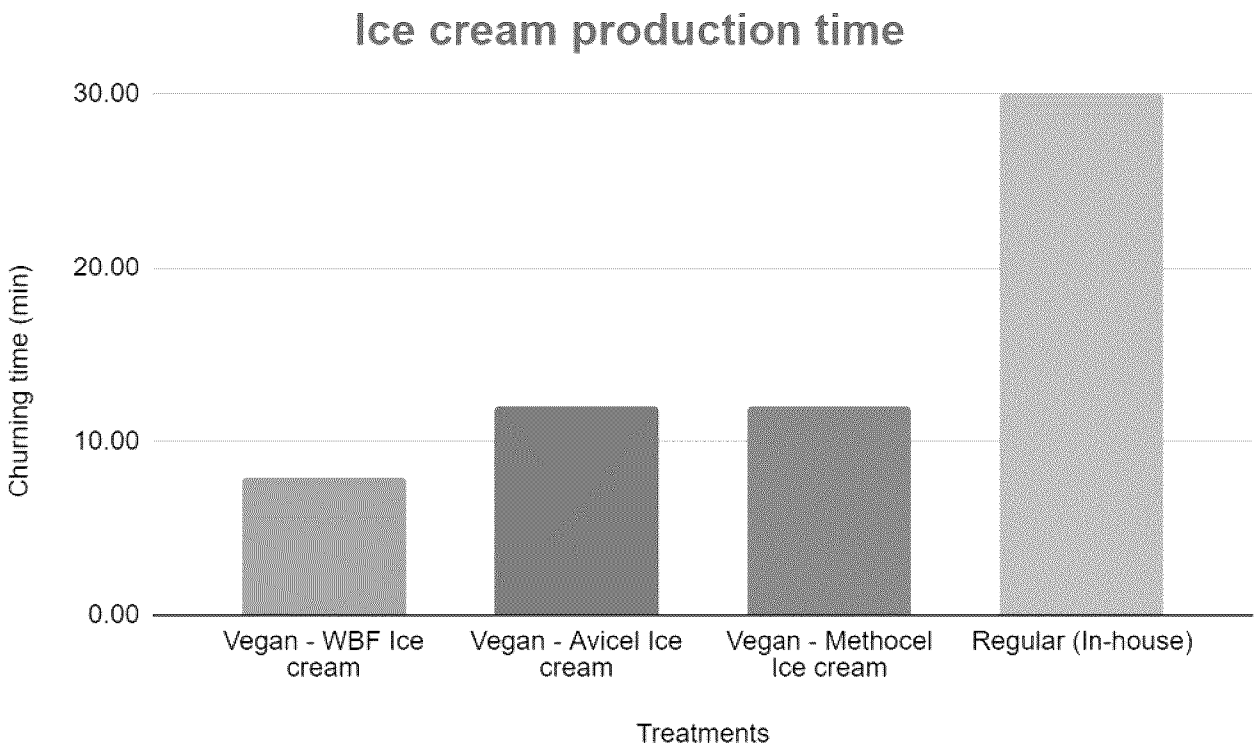
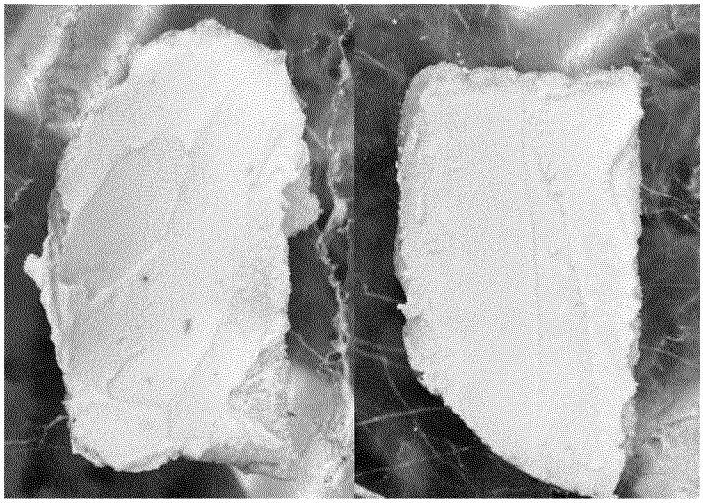
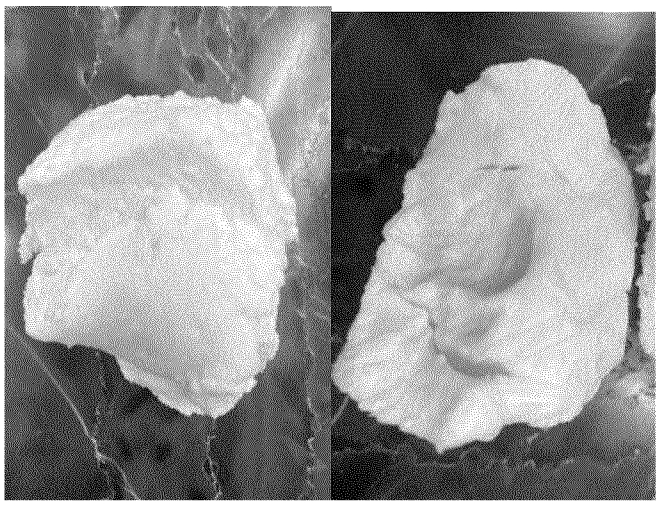

