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(54) Food products based on protein fibres, and process and equipment for their manufacture

(57) The present invention provides food products comprising a coherent body of fibres which are obtained by spinning proteins of vegetable and/or animal origin and are held together by means of an edible binder, characterised in that the unidirectional fibres 1 form a closed web containing an edible binder 2 in the core. The process for the manufacture of the said food products consists in conveying the roving of protein fibres and in impregnating it with an edible binder, in shaping the impregnated web, that is to say in joining the longitudinal sides of the web in a circular movement in order to envelope the binder inside the web of fibres, and in coagulating the binder.

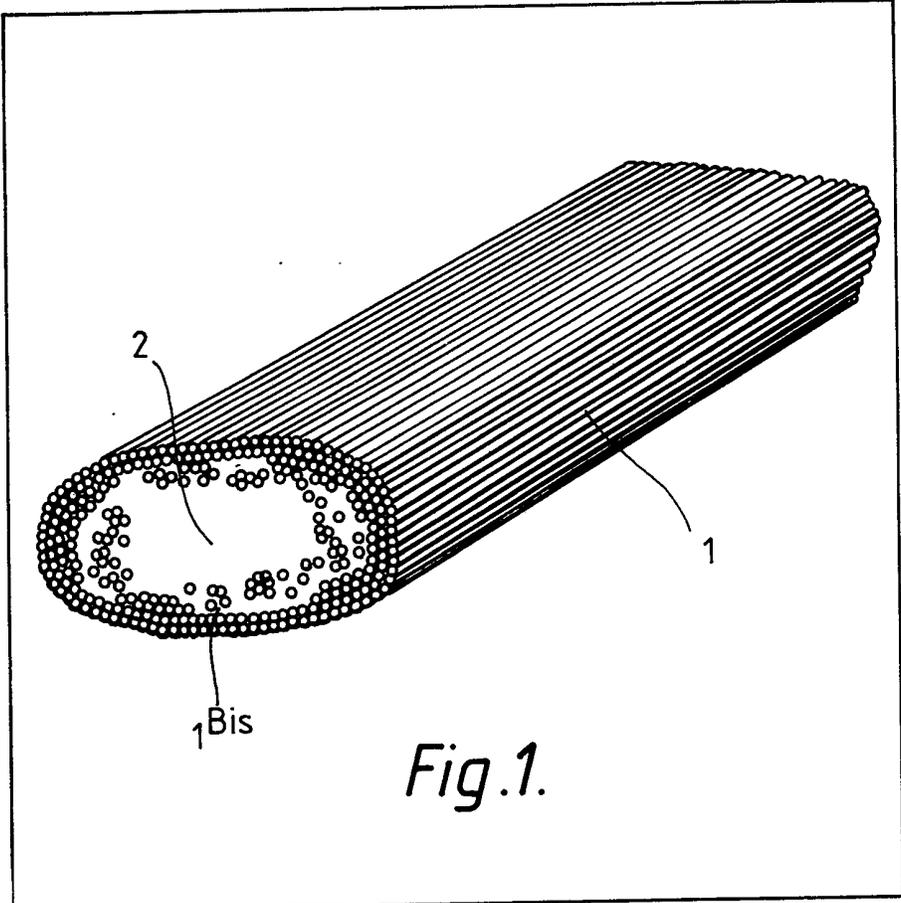


Fig. 1.

Fig. 2.

