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(54) Title: VEGAN MEAT ANALOGUE

(57) Abstract: The present invention relates to a vegan meat analogue comprising non-animal protein, kappa-carrageenan, konjac mannan, preferably cellulose fibres and water.

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VEGAN MEAT ANALOGUE

FIELD OF THE INVENTION

5 The present invention relates to a vegan meat analogue comprising non-animal protein, kappa-carrageenan, konjac mannan and water.

The invention also provides a method of preparing the aforementioned meat analogue. Further provided is a particulate binder system that is preferably free of methylcellulose and that
10 comprises kappa-carrageenan, konjac mannan and cellulose fibres.

BACKGROUND OF THE INVENTION

Meat is considered the highest quality protein source, not only due to its nutritional
15 characteristics, but also for its appreciated taste. Meat is nutritious because meat protein contains all essential amino acids for humans. In addition, meat comprises essential vitamins, such as vitamin B12, and is rich in minerals. Meat also contains fat tissue, which greatly contributes to food acceptability by imparting specific characteristics such as appearance, texture, and mouthfeel. The fat tissue also contributes to the properties of the meat as it is
20 prepared and cooked.

However, from a health point of view, an excessive intake of meat products cannot be recommended, especially because the fat tissue in meat contains cholesterol and a higher proportion of saturated fats.
25

Further, due to animal diseases such as mad cow disease, a global shortage of animal protein, growing consumer demand for religious (halal or kosher) food, and for economic reasons, there is an increased interest in the consumption of non-meat proteins by consuming meat analogues instead of actual meat products.
30

Meat analogues are prepared such that they resemble meat as much as possible in appearance, taste and texture. Meat analogues are typically prepared from proteinaceous fibres of non-animal origin. Proteinaceous fibres, such as texturised vegetable protein, are characterised by having an identifiable structure and a structural integrity, such that each unit
35 will withstand hydration, cooking and other procedures used in preparing the fibres for consumption.

Methylcellulose is commonly used as a binder in vegan meat analogues, often as a replacement for egg white. However, vegan meat analogues tend to have a low undesirable manufacturing efficiency.

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ADDITIONAL INFORMATION

US 4,427,704 describes a food product having a pH not higher than 8 comprising a gelled aqueous phase and at least one other food material, said gelled phase comprising 0.01 to 5 percent by weight of a mixture or reaction product of at least one glucomannan and at least one carrageenan in a ratio of glucomannan to carrageenan from 20:1 to 1:20.

CN 112655896 describes a binding composition for meat products comprising κ -carrageenan, konjac gum, and tetrapotassium pyrophosphate.

15

CN 101558890 describes a simulated fat comprising konjac flour and carrageenan in a weight ratio of 1: 0.3 to 0.45, ovalbumin, an antifoaming agent, an alkaline gelling agent and water.

WO 2022/038244 describes a salmon analogue comprising a first layer and a second layer, wherein the first layer comprises plant protein, a glucomannan source, a carrageenan source, a potassium salt, a sodium salt, and the second layer comprises an insoluble fiber source and a calcium salt.

WO 2022/229299 describes a composition of a dehydrated meat analogue product comprising:

- i) 40 to 85 wt.% of a textured protein;
- ii) 0.1 to 30 wt.% of a dietary fibre;
- iii) 1 to 20 wt.% of an un-textured plant protein;
- iv) 1 to 15 wt.% of a citrus fibre;
- v) 1 to 30 wt.% of a flavour;

wherein the dietary fibre is not a citrus fibre and has a water-holding capacity between 25 to 60 grams per gram of dietary fibre (dry weight of fibre) and a tan delta value between 0.2 to 0.7 at 20°C.

WO 2020/089445 describes a meat analogue product that is free from methylcellulose, which meat analogue product comprises e.g. potato protein and potato fiber.

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Research Disclosure "Ingredients Supporting Clean Label for Plant-based Meat analogs", Wong et al. (electronically published by ip.com on 18 September 2020) describes an investigation in which methylcellulose in meat analogues was replaced with a combination of pectin, citrus fibre, gellan gum, and curdlan gum.

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WO 2021/110760 describes a composition suitable for use in a plant-based food product comprising:

a) Carrageenan;

b) Cellulose ether;

10

c) Glucomannan;

d) Plant-based protein(s);

e) Starch;

f) Potassium chloride.

15

SUMMARY OF THE INVENTION

The inventors have developed a binder system that can suitably be used in vegan meat analogues. The binder system of the present invention comprises a combination of kappa-carrageenan, konjac mannan and preferably cellulose fibres (e.g. citrus fibre).

20

The inventors have found that the combined application of kappa-carrageenan and konjac mannan and optionally cellulose fibers in vegan meat analogues in the specified amounts yields a product that, after cooking, exhibits excellent juiciness without the mushiness and lack of firmness of known vegan meat analogues. Furthermore, vegan meat analogues containing this combination of hydrocolloids were found to have exceptionally high manufacturing efficiency. The meat analogues of the present invention are ideally suited for production on an industrial scale as, following heat treatment, the shaped meat analogues do not fall apart or change shape during cooling and transportation on a conveyor belt.

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30 The vegan meat analogues of the present invention have the unique property that they provide the desirable firmness expected of e.g. a burger when consumed hot (e.g. 55°C) and upon subsequent cooling to e.g. 19°C increases in firmness.

Accordingly, the present invention provides a vegan meat analogue that is preferably free of methylcellulose and that comprises kappa-carrageenan, konjac mannan, optionally cellulose fibers, and further:

35

- a) non-animal protein, preferably in an amount of 8-25 wt.% by weight of the meat analogue, preferably whereby at least 50 wt% of said protein is present in the form of pieces of texturised vegan protein;
- b) 0-20 wt.% of fat by weight of the meat analogue;
- 5 c) water preferably in an amount of 55-75 wt.% by weight of the meat analogue,
- d) whereby the combined amount of kappa-carrageenan, konjac mannan and, if used cellulose fibers, is present in an amount of 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue; whereby preferably said combined amount comprises
- 10 i) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
- ii) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan / (amount of konjac mannan + total moisture)); and
- 15 iii) preferably 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)).
- 20 The present invention further provides a vegan fowl or mammal meat analogue that is preferably free of methylcellulose and that comprises kappa-carrageenan, konjac mannan, optionally cellulose fibers, and further:
- a) non-animal protein, whereby at least 50 wt% of said protein is present in the form of pieces of texturised vegan protein;
- 25 b) 0-20 wt.% of fat by weight of the meat analogue;
- c) water preferably in an amount of 55-75 wt.% by weight of the meat analogue,
- d) whereby the combined amount of kappa-carrageenan, konjac mannan and, if used cellulose fibers, is present in an amount of 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue; whereby
- 30 preferably said combined amount comprises
- i) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
- ii) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue
- 35 whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan / (amount of konjac mannan + total moisture)); and

- iii) preferably 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)).

5

The present invention further provides a vegan meat analogue that is preferably free of methylcellulose and that comprises:

- a) 8-25 wt.% of non-animal protein by weight of the meat analogue;
- b) 0-20 wt.% of fat by weight of the meat analogue;
- 10 c) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
- d) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan /
15 (amount of konjac mannan + total moisture));
- e) preferably 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)); and
- f) 55-75 wt.% of water by weight of the meat analogue.