Ice cream production time
30.00
20.00
10.00
0.00
Churning time (min)
Vegan - WBF Ice cream
Vegan - Avicel Ice cream
Vegan - Methocel Ice cream
Regular (In-house)
Treatments

Figure 60



(a) (b)

Figure 61



(a) (b)

Figure 62



Figure 63

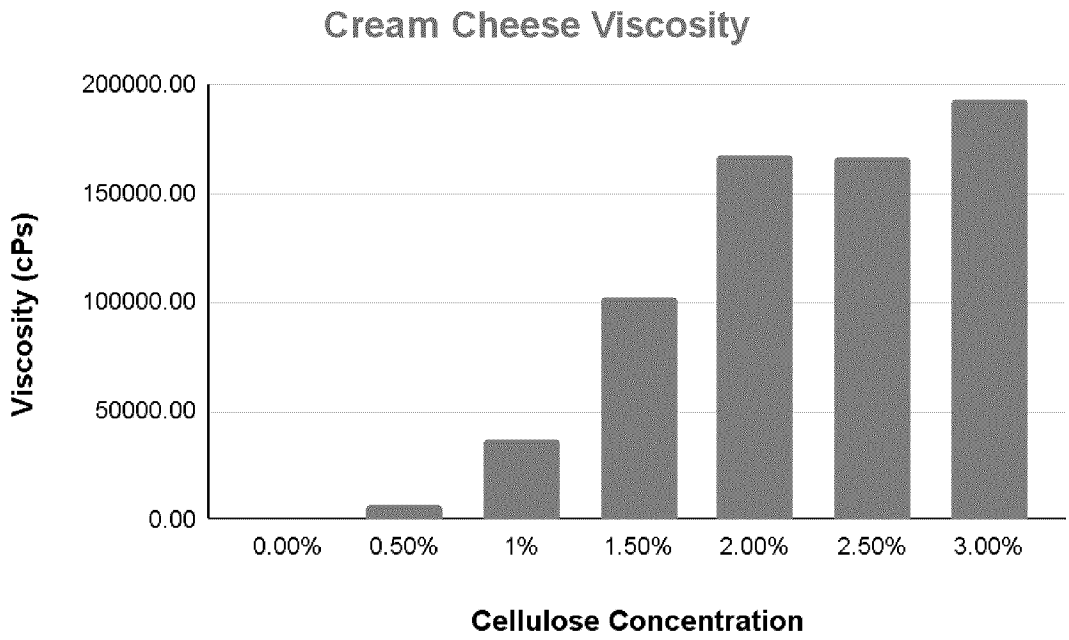

Cream Cheese Viscosity
200000.00
150000.00
100000.00
50000.00
0.00
Viscosity (cPs)
0.00%
0.50%
1%
1.50%
2.00%
2.50%
3.00%
Cellulose Concentration

Figure 64

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2024/051263

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***A23J 3/22*** (2006.01), ***A23C 20/00*** (2006.01), ***A23J 3/14*** (2006.01), ***A23L 5/00*** (2016.01), ***A23L 7/10*** (2016.01), ***A23L 11/00*** (2021.01) (more IPCs on the last page)

CPC: A23C 20/00 (2013.01), A23J 3/14 (2013.01), A23J 3/227 (2016.08), A23L 7/10 (2016.08), A23L 29/20 (2016.08) (more CPCs on the last page)

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)
IPC: A23J 3/22 ; A23C 20/00 ; A23J 3/14 ; A23L 5/00 ; A23L 7/10 ; A23L 11/00 ; A23L 11/50 ; A23L 19/00 ; A23L 29/20 ; A23L 29/262 ; A23L 13/00
CPC: A23J 3/227 ; A23C 20/00 ; A23J 3/14 ; A23L 7/10 ; A23L 29/20 ; A23L 29/212 ; A23L 29/262 ; A23L 13/00 ; A23L 5/00 ; A23L 11/00 ; A23L 11/50 ; A23L 19/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel Orbit / FAMPAT: plant, vegan, salmon, fish, bleach, whiten, cellulose, mercer, decell, protein, thickener
Scopus: bleached, cellulose, salmon, food

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2023/004515 A1 (PELLING, A. E. et al) 2 February 2023 (02-02-2023) *whole document*	1-16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"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 22 November 2024 (22-11-2024)	Date of mailing of the international search report 17 December 2024 (17-12-2024)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer David Dalrymple Ph: 1-873-354-5237

