

THERMO IRREVERSIBLE GELLING SYSTEM
AND EDIBLE MATERIALS BASED THEREON

This invention relates to gelling systems and especially to gelling systems that can be used to produce edible materials having a pH below about 8.

British Specification No. 2048642

5 describes and claims edible materials having a pH below 8 and having a thickened or gelled aqueous phase produced from a mixture or a reaction product of at least one glucomannan with at least one carrageenan.

That specification indicates that thermo-
10 irreversible gels can be produced by reacting a mixture of at least one glucomannan and at least one carrageenan at a temperature of at least 100°C for a sufficient period of time provided that the pH is at least 5 but that in the presence of certain foodstuffs, especially meat and other
15 proteinaceous materials the gels formed under the same conditions are thermo-reversible.

This invention is based on the observation that by suitably adjusting the conditions of gel formation thermo-irreversible gels can be produced, when the pH of
20 the aqueous phase is between 5 and 8, whether or not the temperature is above 100°C and whether or not meats and other proteinaceous materials are present in the aqueous phase.

The invention is particularly based on the
25 observation that thermo-irreversible gels can be produced using a carrageenan/glucomannan reaction system when the

the pH is between 5 and 8 provided that the heat input is sufficient, even though the temperature of the system is not raised above 100°C and/or proteinaceous material of vegetable or animal origin is present.

5 This invention therefore provides an edible food product having a pH between 5 and 8 wherein the aqueous phase is gelled in the form of a thermo-irreversible gel. The gel structure is provided by a mixture of at least one glucomannan and at least one carrageenan.

10 The invention provides a process for the production of an edible product having a pH between 5 and 8 and having a gelled aqueous phase provided by a mixture of at least one glucomannan and at least one carrageenan, which comprises subjecting a gellable combination of at
15 least one glucomannan and at least one carrageenan to a temperature of at least 50°C but less than 100°C for a period of up to 16 hours such as to form a thermo-irreversible gel in the aqueous phase.

 The heat input required to make a thermo-
20 irreversible gel using the carrageenan-glucomannan gelling system of the invention depends on a number of factors. It appears to be essential that the pH is at least 5 but apart from this the heat input can be lower, the closer the pH is to 8 and the higher the concentration of gellable constituents
25 in the aqueous phase of the system. The higher the temperature, of course, the shorter the heating period required to form a thermo-irreversible gel.

 Surprisingly, moreover, it has been found that the

time to form a thermo-irreversible gel can be greatly reduced, when all other factors are the same if the gelling system, having been produced by dissolving the ingredients in a hot aqueous phase, is cooled and, preferably, subjected to an ageing process at room temperature before it is reheated to form the gel.

British Specification No: 2048642 moreover suggests that the presence of meats and other proteinaceous materials in glucomannan / carrageenan systems often leads to thermo-reversible gels. It has now been found that this is not caused by some inherent antagonism but by the effect such ingredients have on the process parameters which govern the conversion to a thermo-irreversible gel, such as pH, heat penetration ratio, potassium ion concentration etc.

The invention therefore also provides a process for the production of a meat analogue having a pH between 5 and 8 comprising proteinaceous material dispersed in and bound together by a thermo-irreversible gelled aqueous phase which comprises subjecting the proteinaceous material, together with a gellable combination of at least one glucomannan and at least one carrageenan to a temperature of at least 50°C for a period of up to 16 hours such as to form a thermo-irreversible gel in the aqueous phase.

The invention moreover provides a meat analogue comprising proteinaceous material dispersed in and bound together by a thermo-irreversible gelled aqueous phase, wherein the gelling system comprises a mixture of at least one glucomannan and at least one carrageenan.

The edible product of this invention may be any foodstuff or confectionery in which it is desired to have a structured or shaped form which is resistant to structural breakdown upon heating. The gelled foodstuff may include flavouring, and colouring ingredients. If desired, humectants and fungistats may be included to provide microbiological stability in, for example, so-called "semi-moist" foods. A major advantage of the gelling

system over other polysaccharide gelling systems such as alginates and polypectates is that there is no necessity for treatment with divalent or polyvalent ions, a process which often imparts a palatability negative to the product
5 unless an efficient washing stage is included.