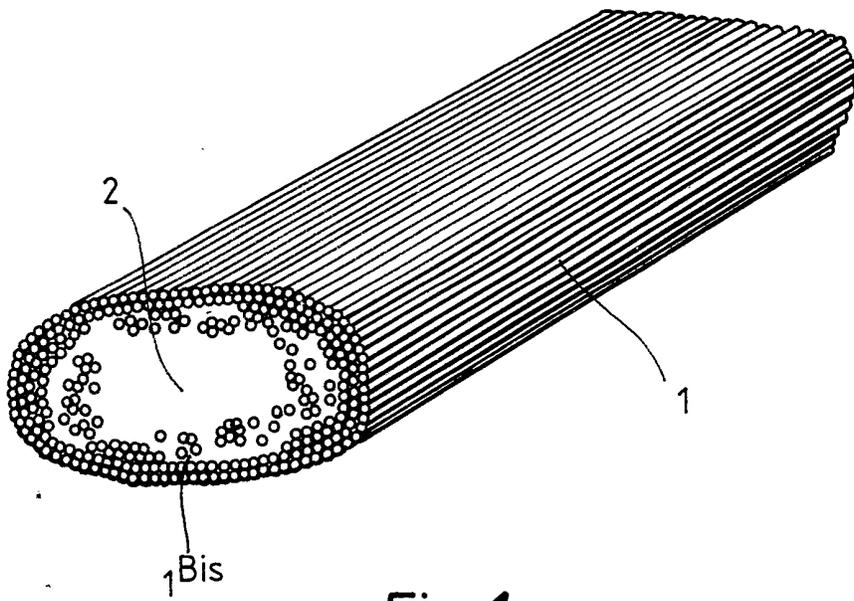
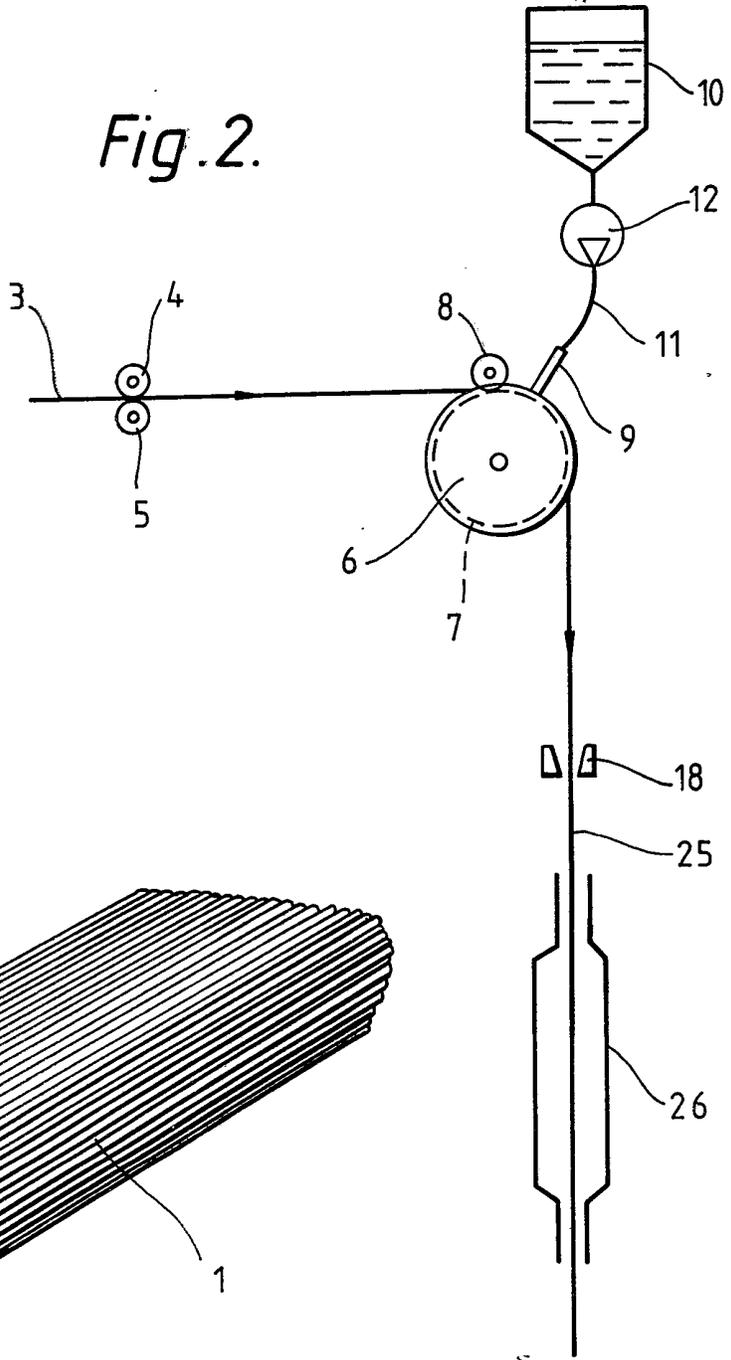


Fig. 1.