20

The present invention further provides a vegan meat analogue that is preferably free of methylcellulose, wherein the meat analogue is mammal or fowl meat analogue and that comprises:

- a) 8-25 wt.% of non-animal protein by weight of the meat analogue;
- 25 b) 0-20 wt.% of fat by weight of the meat analogue;
- c) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
- d) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan /
30 (amount of konjac mannan + total moisture));
- e) preferably 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)); and
- 35 f) 55-75 wt.% of water by weight of the meat analogue.

The present invention further provides a vegan meat analogue that is free of methylcellulose and that comprises:

- a) 8-25 wt.% of non-animal protein by weight of the meat analogue;
- b) 0-20 wt.% of fat by weight of the meat analogue;
- 5 c) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
- d) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan /
10 (amount of konjac mannan + total moisture));
- e) preferably 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)); and
- f) 55-75 wt.% of water by weight of the meat analogue;
- 15 whereby the kappa-carrageenan, konjac mannan and optional cellulose fibres are homogeneously dispersed throughout the meat analogue.

The invention further relates to a vegan meat analogue that is free of methylcellulose and that comprises:

- 20 a) 8.5-22 wt.% of non-animal protein by weight of the meat analogue;
- b) 1-18 wt.% of fat by weight of the meat analogue;
- c) 0.8-2.2 wt.% of kappa-carrageenan wt.%, based on the water content of the meat analogue;
- d) 0.2-2.5 wt.%, preferably 1.0-2.0 wt.% of konjac mannan, based on the water content of the
25 meat analogue;
- e) 3-14 wt.% of cellulose fibres, based on the water content of the meat analogue; and
- f) 58-72 wt.% of water by weight of the meat analogue.

The invention further relates to a vegan meat analogue that is free of methylcellulose and that
30 comprises:

- a) 9.0-18 wt.% of non-animal protein by weight of the meat analogue;
- b) 3-12 wt.% of fat by weight of the meat analogue;
- c) 1.0-2.0 wt.% of kappa-carrageenan wt.%, based on the water content of the meat analogue;
- 35 d) 0.2-2.5 wt.%, preferably 1.0-2.0 wt.% of konjac mannan, based on the water content of the meat analogue;
- e) 4-12 wt.% of cellulose fibres, based on the water content of the meat analogue; and

f) 60-70 wt.% of water by weight of the meat analogue.

The invention further relates to a vegan meat analogue that is free of methylcellulose and that comprises:

- 5 a) non-animal protein;
b) fat;

a combined amount of kappa-carrageenan, konjac mannan and cellulose fibers of 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue.

10

The invention also provides a vegan meat analogue comprising, non-animal protein, fat, kappa-carrageenan, konjac mannan and optionally cellulose fibres, said vegan meat analogue having a cooking yield of more than 90%, preferably more than 95% whereby the cooking yield is determined after cooking the meat analogue shaped as burgers (diameter = 42 mm, height of 21mm, weight 27 g) in a steam oven at 100 °C with 100% steam for 8 min using the following equation.

15

$$\text{Cooking yield (\%)} = \frac{\text{cooked weight (g)}}{\text{raw weight (g)}} * 100$$

The invention also relates to a method of preparing the vegan meat analogue of the present invention, said method comprising:

20

- a) providing a hydrated source of non-animal protein;
b) combining the hydrated source of non-animal protein with kappa-carrageenan, konjac mannan, if used cellulose fibres, water and any remaining ingredients to form a meat analogue dough;
25 c) shaping said meat analogue dough;
d) heating said shaped meat analogue to at least 70°C to form a meat analogue.
e) optionally coating said shaped meat analogue with a crispy coating;
preferably whereby the heated meat analogue is solid at a temperature of at least 60°C;

25

The invention further relates to a method of preparing the vegan meat analogue of the present invention, the method comprising:

30

- a) providing hydrated pieces of texturised vegan protein having a water content of 50-85 wt.% and comprising, calculated by weight of dry matter, 65-88 wt.% of plant protein;
b) combining the hydrated texturised vegan protein with kappa-carrageenan, konjac mannan,
35 cellulose fibres, water and any remaining ingredients to form a meat analogue dough;
c) shaping said meat analogue dough;

35

- d) heating said shaped meat analogue to 75 to 105 °C to form a meat analogue;
wherein kappa-carrageenan and konjac mannan are applied in a weight ratio of 1:2 to 3:1 and
wherein kappa-carrageenan and cellulose fibres are applied in a weight ratio of 1:3 to 2:1;
e) optionally coating said shaped meat analogue with a crispy coating;
5 preferably whereby the heated meat analogue is solid at a temperature of at least 75°C;

The invention also relates to a particulate binder system that is free of methylcellulose and
10 that comprises, by weight of the particulate binder system :

- a) 5-50 wt.% of kappa-carrageenan by weight of the particulate binder system;
b) 4-40 wt.% of konjac mannan;
c) 10-80 wt.% of cellulose fibres;

wherein the combination of kappa-carrageenan, konjac mannan and cellulose fibres
15 constitutes at least 30 wt.% of the binder system;

wherein kappa-carrageenan and konjac mannan are present in a weight ratio of 1:2 to 3:1;
and

wherein kappa-carrageenan and cellulose fibres are present in a weight ratio of 1:3 to 2:1.

20 DETAILED DESCRIPTION OF THE INVENTION

The terms “a” and “an” and “the” and similar referents as used herein refer to both the singular
and the plural, unless otherwise indicated herein or clearly contradicted by context.

25 Throughout this specification and the claims which follow, unless the context requires
otherwise, the word “comprise” and variations such as “comprises” or “comprising” will be
understood to imply the inclusion of a stated integer or step or group of integers or steps but
not the exclusion of any other integer or step or group of integers or steps.

30 The amount of ingredients of the meat analogue are expressed as wt% by weight of the meat
analogue, unless indicated otherwise or clear from the context. The applies mutatis mutandis
for the ingredients of particulate binder system which are by weight of the particulate binder
system.

35 Whenever reference is made herein to a concentration based on the water content of the meat
analogue, unless indicated otherwise, what is meant is the concentration of a component or a

combination of components that is calculated on the basis of the total water content of the meat analogue as follows:

total amount of component(s) / (total amount of water + total amount of components(s));

wherein the total amount of component(s) and the total amount of water are expressed in the

5 same unit of mass and wherein the calculated concentration is expressed in weight percentage (wt.%). The terms "total water content", "total amount of water", "total moisture" are used interchangeably in the concentration calculations above and are understood to refer to the water content of the meat analogue including H₂O added as such and H₂O present in other ingredients used the meat analogue. The terms "total water content", "total amount of
10 water" " and total moisture" as used herein refer to the amount of moisture in the meat analogue as measured in an analytical method calculated as percentage change in mass following the evaporation of water from a sample. Moisture content measurement is routinely carried out by commercial laboratories like Eurofins in Europe. One preferred test method is moisture content measurement according to ISO 1442 at 103°C.