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2024/051263

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos.:

1-16

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Continuation of Box III: Unity

Reference is made to the following document:

D1 – WO 2023/004515 A1 (PELLING, A. E. et al) 2 February 2023 (02-02-2023)

This application appears to be directed to a plurality of potential inventions (as defined in PT Rule 13) as follows:

Group 1 (Claims 1-16): plant-based food product comprising bleached cellulose-based plant material, at least one protein, at least one thickening/gelling agent, one or more additives;

Group 2 (Claim 17): plant-based food product comprising plant-derived cellulosic material, bleached plant material, isolate protein, tapioca starch, and various other additives;

Group 3 (Claim 18): plant-based food product comprising plant-derived cellulosic material, bleached plant material, isolate protein, and various other additives;

Group 4 (Claims 19-34): plant-based food product comprising bleached cellulose-based plant material, at least one cellulose material, at least one fatty acid group, at least one thickening/gelling agent, one or more additives;

Group 5 (Claim 35): bleached apple, bamboo fiber, konjac gum, omega 3, and various other additives;

Group 6 (Claim 36-42, 54): a plant-based white lines mimic comprising egg white and/or gelatin substitute, a vegetable oil, and a cellulose source;

Group 7 (Claims 43-51, 53): a plant-based yogurt comprising a cellulosic and/or nanocellulose material, and one or more food additives;

Group 8 (Claim 52): use of a bleached cellulose-based plant material for production of a plant-based seafood or meat product;

Group 9 (Claims 55-66): method of manufacturing a plant-based product comprising (a) mixing cellulose-based plant material, at least one gelling agent, and one or more additives (b) heating the mixture (c) adding calcium hydroxide (d) adding additional protein, and (e) wrapping and vacuum sealing the final mixture;

Group 10 (Claim 67-76): method of preparing a plant-based food product comprising (a) preparing a dry mixture comprising cellulose and protein, (b) preparing a wet mixture comprising a bleached cellulose-based plant material, oil, fatty acid and water, (c) mixing the wet mixture with any additional additives, (d) pouring the dry mixture into the wet mixture, (e) heating the final mixture, (f) adding one or more preservatives, (g) wrapping and sealing the final mixture;

Group 11 (Claims 77, 78): a method of making a vegan yogurt;

Group 12 (Claims 79-97): a plant-based food product comprising a dry cellulosic material, a texturized vegetable protein, a thickening/gelling agent, an additive;

Group 13 (Claims 98-110): a plant-based ice cream comprising a cellulosic material, at least one thickener/gel, a starch, a milk alternative, and a food additive;

Group 14 (Claims 111-122): a plant-based cheese comprising cellulosic material, plant-based texturizer, vegetable oil, an additive;

Group 15 (Claim 123): use of a plant-based cellulosic material to prepare a plant-based tuna formulation and plant-based dairy formulation.

Continued on following sheet

Continuation of Box III: Unity

The only common matter between all the groups is the use of a cellulosic material to prepare a plant-based food product. Groups 1-5 and 8 are further linked by the use of a bleached cellulosic material to prepare a plant-based food product. This feature is known from D1.

D1 discloses a vegan sashimi containing a bleached cellulosic material ("mercerized apple", para. 384) and several other ingredients. A person skilled in the art would understand that the mercerization process would involve bleaching unless otherwise explicitly indicated (paras. 236 and 266) and that the mercerization process is performed on decellularized apple (para. 234) which a person skilled in the art would recognize as a cellulosic material. See also para. 88.

There does not appear to be any technical relationship between the features of Groups 1 thru 15 that are not disclosed in D1, therefore there does not appear to be a single "special technical feature" as defined in PCT Rule 13.2. The groups include a variety of ingredients which may or may not include proteins, texturizers, or other additives.

Therefore, the claims of the present application define fifteen distinct "special technical features" over the prior art, and therefore define fifteen groups, each containing a distinct potentially inventive concept.

IPC:
A23L 11/50 (2021.01), ***A23L 19/00*** (2016.01), ***A23L 29/20*** (2016.01), ***A23L 29/262*** (2016.01), *A23L 13/00* (2016.01)

CPC:
A23L 29/212 (2016.08), A23L 29/262 (2016.08), A23L 13/00 (2016.08)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2024/051263

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO2023004515A1	02 February 2023 (02-02-2023)	AU2022320142A1	22 February 2024 (22-02-2024)
		CA3227241A1	02 February 2023 (02-02-2023)
		CN118139969A	04 June 2024 (04-06-2024)
		EP4377442A1	05 June 2024 (05-06-2024)
		IL310495A	01 March 2024 (01-03-2024)
		MX2024001419A	17 May 2024 (17-05-2024)
		US2024336895A1	10 October 2024 (10-10-2024)