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Fig.3.

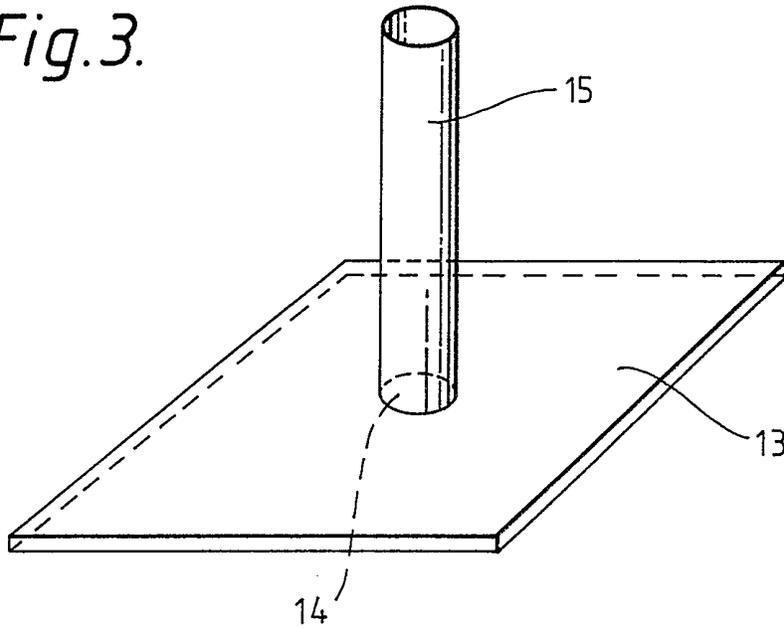
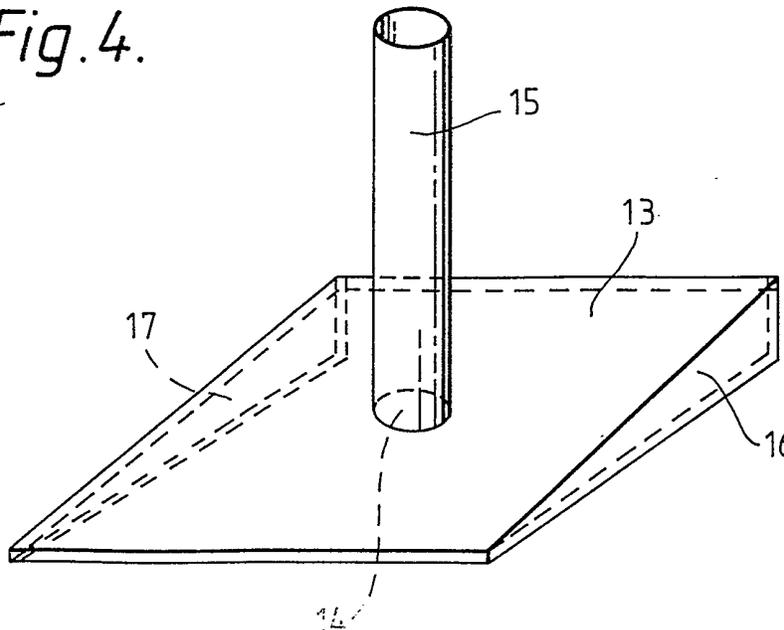


Fig.4.