Another advantage of the gelling system over calcium alginates lies in the stability of the glucomannan/carrageenan gels to heating in the presence of polyphosphates. Food analogues structured by calcium alginate soften
10 considerably when heated in the presence of polyphosphates whereas the products of this invention do not. This is particularly useful for meat analogues which are to be included in common convenience foods since these often contain polyphosphates.

15 Yet another advantage of the gelling system used in this invention is that it is odourless and flavourless even after severe heat treatment. This is in marked contrast to many vegetable protein binders such as the soya, cottonseed, and wheat proteins used in commerce. The
20 gelling system of the invention does not therefore contribute a palatability negative to the foodstuff in which it is included.

Any carrageenan or carrageenan-type polysaccharide, for example, furcellaran is suitable. The carrageenan may
25 be used in a crude form (e.g. washed seaweed) or in an alkaline modified form or in the form of the conventional carrageenan extracts of commerce. The carrageenan may be

any form of carrageenan such as lambda, iota or kappa carrageenan or any mixture thereof, but the preferred carrageenan types are those containing some kappa carrageenan.

- 5 The glucomannans may be used in a purified form or in the crude form. The crude form may merely be the ground source of glucomannan without further treatment. Although any glucomannan is suitable, the preferred glucomannans are found in the corms of the *Amorphophallus* genus and in particular *A. rivieri* (Syn *A. Konjac*),
10 *A. oncophyllus*, *A. variabilis*, *A. bulbifera* and *A. blumei*.

The preferred weight ratio of glucomannan to carrageenan is in the range 20:1 to 1:20 and the preferred concentration of the combined mixture in the aqueous phase is 0.01% to
15 5%, preferably 0.5 to 5% by weight.

The mechanism of thermo-irreversible gel formation in an aqueous solution of a mixture of glucomannan and carrageenan is still not fully understood.

The time for which the solution or gel must be
20 heated to achieve thermo-irreversibility is dependent upon several factors, in particular pH, the gum content, the ageing period prior to heat treatment and the presence of other ingredients. All other factors being constant, the minimum time of heat treatment required to provide thermo-
25 irreversibility is reduced by higher pH, higher gum content, presence of synergistic ingredients (e.g. potassium ions or carob gum) or ageing (or conditioning) at room temperature prior to heat treatment. All other factors being constant

the above changes will also provide tougher, more resilient gels or bound food products.

The following examples illustrate the invention.

EXAMPLE 1

5 This example demonstrates the preparation of a typical thermally irreversible meat analogue product. The meat analogue product was prepared using the following recipe:-

	<u>Ingredients</u>	<u>% by Weight</u>
10	(Fibrous Muscle Meats	27.3
	(Offal Meats	16.2
	(Ground Bone	6.5
	Gravy (Amorphophallus sp. extract	1.5
	(kappa - carrageenan	1.0
15	(Water	<u>47.5</u>
		<u>100.0</u>

 The meats were coarsely chopped and then mixed in the proportions given above, before being minced through a 5 mm screen. The minced meats were then added to the correct proportion of water and the whole was then heated to 90°C with occasional stirring. When the mixture had attained a temperature of 90°C the gravy powders were added, using the proportions given above, while the mixture was thoroughly macerated using a high-shear stirrer. During the addition of the gravy powders the temperature of the

mixture was kept in the range 90-95°C. When the gravy powders were evenly dispersed, the mixture was poured into an aluminium tray, covered and left to cool. When cool, the product was processed in a pressure cooker after which
5 time the product was cooled.

When cool, the product was found to be tough, with a meaty appearance and could be cut cleanly into chunks with little or no fines being produced. The product resembled cooked lung.