15

Numerical ranges expressed in the format "from x to y" are understood to include x and y.

Whenever components A and B are said to be present in a weight ratio of x:y, what is meant
20 is that the concentration of component A in wt.% divided by the concentration of component B in wt.% equals x:y.

Concentrations expressed by weight of dry matter, as mentioned herein, refer to the amount of dry ingredient present in a composition as a percentage of the total amount of dry matter
25 contained in the same composition.

Ratios mentioned herein are based on weight/weight, unless indicated otherwise. Similarly, all percentages are percentages by weight (w/w) unless otherwise indicated.

30 When multiple preferred ranges are described in the format "from x to y" for a specific feature, it should be understood that all ranges combining the different endpoints are also contemplated.

If, for a particular component, a range of 0% to y% or less than y% is recited, said ingredient
35 may be absent.

The term "meat analogue", as used herein, refers to an edible product that does not contain animal meat but is designed to have the flavour, appearance, mouthfeel of animal meat. Examples include burgers, sausages, nuggets, schnitzels etc. If the meat analogue is coated such as a nugget or schnitzel, the term "meat analogue" is understood to refer to the composition without the coating.

The term "vegan", as used herein, in relation to a product or an ingredient, refers to a product or an ingredient that has not been derived from animals. Meat, eggs and dairy products are examples of products that are not vegan.

The term "non-animal protein" as used herein refers to protein from a non-animal source like a plant protein, a fungal protein, a microbial protein, algae protein. It excludes protein from mammals, fish, crustacean, birds.

The term "texturised vegan protein" or "TVP" as used herein refers to proteinaceous fibrous material that is produced by cooking an aqueous mixture of water, vegan protein concentrate (optionally vegan protein isolates) and optionally other ingredients in an extruder cooker and extruding the mixture. The extruded material is hydrated and can be used without further hydration as hydrated non-animal protein or hydrated TVP. After extrusion the TVP may also be cut in chunks and dried. Typical examples of dried TVP include Response™ TVP's from Solae (US), and Arcon™ TVP's from ADM (US). Such dry irregular chunks are generally hydrated in the process of preparing a meat analogue. Some or all of the hydrated TVP may also be cut or ground for use in a meat analogue in e.g., meat grinder with a plate having 5 mm apertures. The term pieces in this context encompasses both chunks before and after comminution.

The term "fat" as used herein, refers to glycerides selected from triglycerides, diglycerides, monoglycerides, phosphoglycerides and combinations thereof. The term "fat" encompasses fats that are liquid at 20 °C and fats that are solid or semi-solid at 20 °C. The melting point of a fat can be determined according to ISO 6321 (2021).

The term "konjac mannan", as used herein, refers to the glucomannan that is present in konjac gum. Konjac mannan is a heteropolysaccharide comprising β -D-glucose and β -D-mannose

The term "cellulose fibres", as used herein, refers to fibres comprising very fine fibrils consisting primarily of cellulose. Examples of cellulose fibres include oat fibre, citrus fibre,

potato fibre, bamboo fibre and wheat fibre. The term 'cellulose fibres' excludes methylcellulose.

The term "cooking yield" as used herein can be determined as disclosed in the experimental section.

The vegan meat analogue

Preferably, the meat analogue according to the invention comprises non-animal protein, kappa-carrageenan, konjac mannan, preferably cellulose fibres and water.

The meat analogue according to the present invention preferably is designed to be a analogue of mammal or fowl meat. Preferred mammal meat includes beef, porc, lamb and combinations thereof. Fowl meat includes chicken, turkey and combinations thereof. The meat analogue according to the present invention preferably is not a sea food analogue like fish analogue, squid analogue, crustacean analogue or shell-fish analogue. The meat analogue according to the present invention preferably is not a salmon analogue.

The meat analogue according to the invention is normally and preferably to be heated before consumption by the user in any conventional cooking method such a pan, oven, deep frying in oil, steaming etc. The inventive meat analogue should preferably be able to be heated to a core temperature at least 80°C for 5 sec without melting. Preferably, the meat analogue according to the present invention is solid at temperatures of at least 50°C, preferably at least 60°C, more preferably at least 75°C.

In case the meat analogue of the present invention comprises separate layers of different composition, it is preferred that at least one of said separate layers contains kappa-carrageenan, konjac mannan and cellulose fibres. More preferably, at least one of said separate layers contains by weight of said at least one separate layer at least 0.1 wt.% of kappa-carragenan, at least 0.1 wt.% of konjac mannan and at least 0.5 wt.% of cellulose fibres. Even more preferably, at least one of said separate layers contains by weight of said at least one separate layer at least 0.5 wt.% of kappa-carrageenan; at least 0.2 wt.%, of konjac mannan; and at least 2 wt.% of cellulose fibres.

Preferably, the meat analogue of the present invention does not comprise one or more separate layers comprising at least 80 wt.% insoluble fiber and at least 5 wt.% calcium salt selected from calcium carbonate, calcium sulphate, calcium phosphate, tricalcium citrate and combinations thereof. Even more preferably, the meat analogue does not comprise one or more separate layers comprising at least 30 wt.% insoluble fibre.

Preferably, the meat analogue of the present invention does not comprise one or more separate layers containing at least 80 wt.% insoluble fibre and at least 1 wt.% calcium salt selected from calcium carbonate, calcium sulphate, calcium phosphate, tricalcium citrate and combinations thereof.

The total water content of the meat analogue is preferably in the range of 55-75 wt.%, more preferably 58-72 wt.%, more preferably in the range of 60-70 wt.%. The vegan meat analogue of the present invention may be provided in different shapes. Examples of meat analogues encompassed by the present invention include patties, balls, nuggets and sausages. These may have a crispy coating like a nugget or schnitzel. The terms "crispy coating" and "coating" as used herein are understood to mean a layer of coating, which will be at least crunchy or crispy after cooking, frying or

baking. Coated meat analogues and real meat products are known in the art such as fried (chicken) nuggets and schnitzels and may also be referred to as battered meat analogues. Any suitable type of coating known in the art may be used. Usually such coating is starch based e.g. flour, cornflakes. If the meat analogue is coated such as a nugget or schnitzel, the term "meat analogue" is understood to refer to the meat analogue composition without the coating.

Non-animal protein

The non-animal protein in the meat analogue is preferably selected from legume protein, cereal protein, oilseed protein, sesame protein, algae protein, fungal protein, microbial and combinations thereof. More preferably, the non-animal protein is selected from legume protein, cereal protein, oilseed protein and combinations thereof. Even more preferably, the non-animal protein is selected from legume protein, cereal protein and combinations thereof. Examples of legume proteins that may be used include soy protein, pea protein, lupin protein, mung bean protein, faba bean protein, lentil protein, chickpea protein and combinations thereof.

The meat analogue preferably comprises at least 8.5 wt.% of non-animal protein, preferably at least 8.8 wt.% of non-animal protein, preferably at least 9.0 wt.% of non-animal protein, most preferably, the meat analogue comprises at least 11wt.% of non-animal protein.

Preferably, the meat analogue comprises at most 25 wt.%, more preferably at most 22 wt.% of non-animal protein, preferably at most 20 wt.% of non-animal protein, most preferably the meat analogue comprises at most 18 wt.% of animal protein.