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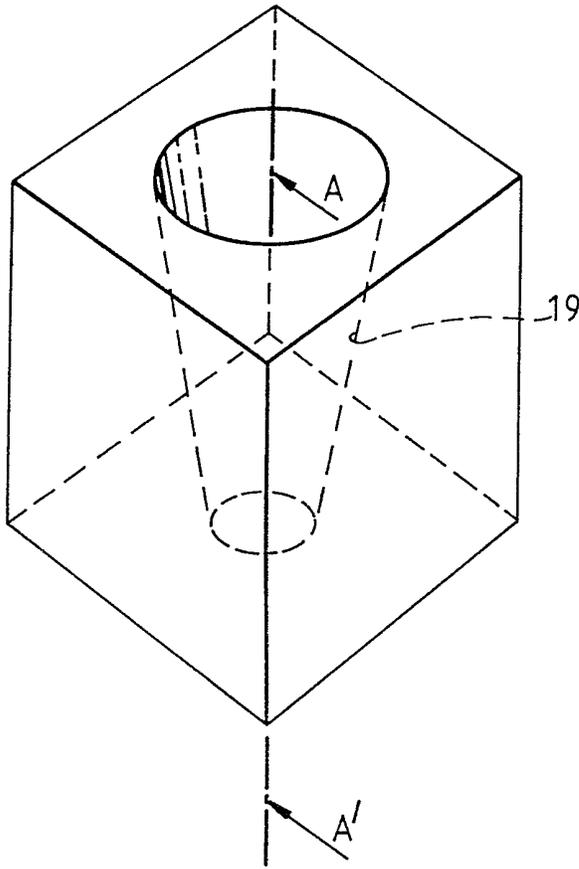


Fig. 5.

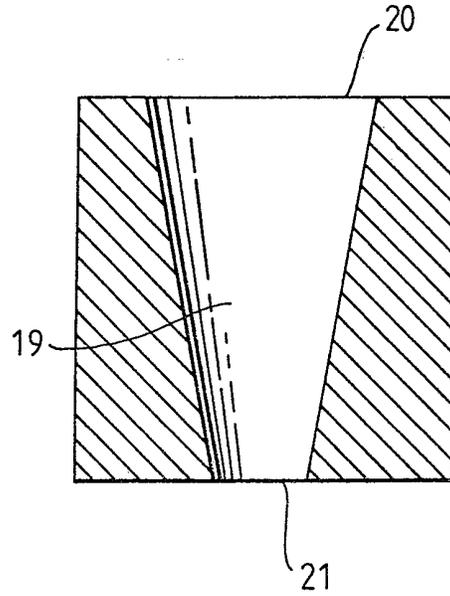


Fig. 6.

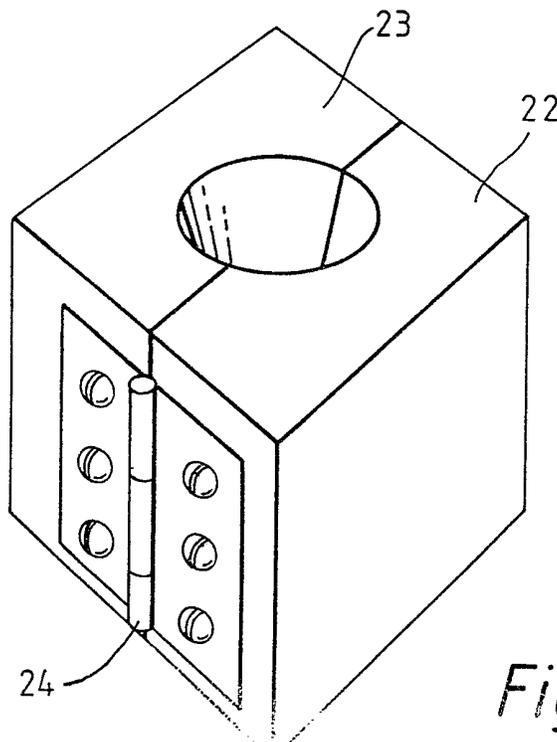


Fig. 7.

SPECIFICATION

Food products based on protein fibres, and process and equipment for their manufacture

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The present invention relates to products simulating meat, also referred to as "meat substitutes", based on protein fibres in a closed web. It also relates to the process and the equipment which

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make it possible to manufacture the said products. Meat substitutes are prepared, in accordance with various texturing methods, from vegetable or animal proteins, such as those extracted from the seeds of soya, sunflower, horsebean, pea or groundnut, or

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from milk casein. The most commonly used methods of converting crude proteins into more refined products which can replace meat are extrusion and spinning.