10 The pH of the product was 6.4. The product was found to be thermally-irreversible when assessed in the following manner:-

The product was cut into cubes of side-length about 25 mm and 250 g of the cubes were placed in a metal
15 can. The can was then filled with water and sealed before being processed in a pressure cooker at 130°C for one hour. The can was then cooled by immersion in cold, running water. When cool, the can was opened and the contents assessed. Thermo-irreversibility was confirmed since the chunks were
20 still tough and discrete with clean surfaces after this treatment. Thermally-reversible chunks fuse together under the test conditions forming a single lump.

The structural integrity of the analogue is entirely due to the glucomannan and carrageenan present,
25 since any contribution from the meats was destroyed by the 90°C pre-heat treatment.

EXAMPLE 2

This example demonstrates the advantage of ageing the analogue mix prior to the heat forming process to improve the analogue toughness.

5		<u>Ingredients</u>	<u>% by Weight</u>
		(Fibrous Muscle Meats	27.3
		(	
	Meats	(Offal Meats	16.2
		(	
		(Ground Bone	6.5
	Gravy	(Amorphophallus sp. extract	0.75
		(	
10		(kappa - carrageenan	0.5
		(	
		(Water	48.75
			100.0

Using the above recipe the process of Example 1 was repeated up to and including the addition of the gums at 90° to 95°. When the gums were evenly dispersed, the mixture was split into two equal portions.

Product A

The hot mixture of one of the portions was poured into cans which were immediately sealed and transferred to a pre-heated autoclave. Without delay the cans and contents were heat sterilized at 130°C for 50 minutes after which time they were cooled to room temperature by immersing in cold water. This product had had no ageing prior to the heat setting process.

(17)

Product B

The hot mixture of the second portion was poured into cans which were sealed and left to cool to room temperature overnight. After 12 hours at room temperature, 5 the cans and contents were heat sterilized in a similar manner to Portion A. This product has been aged prior to the heat setting process.

The meat analogues resulting from Portion A and Portion B were cut into chunks and subjected to the test 10 for thermo-irreversibility and described in Example 1.

Chunks from Product A were fused together to form a single lump. Some chunk definition was evident within the lump but the chunks were weak.

Chunks from Product B were discrete, had clean 15 surfaces and were tougher than the chunks from Product A. The pH of both products was 6.5.

Example 3

This example illustrates the preparation of a thermally irreversible meat analogue product using raw meats.

20 The product was prepared according to the following recipe:-

<u>Ingredients</u>		<u>% by Weight</u>
25	Gravy	
	(Fish	50
	(Water	47.5
	(kappa - carrageenan	1.0
	(Amorphophallus sp. extract	<u>1.5</u>
		<u>100.0</u>

The fish was chopped and then minced through a 5 mm screen.

The gravy was prepared separately, by firstly heating the water to a temperature of 90°C. The water was maintained at this temperature while the Amorphophallus sp. extract and the kappa carrageenan were added and dispersed using a high shear mixer. When the powders were fully dispersed, the gravy was added to the minced fish and the resultant mixture was homogenized using a high shear mixer.

The product was then left to cool to room temperature before being processed in a pressure cooker at 110°C for one hour. The product was finally allowed to cool to room temperature before being assessed for appearance, pH, toughness and thermo-irreversibility.

The thermally-irreversible product was tough with a texture similar to a meat loaf, the fish being evenly dispersed throughout the pack. The pH of the product was 7.1.

20 Example 4

This example demonstrates the use of the glucomannan/carrageenan gel system to provide a meat analogue with high pet animal acceptance.

1. Analogue Preparation

25 The following recipe was used:-

	<u>Ingredient</u>	<u>% w/w</u>
	Liver	12
	Offal Meats	28
	Fibrous Muscle Meat	16
5	Hydrated TVP	10
	Condensed Whey	3
	Carob gum	0.5
	Flavouring salts	0.2
	Dye Solution	0.7
10	Water	26.5
		96.9

The ingredients were mixed together and minced through a 4 mm plate.

The minced product was stirred using a low shear mixer whilst adding 1.5% Amorphophallus extract and 1.6% commercial grade kappa carrageenan ensuring that the gums were well dispersed. The resulting mixture was heated in an autoclave for one hour at 130°C in a suitable container.