- 5 Non-animal protein is preferably contained in the meat analogue in a concentration of 8.5-22 wt.%, more preferably of 8.8-20 wt.%, even more preferably 9 to 18 wt.% and most preferably of 11 -25 wt.%.

10 Preferably in the present invention, at least 50 wt.%, preferably at least 80 wt.%, more preferably at least 90 wt.% of the non-animal protein that is contained in the meat analogue is provided by pieces of texturized vegan protein (TVP). Said pieces of TVP may also be ground before use. Said pieces of TVP may also be ground or cut before use in the process of preparing the meat analogue. For the avoidance of doubt the term "pieces" in this context encompasses both the TVP before and after comminution. Unexpectedly it was found that
15 using these amounts of TVP, the structure of the meat analogues even further resembled the mouthfeel of e.g. real mammal and fowl meat .

The meat analogue of the present invention preferably comprises, calculated by weight of dry matter, 30-65 wt.%, more preferably 35-50 wt.% of pieces of texturised vegan protein (TVP).
20

The pieces of TVP preferably have a water content of 40-90 wt.%, more preferably 50-85 wt.% and most preferably 55-75 wt.%.

The fat content of the pieces of TVP, calculated by weight of dry matter, is preferably in the range of 0-10 wt.%, more preferably in the range of 0-6 wt.% and most preferably in the range of 0-4 wt.%.
25

The pieces of TVP present in the meat analogue, calculated by weight of dry matter, preferably contain 0-15 wt.%, more preferably 0.5-12 wt.% and most preferably 1-10 wt.% of dietary fibre.
30

The pieces of TVP in the meat analogue of the present invention typically contain, calculated by weight of dry matter, 50-90 wt.%, more preferably 65-88 wt.% and most preferably 70-86 wt.% of plant protein. The plant protein preferably is selected from legume protein, cereal protein, oilseed protein and combinations thereof. More preferably, the plant protein is selected from legume protein, cereal protein and combinations thereof. Examples of legume
35 proteins that may be used include soy protein, pea protein, lupin protein, mung bean protein,

faba bean protein, lentil protein, chickpea protein and combinations thereof. Gluten is an example of cereal protein that may be contained in the pieces of TVP.

According to a particularly preferred embodiment, at least 50 wt.%, more preferably at least 80 wt.% and most preferably at least 90 wt.% of the plant protein that is present in the pieces of TVP is soy protein.

Binders

The binders of the present invention comprises a combination of kappa-carrageenan, konjac mannan and preferably cellulose fibres (e.g. citrus fibre).

Preferably, the combination of kappa-carrageenan and konjac mannan constitutes at least 0.8 wt.%, more preferably at least 1.0 wt.%, even more preferably at least 1.5 wt.%, most preferably at least 2.0 wt.% of the meat analogue, based on the water content of the meat analogue.

The combination of kappa-carrageenan and konjac mannan preferably constitutes at most 4.4 wt.%, more preferably at most 4.2 wt.%, even more preferably at most 4.1 wt.%, most preferably at most 4.0 wt.% of the meat analogue, based on the water content of the meat analogue.

The combination of kappa-carrageenan and konjac mannan is preferably contained in the meat analogue in a concentration of 0.8-4.4 wt.%, more preferably of 1.0-4.2 wt.%, even more preferably of 1.5-4.1 wt.% and most preferably of 2.0-4.0 wt.%, based on the water content of the meat analogue.

The weight ratio of kappa-carrageenan and konjac mannan in the meat analogue is preferably from 1:4 to 12:1, more preferably from 1:3 to 9:1, even more preferably from 1:2.5 to 6:1, most preferably from 1:2 to 3:1.

Preferably, the meat analogue comprises at least 0.6 wt.%, more preferably at least 0.8 wt.%, most preferably, at least 1.0 wt.% kappa-carrageenan, based on the water content of the meat analogue.

The meat analogue comprises preferably at most 2.4 wt.%, more preferably at most 2.2 wt.%, most preferably at most 2.0 wt.% kappa-carrageenan, based on the water content of the meat analogue.

Kappa-carrageenan is preferably contained in the meat analogue in a concentration of 0.6-2.4 wt.%, more preferably of 0.8-2.2 wt.%, most preferably of 1.0-2.0 wt.%, based on the water content of the meat analogue.

5

Preferably, the meat analogue according to the invention comprises potassium cations in a concentration of at least 0.1 mmol per kg of the total amount of water that is contained in the meat analogue. More preferably the meat analogue comprises potassium cations in a concentration of 0.5-1,200 mmol per kg of the total amount of water that is contained in the meat analogue. Most preferably the meat analogue comprises potassium cations in a concentration of 1.0-500 mmol per kg of the total amount of water that is contained in the meat analogue.

10

Potassium cations are preferably contained in the meat analogue in a concentration of at least 25 mmol per kg of kappa carrageenan, more preferably in a concentration of 50-25,000 mmol per kg of kappa carrageenan and most preferably in a concentration of 200-10,000 mmol per kg of kappa carrageenan.

15

Preferably, the meat analogue comprises at least 0.4 wt.%, more preferably at least 0.7 wt.%, most preferably at least 1.0 wt.% konjac mannan, based on the water content of the meat analogue.

20

The meat analogue comprises preferably at most 2.3 wt.%, more preferably at most 2.1 wt.%, most preferably at most 2.0 wt.% konjac mannan, based on the water content of the meat analogue.

25

Konjac mannan is preferably contained in the meat analogue in a concentration of 0.4-2.3 wt.%, more preferably of 0.7-2.1 wt.%, most preferably of 1.0-2.0 wt.%, based on the water content of the meat analogue.

30

The inventors have found that the inclusion of cellulose fibres increases the firmness and cohesiveness of the meat analogue at high temperatures, thereby rendering the meat analogue more robust. Thus, according to a particularly preferred embodiment, the meat analogue comprises at least 2.0 wt.%, more preferably at least 3.0 wt.%, most preferably at least 4.0 wt.% cellulose fibres, based on the water content of the meat analogue.

35

The meat analogue preferably comprises at most 18 wt.%, more preferably at most 14 wt.%, most preferably at most 12 wt.% cellulose fibres, based on the water content of the meat analogue.

- 5 Cellulose fibres are preferably contained in the meat analogue in a concentration of 2.0-18 wt.%, more preferably of 3.0-14 wt.%, most preferably of 4.0-12 wt.%, based on the water content of the meat analogue.

10 The cellulose fibres used in accordance with the present invention is preferably sourced from citrus, cereal and/or sugar beet. More preferably, the cellulose fibres are sourced from citrus and/or cereal. Most preferably, the cellulose fibres are sourced from citrus and/or oat.

15 In a preferred embodiment, the meat analogue contains 1-8 wt.% , more preferably 2-7 wt.% cellulose fibres sourced from citrus, based on the water content of the meat analogue.

According to particularly preferred embodiment, the meat analogue comprises a combination of cellulose fibre sourced from citrus and cellulose fibre sourced from cereal, especially oat. Cellulose fibre sourced from cereal is preferably contained in the meat analogue in a concentration of 1-8 wt.%, more preferably of 2-7 wt.%, based on the water content of the meat analogue.