After cooling, the solid pack was cut into chunks approximately 10 mm x 7 mm x 7 mm in size to provide the meat analogue.

2. Preparation of Pet Food

The following recipes were used:-

	<u>Ingredients</u>	Product A	Product B
		<u>% w/w</u>	<u>% w/w</u>
	Meat analogue (as above)	70	-
	Gravy A	30	-
5	Raw Meat Mix (as in 1. above)	-	97
	kappa Carrageenan (Commercial Grade)	-	0.2
	Water	-	2.8
		<u>100.0</u>	<u>100.0</u>
10	<u>Gravy A</u>		
	<u>Ingredient</u>	<u>% w/w</u>	
	Water	87.5	
	Liver	12	
	Dye Solution	0.3	
15	Flavour	0.2	
		<u>100.0</u>	

The liver and flavour salts were added to the
gravy to ensure that in Product A, the concentrations of
these palatable ingredients were similar to those in

20 Product B.

Product A

The appropriate weight of chunks analogue was
added to the cans and the cans were filled with Gravy A to
give the correct ratio of chunks to gravy. The cans and
25 contents were sealed.

Product B

All of the ingredients were mixed together and sealed in cans.

Both products were heat sterilized @ 130°C for 5 one hour. After cooling to room temperature the cans were stored for one day at room temperature before opening to assess the contents. Samples of Product A and Product B were also fed to cats in a preference situation.

Product A consisted of tough, integral, well 10 defined, chunks of meat in a weakly gelled gravy.

Product B consisted of a solid pack of minced meats embedded in a fairly tough clear thermo-reversible jelly.

To a human panel the chunks from Product A 15 tasted similar to the Product B. There was no detectable flavour difference resulting from the inclusion of Amorphophallus extract and carrageenan as the binder system in Product A.

In Cat Preference trials, a panel of 40 felines 20 ate both products with equal relish.

EXAMPLE 5

This example demonstrates the use of hot gum dispersion to aid the development of thermo-irreversible glucomannan/carrageenan gels.

25 Two meat analogue materials were prepared:-

1. With gums mixed in the cold.
2. With gums mixed at elevated temperature.

Both had the following recipe:-

<u>Ingredient</u>	<u>% by Weight</u>
Offal Meats	12.8
Fibrous Muscle Meats	22.0
5 Ground Bone	5.2
Water	57.5
kappa - carrageenan	1.0
Amorphophallus sp. extract	1.0
	<u>100.0</u>

10 For each meat analogue material, the meat constituents were roughly chopped, thoroughly mixed in their correct proportions and then minced employing the method illustrated in Example 1. The meat mix was then cooked by boiling in water for five minutes. The meats
15 were strained, cooled to room temperature and employed in the following preparations:-

1. Cold Gum Dispersal

To 40 parts of the above meat mix 57.5 parts of water was added. The mixture was then thoroughly dispersed
20 with a high shear mixer. The required weights of gums were then dispersed into the mix whilst continually shearing for 1-2 minutes. The mixture was then poured into cans, sealed and sterilized at 130°C for one hour.

2. Elevated Temperature Gum Dispersal

25 To 40 parts of meat mix 57.5 parts of water was added.

The mixture was then heated to 90°C whilst continually stirring with a high shear mixer. The gums were then dispersed into the mix using a high shear mixer and maintaining the temperature at 90°C for 1-2 minutes.

- 5 The mixture was then poured into cans, sealed and cooled to room temperature prior to being sterilized at 130°C for one hour.

Both samples 1 and 2 were allowed to cool to room temperature after sterilization, before being assessed for
10 thermo-irreversibility employing the method illustrated in Example 1.

Upon examination of the meat analogue chunks after the thermo-irreversibility test, obvious differences were apparent.

15 1. Cold Gum Dispersal

The chunks had fixed together forming a continuous lump of meat and gel moulded to the shape of the can bottom. Gel had dissolved into the aqueous phase from the chunks producing a very viscous solution. The pH of the solid
20 material was in the range of 6.30 - 6.38.

2. Hot Gum Dispersal

The chunks were completely integral retaining their original shape before the test. They were glossy and juicy in appearance. The pH of the chunks was in the
25 range 6.38 - 6.40. Some excess gel had diffused from the chunks to the aqueous phase to form a viscous solution.

EXAMPLE 6

This example illustrates the formation of thermo-irreversible gels employing a low temperature for a prolonged period of time.

5 Two 1 litre portions of gel were prepared having the following recipe:-

	<u>Ingredient</u>	<u>% w/w</u>
	1. Amorphophallus sp. extract	1.500
	2. kappa carrageenan	1.000
10	3. $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	0.382
	4. Na_2HPO_4	0.618
	5. Water	96.500
		100.000

15 The required quantity of water was taken for two litres of gel and heated to 90°C . The water was then mixed using a high shear stirrer and ingredients 3 and 4 added. Ingredients 1 and 2 were then added and mixing continued whilst maintaining a temperature of 90°C for five minutes. The solution was divided into two equal
20 parts, each being poured into an aluminium tray, covered and allowed to cool.

 One of the trays containing the gel was then heated to 76.5°C for a period of 16 hours, employing a constant temperature water bath and a thermocouple linked
25 to a chart recorder to monitor the gel temperature. The gel was then allowed to cool to room temperature.

Both the heat treated and non heat treated gels were then assessed for thermo-irreversibility employing the method illustrated in Example 1.

Chunks from the non heat treated gel had completely fused together forming one continuous lump at the bottom of the can. The pH of the gel was 6.85.

Chunks from the heat treated gel remained totally integral and retained their original shape. The chunks were tough and glossy in appearance. Some gum had diffused from the chunks into the aqueous phase but this was not excessive.

pH of chunks = 7.01

EXAMPLE 7

This example illustrates the effect of pH on the toughness of the thermally-irreversibility of the meat analogue product.

Two products were prepared using samples of offal meat from the same source. The products were prepared to the same recipe as that given in Example 3, except that the fish was replaced by the same proportion of offal meat.

The products were prepared in the same way as described in Example 3 except that prior to the addition of the gravy, the offal meat was treated with a suspension of calcium hydroxide in water to adjust the pH.

When the preparation of the products was complete, they were assessed for pH and toughness. Product (A) had a pH of 6.85 was thermo-irreversible and was markedly tougher than product (B) which had a pH of 5.65 and was thermo-reversible.

EXAMPLE 8

This Example illustrates the minimum heat input required to product a thermo-irreversible gel.

A pH 7.1 buffer solution was prepared by dissolving
5 the following salts in distilled water.

Ingredient	Wt/g	% w/w
Na_2HPO_4	49.44	0.618
$\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	30.56	0.382
Distilled Water	7920.00	99.000
	8000.00	100.000

1 litre of pH 7.1 buffer solution was taken and heated to 90°C . The solution was then stirred employing a Silverson ^(RTM) high shear mixer whilst maintaining the temperature at 90°C . 15 grams of konjac (glucomannan) and
10 10 grams of carrageenan were then dispersed into the buffer solution and mixed thoroughly with the Silverson high shear mixer for a period of five minutes. During this time the solution temperature was maintained between $90-95^\circ\text{C}$, after which the solution was poured into an aluminium tray,
15 covered and allowed to cool to room temperature. A number of trays were made up in this manner and these were each heated for a period of 16 hours at a different temperature.

Two methods of heating were employed:-

(i) 30-80°C using a constant temperature water bath.

The aluminium tray was submerged in the water to the upper level of gel. The gel temperature was then allowed to equilibrate with that of the water.

(RTM)

(ii) 80-130°C using an Astell autoclave, vented to give temperatures up to 100°C maintaining atmospheric pressure and under elevated pressure to obtain temperatures up to 130°C.