20

Preferably, the combination of kappa-carrageenan, konjac mannan and the optional cellulose fibres is present in a concentration of at least 3 wt.%, more preferably of at least 4 wt.%, even more preferably of at least 6 wt.%, most preferably of at least 8 wt.%, based on the water content of the meat analogue.

25

The combination of kappa-carrageenan, konjac mannan and the optional cellulose fibers preferably constitutes at most 20 wt.%, more preferably at most 18 wt.%, even more preferably at most 16 wt.%, most preferably at most 14 wt.%, based on the water content of the meat analogue.

30

The combination of kappa-carrageenan, konjac mannan and the optional cellulose fibres is preferably contained in the meat analogue in a concentration of 3-20 wt.%, more preferably of 4-18 wt.%, even more preferably of 6-16 wt.% and most preferably of 8-14 wt.%, based on the water content of the meat analogue.

35

The combination non-animal protein, kappa-carrageenan, konjac mannan and the optional cellulose fibres, fat and water preferably constitutes at least 70 wt.%, more preferably at least 80 wt.% and most preferably at least 85 wt.% of the meat analogue.

5 Without wishing to be bound by theory, it is hypothesized that the combination of kappa-carrageenan, konjac mannan and the optional cellulose fibres functions as a binder resulting in a 3D network holding e.g. the TVP and other ingredients together, thus providing coherence and firmness to the meat analogue.

10 In addition to the binder system the meat analogue may contain a fat mimetic. A fat mimetic - also described as fat analogue, fat replica, fat simule and other synonyms - is known in the art of meat analogues. The term "fat mimetic" as used herein refers to a hydrocolloid composition which aims to mimic the appearance of discrete parts of fat in a meat analogue. The hydrocolloids in such a fat mimetic bind the ingredients in the fat mimetic but not other
15 ingredients of the meat analogue as the fat mimetic is added as a separate part or gelled particle to the meat phase.

If a fat mimetic is present, the meat analogue preferably contains kappa-carrageenan in a concentration of at least 0.5 wt.% and konjac mannan in a concentration of at least 0.2 wt.%,
20 both concentrations being calculated as a percentage by weight of the amount of water that equals the total amount of water that is contained in the meat analogue minus the total amount of water that is contained in the fat mimetic. More preferably, if a fat mimetic is present, the meat analogue preferably contains kappa-carrageenan in a concentration of at least 1.0 wt.% and konjac mannan in a concentration of at least 1.0 wt.%, both concentrations being
25 calculated as a percentage by weight of the amount of water that equals the total amount of water that is contained in the meat analogue minus the total amount of water that is contained in the fat mimetic

In case the meat analogue contains a fat mimetic, said fat mimetic preferably contains, by
30 weight of the water that is contained in said fat mimetic, less than 0.5 wt.% kappa-carrageenan or less than 0.2 wt.% konjac mannan. More preferably, in case the meat analogue contains a fat mimetic, said fat mimetic preferably contains, by weight of the water that is contained in said fat mimetic, less than 0.5 wt.% kappa-carrageenan and less than 0.2 wt.% konjac mannan. Most preferably, in case the meat analogue contains a fat mimetic, said fat mimetic
35 preferably contains, by weight of the water that is contained in said fat mimetic, less than 0.1 wt.% kappa-carrageenan and less than 0.1 wt.% konjac mannan.

Fat

The fat component of the meat analogue preferably has a low content of saturated fatty acids. Preferably the fat contains 0-40 wt.%, more preferably less than 30 wt.% and most preferably less than 20 wt.% saturated fatty acids, calculated by weight of the total amount of fatty acids contained in the fat.

The fat preferably contains at least 80 wt.%, more preferably at least 90 wt.% of an oil that is liquid at 20°C. Examples of such liquid oils include linseed oil, castor oil, sunflower oil, soybean oil, rapeseed oil, cottonseed oil, safflower oil, flaxseed oil, rice bran oil, olive oil, tung oil, cotton seed oil, peanut oil, algal oil and mixtures thereof.

The meat analogue preferably comprises 1-18 wt.%, more preferably 2-15 wt.% of fat, more preferably 3-12 wt.% of fat. Preferably the meat analogue contains 0-20 wt.%, more preferably 0 to 10 wt.% and most preferably 0 to 4 wt.% saturated fatty acids, calculated by weight of the meat analogue.

Additional ingredients

The meat analogue of the present invention may comprise additional ingredients besides the ones discussed above. Examples of such additional ingredients include fat mimetic, gelling agents, thickeners, emulsifiers, acidulants, preservatives, colouring, flavouring, dietary fibres, vitamins and minerals.

The meat analogue, according to the invention, preferably comprises flavouring, more preferably 0.05 to 6 wt.%, most preferably 0.1-4 wt.% of flavouring. The flavouring may suitably comprise yeast extract, hydrolysed vegetable protein, aroma compounds and combinations thereof.

Preferably, the flavouring employed in the meat analogue contains at least 0.05 wt.%, more preferably 0.1-3 wt.% of yeast extract, hydrolysed vegetable protein or a combination thereof.

The meat analogue may suitably further comprises a thickener and/or gelling agent. Preferably, the thickener and/or gelling agent are selected from corn starch, potato starch, rice starch and wheat starch and combinations thereof.

The meat analogue preferably has a pH of 5 to 6.5, more preferably a pH 5.2 to 5.8.

The meat analogue of the present invention preferably has a firmness of 30 to 95 kPa, more preferably of 65 to 85 kPa. The firmness of the meat analogue can suitably be determined by the method that is described in Example 1.

5

In addition to the binder system the meat analogue may contain a fat mimetic. A fat mimetic - also described as fat analogue, fat replica, fat simule and other synonyms - is known in the art of meat analogues. The term "fat mimetic" as used herein refers to a hydrocolloid composition which aims to mimic the appearance of discrete parts of fat in a meat analogue. The hydrocolloids in such a fat mimetic bind the ingredients in the fat mimetic but not other ingredients of the meat analogue as the fat mimetic is added as a separate part or gelled particle to the meat phase.

10

If a fat mimetic is present and said fat mimetic comprises kappa-carrageen and konjac mannan, preferably those amounts of kappa-carrageen and konjac mannan are not part of the above cited amounts of kappa-carrageen and konjac mannan.

15

If a fat mimetic is present, the meat analogue preferably contains kappa-carrageenan in a concentration of at least 0.5 wt.% and konjac mannan in a concentration of at least 0.2 wt.%, both concentrations being calculated as a percentage by weight of the amount of water that equals the total amount of water that is contained in the meat analogue minus the total amount of water that is contained in the fat mimetic. More preferably, if a fat mimetic is present, the meat analogue preferably contains kappa-carrageenan in a concentration of at least 1.0 wt.% and konjac mannan in a concentration of at least 1.0 wt.%, both concentrations being calculated as a percentage by weight of the amount of water that equals the total amount of water that is contained in the meat analogue minus the total amount of water that is contained in the fat mimetic

20

25

In case the meat analogue contains a fat mimetic, said fat mimetic preferably contains, by weight of the water that is contained in said fat mimetic, less than 0.5 wt.% kappa-carrageenan or less than 0.2 wt.% konjac mannan. More preferably, in case the meat analogue contains a fat mimetic, said fat mimetic preferably contains, by weight of the water that is contained in said fat mimetic, less than 0.5 wt.% kappa-carrageenan and less than 0.2 wt.% konjac mannan. Most preferably, in case the meat analogue contains a fat mimetic, said fat mimetic preferably contains, by weight of the water that is contained in said fat mimetic, less than 0.1 wt.% kappa-carrageenan and less than 0.1 wt.% konjac mannan.