The temperature of the gel was monitored in each case by means of a previously calibrated thermocouple linked to a twin channel chart recorder. A second thermocouple was also employed to monitor the temperature of the heating environment. Timing at any given temperature was started at the point where the gel temperature was in equilibrium with the heating environment.

The following heating conditions were employed.

Temperature °C	Time/Hours
100	16
85	16
76.5	16
65	16
61.5	16
*50	16
41	16

The gels produced were assessed for thermo-irreversibility and toughness employing the following methods:

Toughness

The gels were measured for toughness employing an Instron ^(RTM) food tester.

The Instron food tester was set up as follows:

5 Load cell = 50 Kg
 Crosshead speed = 500 mm/minute
 Chart speed = 1000 mm/minute

The gel from each of the solutions prepared was emptied from its tray and the subjective textural
10 characteristics of the gel were noted.

Part of the gel was then cut into cubes having approximate side length of 15 mm. 85-90 g of these cubes were transferred into a modified Minnesota cell which included a 10 mm screen. The chunks were then extruded
15 through the screen by means of a plunger which was attached to the Instron load cell. The average toughness value was taken as the maximum load from the Instron recorder trace obtained. This procedure was repeated for four 85-90 g. quantities of chunks and the average toughness
20 value taken.

Thermo-irreversibility

The remaining part of the gel was taken and cut into chunks of approximately 1" (2.5 cm) side. 250 g. of these chunks were placed in a steel can and the remaining volume
25 made up with water. The can was then sealed and processed at 129°C for 59 minutes in an Astell autoclave. It was then allowed to cool to room temperature prior to opening.

A thermo-irreversible gel is confirmed if the gel chunks have retained their integral shapes and are not fused together.

A thermo-reversible gel is identified if the gel chunks have melted and fused together in the bottom of the can.

pH values of the gels were measured both before and after the test for thermo-irreversibility.

The results are illustrated in the following

table:-

Results

Temp. °C	Thermo-irreversibility	Colour	Toughness	pH
100	Yes	Opaque	2.8	6.9
85	Yes	Opaque	4.7	7.0
76.5	Yes	Opaque	6.0	7.0
65	Yes	Opaque	8.0	7.0
61.5	Yes	Opaque	10.0	7.0
*50	Yes/No	Opaque	9.0	7.0
41	No	Translucent	6.6	7.1

* Several experiments were carried out employing 50°C/16 hours heating conditions which produced in some cases, gels which were borderline in terms of thermo-irreversibility and in other cases gels where were thermo-reversible. It can be concluded that the minimum heat input for thermo-irreversibility lies at about 50°C/16 hours.

EXAMPLE 9

In order to establish more clearly the effect of pH on the formation of thermo-irreversible gels in meat analogue materials a number of experiments were carried out using meats at natural pH and at an artificially adjusted neutral pH. For the majority of the experiments the formulation used was as follows:

	Meat	50% by weight
	Konjac	1.5% by weight
10	Carrageenan	1% by weight
	Water	47.5% by weight.

For one experiment using lung the amount of meat was reduced to 40% by weight and the water content, increased accordingly.

15 The required amount of water for 1 Kg. of product was taken and heated to 90°C. This was then stirred with a Silverson high shear mixer during the addition of the required quantities of konjac and carrageenan. Stirring was continued until a homogeneous mix was obtained.

20 The required weight of meat was taken and mixed thoroughly with the aqueous gel blend. The resulting mix was spread evenly into an aluminium tray and allowed to cool.

 The materials in the tray were heated to a temperature of 110°C for a period of 60 minutes in an Astell laboratory autoclave. The trays were then allowed to cool prior to being tested for toughness, pH and thermo-irreversibility using the methods described in Example 8.

25

Results

Meat	Thermo-irreversibility	pH	Chunk toughness/Kg.
Meat trimmings	No	5.7	6.15
Liver trimmings	No	5.7	5.1
Liver trimmings	Yes	6.4	8.7
Fish	Yes	7.1	13.4
Kidney	Yes	7.3	7.3
Lung	Yes	7.2	11.7

In those cases where the pH is below 6 and thermo-irreversibility is not achieved the meat is at its natural pH. In those cases where the pH is above 6.4 and thermo-irreversibility is achieved the pH was initially
5 adjusted to 7-7.5 by the addition of calcium hydroxide.

The results illustrate that when meat is present in the konjac-carrageenan gelling system pH is an important factor in determining whether the gel will be
10 thermo-irreversible or not.



C L A I M S :

1. A process for the production of an edible product having a pH between 5 and 8 and having a gelled aqueous phase provided by a mixture of at least one glucomannan and at least one carrageenan, which
5 comprises subjecting a gellable combination of at least one glucomannan and at least one carrageenan to a temperature of at least 50°C but less than 100°C for a period of up to 16 hours to form a thermo-irreversible gel in the aqueous phase.
10
2. A process as claimed in claim 1 wherein the gel is produced by dissolving the carrageenan and glucomannan in a hot aqueous phase which is then cooled and then reheated to form the thermo-
15 irreversible gel.
3. A process as claimed in claim 2 wherein before being reheated to form the thermo-irreversible gel the solution is held at room temperature for an
20 ageing period.
4. A process for the production of a meat analogue having a pH between 5 and 8 comprising proteinaceous material dispersed in and bound together by a thermo-
25 irreversible gelled aqueous phase, which comprises subjecting the proteinaceous material together with

a gellable combination of at least one glucomannan and at least one carrageenan to a temperature of at least 50°C for a period of up to 16 hours such as to form a thermo-irreversible gel/ in the aqueous phase.

5
5. A process according to claim 4, wherein the proteinaceous material at least partially consists of meat.

10
6. A process according to claim 5, wherein the glucomannan and the carrageenan are dissolved in hot water and the proteinaceous material is then added and dispersed in the solution.

15
7. A process according to claim 5, wherein the proteinaceous material is dispersed in water and the glucomannan and carrageenan are added to the dispersion at an elevated temperature.

20
8. A process according to claim 6 or 7, wherein the mixture of proteinaceous material, glucomannan and carrageenan is allowed to cool before being reheated to form the thermo-irreversible gel.

25
9. A process according to claim 8, wherein before being reheated to form the gel, the mixture is held at room temperature for an ageing period.



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10. A process as claimed in any one of claims 1 to 9, wherein the glucomannan is a glucomannan present in the corms of the *Amorphophallus* genus.
- 5 11. A process as claimed in claim 10, wherein the glucomannan is a glucomannan derived from *A.rivieri*, *A.oncophyllus*, *A.variabilis*, *A.bulbifera* or *A.blumei*.
- 10 12. A process as claimed in any one of claims 1 to 11, wherein the carrageenan is a carrageenan type containing at least some kappa carrageenan.
- 15 13. A process as claimed in any one of claims 1 to 12, wherein the weight ratio of glucomannan to carrageenan is in the range of 20:1 to 1:20.
- 20 14. A process as claimed in any one of claims 1 to 13, wherein the concentration of the mixture of glucomannan and carrageenan in the aqueous phase is from 0.01% to 5% by weight.
- 25 15. A process as claimed in claim 14, wherein the concentration of the mixture of glucomannan to carrageenan in the aqueous phase is from 0.5 to 5% by weight.
16. A meat analogue comprising proteinaceous material dispersed in and bound together by a thermo-

irreversible gelled aqueous phase, wherein the gelling system comprises a mixture of at least one glucomannan and at least one carrageenan.

5 17. A meat analogue as claimed in claim 16, wherein the gelled aqueous phase is produced by a process as claimed in any one of claims 1 to 15.

10 18. A meat analogue as claimed in claim 16 or 17, wherein the proteinaceous material consists at least partially of meat.

15 19. A process as claimed in claim 1, conducted substantially as described in any one of the Examples.

20 20. An edible product having a thermo-irreversible gelled aqueous phase whenever produced by a process as claimed in any one of claims 1 to 15 or 19.

25 21. A meat analogue according to claim 16 substantially as described in any one of Examples 1 to 5, 7 and 9.