30

35

The meat analogue is preferably provided as a packaged product. Preferably, it is packaged under a modified atmosphere. Preferably, the modified atmosphere has an oxygen content of less than 10 vol%, more preferably of less than 5%.

5

According to a particularly preferred embodiment, the meat analogue is free of cellulose ethers.

Method of preparing the meat analogue

10 Another aspect of the invention relates to a method of preparing the meat analogue as described herein before, said method comprising:

f) providing a hydrated source of non-animal protein;
g) combining the hydrated source of non-animal protein with kappa-carrageenan, konjac mannan, preferably fibres, water and remaining ingredients to form a meat analogue
15 dough;

h) shaping said meat analogue dough;

i) heating said shaped meat analogue to at least 70°C to form a meat analogue;

j) optionally coating said shaped meat analogue with a crispy coating;

preferably whereby the heated meat analogue is solid at a temperature of at least 60°C;

20

Surprisingly, it was found that the present invention provides a further advantage for efficient large scale manufacturing. In factories, production time needs to be minimised to increase efficiency of the production process. Avoid prolonged cooling steps saves time and energy if active cooling is involved.

25 After the heating step needed to form said meat analogue, said meat analogue is preferably solid at temperatures of at least 50°C, preferably at least 60°C, more preferably at least 75°C. It was found that, preferably, the inventive preparation method and inventive meat analogue does not need to be cooled for a prolonged period or with active cooling. Instead, the present invention preferably allows transportation of the heated meat analogue, e.g. burgers or
30 nuggets, after the heating step e.g. with a conveyer belt without the movements harming the integrity of the meat analogue, e.g. burgers or nuggets. The term "solid" in the context of the present invention is understood to mean that the meat analogue can be picked up by hand without breaking.

35 Examples of remaining ingredients that may be employed include fat mimetic, emulsifiers, acidulants, preservatives, colouring, flavouring, dietary fibres, vitamins and minerals.

Preferably, the source of non-animal protein are hydrated pieces of texturised vegan protein as described herein before.

5 Kappa-carrageenan and konjac mannan are preferably applied in the meat analogue dough in a weight ratio of 1:2 to 3:1.

Kappa-carrageenan and cellulose fibres are preferably applied in the meat analogue dough in a weight ratio of 1:3 to 2:1.

10 According to a particularly preferred embodiment, besides kappa-carrageenan and konjac mannan, cellulose fibres are applied in the meat analogue dough.

The meat analogue dough that is produced in the course of the present method preferably has a viscosity of 4 to 25 kg, preferably of 6 to 20 kg, more preferably of 7.5 to 15 kg. The
15 viscosity of the meat analogue dough is suitably determined by the method that is described in Example 1.

In the present method the shaped meat analogue is preferably heated to a temperature of 75 to 105 °C.
20

Particulate binder system

A further aspect of the invention relates to a particulate binder system comprising:

- a) 5-50 wt.% of kappa-carrageenan;
 - b) 4-40 wt.% of konjac mannan;
 - 25 c) 10-80 wt.% of cellulose fibres;
- wherein the combination of kappa-carrageenan, konjac mannan and cellulose fibres constitutes at least 30 wt.% of the binder system;
wherein kappa-carrageenan and konjac mannan are present in a weight ratio of 1:2 to 3:1;
wherein kappa-carrageenan and cellulose fibres are present in a weight ratio of 1:3 to 2:1.

30 Preferably, the particulate binder system comprises at least 7 wt.%, more preferably at least 8 wt.%, most preferably at least 9 wt.% kappa-carrageenan.

The particulate binder system preferably comprises at most 50 wt.%, more preferably at most
35 40 wt.%, most preferably at most 30 wt.% kappa-carrageenan.

The particulate binder system preferably comprises at least 5 wt.%, more preferably at least 6 wt.%, most preferably at least 7 wt.% konjac mannan.

5 Preferably, the particulate binder system comprises at most 40 wt.%, more preferably at most 30 wt.%, most preferably at most 25 wt.% konjac mannan.

The particulate binder system preferably comprises at least 20 wt.%, more preferably at least 25 wt.%, even more preferably 30 wt.%, most preferably at least 40 wt.% cellulose fibres.

10 Preferably, the particulate binder system comprises at most 80 wt.%, more preferably at most 77.5 wt.%, most preferably at most 75 wt.% cellulose fibres.

15 The cellulose fibres comprised in the particulate binder system is preferably sourced from citrus, cereal and/or sugar beet. More preferably, the cellulose fibres are sourced from citrus and/or cereal. Most preferably, the cellulose fibres are sourced from citrus and/or oat.

In a preferred embodiment, the combination of kappa-carrageenan, konjac mannan and cellulose fibres constitutes at least 30 wt.% of the binder system, more preferably at least 40 wt.%, most preferably at least 50 wt.% of the particulate binder system.

20

The weight ratio of kappa-carrageenan and konjac mannan in the particulate binder system is preferably from 1:4 to 12:1, more preferably from 1:3 to 9:1, even more preferably from 1:2.5 to 6:1, most preferably from 1:2 to 3:1.

25 The weight ratio of kappa-carrageenan and cellulose fibres in the particulate binder system is preferably from 1:16 to 5:1, more preferably from 1:12 to 4:1, even more preferably from 1:8 to 3:1, most preferably from 1:3 to 2:1.

30 According to a particularly preferred embodiment, the particulate binder system is free of cellulose ethers.

Yet another aspect of the invention relates to the use of the particulate binder system as described herein before in the preparation of a meat analogue.

35 Preferably, the particulate binder system is applied in the meat analogue in a concentration of 2-10 wt.%, more preferably 3-9 wt.% and most preferably 4-8 wt.%, calculated by weight of the final product.

EXAMPLES

All ingredients used in the experiments described below were sourced in Europe, US and China.

5 Example 1 Burgers

Meat analogues in the form of burgers were prepared on the basis of the recipes shown in Table 1.

Table 1

Ingredient (wt%)	Sample		
	A	1	2
Texturised vegan protein ¹	15.75	14.92	13.79
Total water	67.13	67.30	65.80
Methylcellulose	1.74	0	0
Kappa-carrageenan ²	0	1.25	1.25
KCl	0	0.04	0.04
Konjac gum ³	0	1.25	0.75
Citrus fibre ⁴	0	4.00	4.00
Oat fibre ⁵	3.48	0	4.00
Waxy corn starch	0.93	0.88	0.81
Sunflower oil	6.06	5.74	5.31
Flavouring and preservatives	4.91	4.66	4.29
Total	100	100	100
Dough pH	5.6	5.5	5.5

- 10 ^{1.} Soy based, protein content ≥ 60 wt.%, $\leq$ Fiber 3.5 moisture content ≤ 12 wt.%, fat ≤ 1 wt. % Wilfib 706Z (Wilmar CN)
- ^{2.} WELCO Gelform 1263, Welding GmbH & Co. KG, Germany, (kappa-carrageenan preparation made from natural strains of Eucheuma seaweed containing E508 and maltodextrin for standardisation)
- 15 ^{3.} Contains 88 wt.% glucomannan
- ^{4.} Herbacel AQ Plus Citrus, Herbafood Ingredients GmbH
- ^{5.} Vitacel HF 200 Oat Fiber, JRS J. Rettenmaier & Söhne GmbH

The burgers were prepared as follows:

- 20 1. Texturised Vegan Protein (TVP) was mixed with chilled water (4 °C) and left to pre-hydrate for 10 minutes.
2. The hydrated TVP was subsequently ground using a Kenwood® grinder using a plate with 5 mm-sized holes.
3. The ground TVP was mixed for 30 sec in a Kenwood® kitchen mixer on speed setting 1.
- 25 This was followed by 30 sec mixing at the same speed after adding a powder mix

containing the flavours, preservatives, binders (methylcellulose, kappa-carrageenan, konjac gum), and fibres (oat fibre, citrus fibre).

4. Following the dry mix, the remainder of the water was added for 60 sec at speed setting.

5. Lastly, sunflower oil was mixed into the dough at speed setting 2 for 30 sec.

5 6. The resulting dough was cooled down to 2 °C in a freezer at -20 °C, before forming it into miniburgers (diameter = 42 mm, height of 21mm, weight 27 g) using a burger press.

The viscosity of the dough obtained in step 6 was determined at 20 °C by measuring the force (kg) required for extruding the dough through a 15 mm hole, using a forward extrusion utility (Stable Micro Systems, United Kingdom, Godalming) mounted onto a texture analyser. The dough was loaded up to 4 cm in the column and air pockets were removed as much as possible using a spoon. The extrusion continued for 30 sec at 1.0 mm/s. After reaching a plateau value in force, the mean force over 10 sec was extracted using Exponent software. The measurement was performed in triplicate at room temperature.

The dough of the samples according to the invention could be easily processed and shaped into a desirable form like a nugget or burger at large scale.

Example 2

20 The burgers of Example 1 were prepared for evaluation and analysis by first pre-cooking the burgers in a steam oven (Metos BV, The Netherlands, Deventer) steam oven at 100 °C with 100% steam for 8 min. The core temperature was checked using a core thermometer (VWR, United States, Radnor) to be at least 80 °C. These samples were frozen at -18 °C for storage or used as precooked samples for measurement. The stored samples were baked directly from the freezer in a steam oven at 130 °C at 100% steam for 10 min to deliver ready-to-eat samples.

The firmness of the burgers after the final baking step preparation, was determined by Texture Profile Analysis (TPA), using a texture analyser (Stable Micro Systems, United Kingdom, Godalming) that was placed in a thermal cabinet. A load cell of 50 kg was used, and the texture analyser was calibrated each day of measurement using a 5 kg weight. A square compression probe of 4900 mm² was used. The TPA sequence consisted of a double compression at 5 mm/s up to 0.5 strain and a compression interval of 5 sec. The measurements were performed at 19 °C and 55 °C with seven replicates per temperature per sample. The firmness (in N/m²) was calculated by dividing the measured force (in N) by the contact surface area (in m²)

In addition, to manufacturing efficiency was determined by measuring the Cooking yield after the pre-cooking step according to the following equation:

$$\text{Cooking yield (\%)} = \frac{\text{cooked weight (g)}}{\text{raw weight (g)}} * 100$$

- 5 Surprisingly, the samples according to the invention provided an increase in cooking yield compared to the comparative sample A with methyl cellulose after the first pre-cooking step. Normally, such pre-cooked meat analogues are packaged and sold to the end user (frozen or chilled). The increase in cooking yield provides an unexpected increase in manufacturing efficiency. In addition, the samples according to the invention showed good firmness lacking
10 the undesirable mushiness of prior art meat analogues at typical consumption temperature (55°C) while the firmness increased when cooled (19°C)

To assess the robustness of miniburgers at temperature 75 °C, a pick-up test was performed. Miniburgers were picked up by hand and their subsequent deformation was assessed. Lack
15 of robustness indicates that samples will be unlikely to manufactured on industrial scale as the cooked process need to be transported in the factory when hot.

The results showed that at temperature of 75 °C both burgers according to the invention passed this test.

20

Example 3 Sensory test of nuggets

Nuggets were prepared in the same way as the burgers of Example 1, except that, after cooling in step 6, the dough was formed into nuggets using a custom-made mould and a hard spatula, followed by the following additional process steps:

- 25 7. The raw nuggets were stored frozen at -18 °C.
8. The frozen nuggets were dusted, followed by precooking in a steam oven at 95 °C and 100% steam for 7 min.
9. After precooking, the precooked nuggets were immersed in batter, followed by the application of a coating of cornflakes.
30 10. The coated nuggets were pre-fried for 35 sec at 185 °C in a fryer using rapeseed oil. The pre-fried samples were cooled down in open air to room temperature and stored at -18 °C.

The frozen nuggets were prepared for evaluation by frying for 3.5 min at 175 °C.

- 35 Following preparation, the finish-fried nuggets were subjected to a sensory evaluation. Panel members (n=12) received the coded samples on a heated plate. Participants rated the

“juiciness” of the samples. The samples according to the invention showed an improved juiciness compared to the sausage with methylcellulose while at the same time the dough showed good processability (dough not so wet, sticky or soft such that it could easily be shaped into nuggets. In addition, the nuggets were evaluated as firm and lacked undesirable mushiness.

5

CLAIMS

1. A vegan meat analogue that is free of methylcellulose and that comprises kappa-carrageenan, konjac mannan, optionally cellulose fibers, and further:
 - a) non-animal protein, preferably in an amount of 8-25 wt.% by weight of the meat analogue, preferably whereby at least 50 wt% of said protein is present in the form of pieces of texturised vegan protein;
 - b) 0-20 wt.% of fat by weight of the meat analogue;
 - c) water preferably in an amount of 55-75 wt.% by weight of the meat analogue,
 - d) whereby the combined amount of kappa-carrageenan, konjac mannan and, if used cellulose fibers, is present in an amount of 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue; whereby preferably said combined amount comprises
 - i) 0.5-2.5 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue whereby the concentration of kappa-carrageenan is to be calculated as (amount of kappa-carrageenan / (amount of kappa-carrageenan + total moisture));
 - ii) 0.2-2.5 wt.%, of konjac mannan, based on the water content of the meat analogue whereby the concentration of konjac mannan is to be calculated as (amount of konjac mannan / (amount of konjac mannan + total moisture)); and
 - iii) optionally 2-18 wt.% of cellulose fibres based on the water content of the meat analogue whereby the concentration of cellulose fibres is to be calculated as (amount of cellulose fibres / (amount of cellulose fibres + total moisture)).
2. Meat analogue according to claim 1, wherein the meat analogue comprises, calculated by weight of dry matter, 30-65 wt.% of pieces of texturised vegan protein.
3. Meat analogue according to claim 1 or 2, wherein the combination of kappa-carrageenan and konjac mannan constitutes, 0.8-4.4 wt.%, preferably 1-4.2 wt.%, more preferably 2.0-4.0 wt.% based on the water content of the meat analogue.
4. Meat analogue according to any one of the preceding claims, wherein kappa-carrageenan and konjac mannan are present in a weight ratio of 1:2 to 3:1.
5. Meat analogue according to any one of the preceding claims whereby the meat analogue has a pH 5 to 6.5, more preferably a pH 5.2 to 5.8.

6. Meat analogue according to any one of the preceding claims, wherein the combined amount of kappa-carrageenan, konjac mannan and, optionally cellulose fibers is 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue.
7. Meat analogue according to any one of the preceding claims, wherein the meat analogue comprises 2-15 wt.% fat by weight of the meat analogue.
8. Meat analogue according to any one of the preceding claims, whereby the meat analogue comprises 1 to 8 wt.%, preferably 2 to 7 wt.% cellulose fibre sourced from citrus, based on the water content of the meat analogue.
9. Meat analogue according to the preceding claim, whereby the meat analogue comprises cellulose fibre sourced from cereal, preferably in an amount of 1 to 8 wt.%, preferably 2 to 7 wt.% based on the water content of the meat analogue.
10. Meat analogue according to the preceding claim, whereby if a fat mimetic is present, the fat mimetic contains, by weight of the water that is contained in said fat mimetic, less than 0.5 wt.% kappa-carrageenan and less than 0.2 wt.% konjac mannan.
11. Meat analogue according to any one of the preceding claims having a cooking yield of more than 90%, preferably more than 95% whereby the cooking yield is determined after cooking the meat analogue shaped as burgers (diameter = 42 mm, height of 21mm, weight 27 g) in a steam oven at 100 °C with 100% steam for 8 min using the following equation.
$$\text{Cooking yield (\%)} = \frac{\text{cooked weight (g)}}{\text{raw weight (g)}} * 100$$
12. Meat analogue according to the preceding claim 1, wherein the meat analogue comprises:
 - a) 9.0-18 wt.% of non-animal protein by weight of the meat analogue;
 - b) 3-12 wt.% of fat by weight of the meat analogue;
 - c) 1.0-2.0 wt.% of kappa-carrageenan wt.% based on the water content of the meat analogue;
 - d) 0.2-2.5 wt.%, preferably 1.0-2.0 wt.% of konjac mannan, based on the water content of the meat analogue;
 - e) 2-12 wt.%, preferably 4-12 wt.% of cellulose fibres based on the water content of the meat analogue, said cellulose fibres being sourced from citrus and optionally oat; and
 - f) 60-70 wt.% of water by weight of the meat analogue;

wherein the combined amount of kappa-carrageenan, konjac mannan and cellulose fibers is 4 to 18 wt.%, preferably 6 to 16 wt.%, more preferably 8 to 14 wt.%, based on the water content of the meat analogue;
whereby the meat analogue has a pH 5 to 6.5, more preferably a pH 5.2 to 5.8.

13. A method of preparing a meat analogue according to any one of the preceding claims, wherein the method comprises:

- a) providing a hydrated source of non-animal protein;
 - b) combining the hydrated source of non-animal protein with kappa-carrageenan, konjac mannan, optionally cellulose fibres, water and any remaining ingredient to form a meat analogue dough;
 - c) shaping said meat analogue dough;
 - d) heating said shaped meat analogue to at least 70°C to form a meat analogue;
 - e) optionally coating said shaped meat analogue with a crispy coating;
- preferably whereby the heated meat analogue is solid at a temperature of at least 60°C;

14. Method according to claim 13, wherein the meat analogue dough has viscosity of 4 to 25 kg, preferably of 6 to 20 kg, more preferably of 7.5 to 15 kg, said viscosity being determined by the method that is described in the specification.

15. Method according to claim 13 or 14, wherein the method comprises:

- a) providing hydrated texturised vegan protein having a water content of 50-85 wt.% and comprising, calculated by weight of dry matter, 65-88 wt.% of plant protein;
 - b) combining the hydrated texturised vegan protein with kappa-carrageenan, konjac mannan, cellulose fibres, water and any remaining ingredients to form a meat analogue dough;
 - c) shaping said meat analogue dough;
 - d) heating said shaped meat analogue to 75 to 105 °C to form a meat analogue;
- wherein kappa-carrageenan and konjac mannan are applied in a weight ratio of 1:2 to 3:1 and wherein kappa-carrageenan and cellulose fibres are applied in a weight ratio of 1:3 to 2:1
- f) optionally coating said shaped meat analogue with a crispy coating;
- preferably whereby the heated meat analogue is solid at a temperature of at least 75°C;

INTERNATIONAL SEARCH REPORT

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PCT/EP2024/058543

A. CLASSIFICATION OF SUBJECT MATTER					
INV.	A23L29/206	A23J3/22	A23L29/244	A23L29/256	A23L29/262
	A23L33/185				
ADD.					
According to International Patent Classification (IPC) or to both national classification and IPC					
B. FIELDS SEARCHED					
Minimum documentation searched (classification system followed by classification symbols)					
A23L A23J					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)					
EPO-Internal					
C. DOCUMENTS CONSIDERED TO BE RELEVANT					
Category*	Citation of document, with indication, where appropriate, of the relevant passages				Relevant to claim No.
X	WO 2021/110760 A1 (DUPONT NUTRITION BIOSCI APS [DK]; DUPONT NUTRITION USA INC [US]) 10 June 2021 (2021-06-10) claim 1 claim 2 claim 4 claim 7 claims 12,13 claim 16 claim 17 table 3 page 4; table 4 page 6, line 2 - line 8 page 13, line 2 - line 5 page 14, line 3 - line 5 ----- - / - -				1 - 15
☒ Further documents are listed in the continuation of Box C.					
☒ See patent family annex.					
* Special categories of cited documents :					
"A" document defining the general state of the art which is not considered to be of particular relevance			"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		
"E" earlier application or patent but published on or after the international filing date			"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		
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"O" document referring to an oral disclosure, use, exhibition or other means			"&" document member of the same patent family		
"P" document published prior to the international filing date but later than the priority date claimed					
Date of the actual completion of the international search			Date of mailing of the international search report		
19 June 2024			04/07/2024		
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016			Authorized officer Alonso Martínez, D		

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 427 704 A (CHENEY PETER A [GB] ET AL) 24 January 1984 (1984-01-24) column 3, line 41 - line 45 -----	1 - 15
A	CN 112 655 896 A (QINGDAO HYZLIN BIOLOGY DEV CO LTD) 16 April 2021 (2021-04-16) claim 1 claim 6 -----	1 - 15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2024/058543

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		CN 115209742 A	18-10-2022
		EP 4068982 A1	12-10-2022
		US 2023000109 A1	05-01-2023
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