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The term "spinning" is to be understood as meaning a process for the formation of threads by extruding a solution, a dispersion or a gel through a plate provided with orifices of small diameter, or a spinneret, of suitable shape and dimensions. The products obtained by the spinning process will be

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denoted by the terms "threads, filaments and fibres", and the combination of the said filaments will be denoted by the terms "roving or bundle". Spinning offers the advantage of reproducing the fibrous nature of meats and of making it possible to

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obtain products which vary as regards their appearance and their nutrient properties. However, it requires the use of purified proteins, such as isolates, which are powders generally containing more than 90% of proteins. In fact, products having less

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than 70% of proteins cannot be spun directly. In order to be spun, the proteins must first be converted to a protein gel; as used herein, the terms protein gel or colloid refer to a dispersion of protein isolates in a suitable dispersing medium, such

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as an alkaline solution, it being possible for the dispersion to be, in fact, a colloidal solution, depending on the type of proteins dispersed and the dispersing agent used. The filaments obtained by spinning are usually coagulated in an acid bath optionally containing a salt, and are then drawn, neutralised and

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washed. This gives bundles of filaments of different sizes, depending on the number and the diameter of the holes in the spinneret. The coagulation fixes the structure of the filaments and the drawing makes it possible, by orientating them, to influence their relative tenderness or toughness. However, for the proteins shaped in this way to be able to imitate meat as closely as possible (the term "meat", used herein, covers both the flesh of mammals and the flesh of

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birds, fish, crustaceans and other animals which man consumes for food), it is essential to have, apart from the fibrous character, a texture and consistency which gives the sensation, which is difficult to reproduce, of "mastication" during the ingestion of

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the product, and also all the taste qualities of animal flesh. It is therefore necessary to provide the proteins with the cohesion and the texture of the natural products which it is desired to reproduce.

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It has been proposed to bind the protein fibres, without the addition of a binder, by subjecting the

fibres to the action of heat and pressure and by continuing the heating until the fibres melt, thus forming the bundle (see e.g., U.S. Patent No. 2,785,069).

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Edible binders, generally containing albumin, have been developed, thus making it possible to provide the bundle of fibres with cohesion. A known technique (see U.S. Patent No. 3,343,963) consists in circulating the roving of neutralised fibres in a bath containing the binder composition, and then in causing the impregnated fibres to set by heating, for example by baking in an oven or by steam treatment. In this case, in order to ensure uniform distribution of the binder, it is necessary to emulsify the various ingredients of the impregnating composition

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by adding edible emulsifiers, for example fatty acid monoglycerides and diglycerides or higher fatty acid esters or sugar. The distribution of a treating fluid, in particular the binder, throughout the bulk of the bundle of fibres has been improved by introducing the fibres into a bath of treating fluid and by subsequently causing the fibres and the fluid to vibrate in order to bring the fibres and the fluid into intimate contact (see French Patent No. 1,391,181). The impregnation of the roving is carried out continuously and the excess fluid is removed by compression, which tends to make the roving compact and results in incomplete impregnation of the fibres, thus leading to products which do not possess all the usual characteristics of meat.

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Furthermore, equipment has been specially designed (U.S. Patent No. 3,403,027) for impregnating a roving of protein fibres with a treating fluid. This involves conveying the roving of fibres in one direction and the treating fluid in counter-current, and causing the roving to follow a winding path between a series of gearwheels which exert a mechanical pressure on the roving. Apart from the fact that the equipment used is relatively complicated, it is preferable, for the manufacture of products for human consumption, not to employ an apparatus of this type, since it is likely to present hygiene problems.

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The products obtained by the processes and with the apparatuses known hitherto make it possible to obtain a flat roving of fibres which is more or less impregnated with binder; the culinary treatment of such fibres, namely cooking in boiling water, grilling or frying, frequently leads to the release of the binder composition, and this causes detexturisation of the cooked products, which then only very poorly imitate the natural products.

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Another process uses segmented protein fibres (French Patent No. 1,453,914) and consists in intimately mixing the orientated protein fibres and the additives, in subsequently forcing the mixture through a confined passage, by compressing it, and then in heating the mixture. The resulting product, coagulated under the action of heat, can be ground and then resembles minced natural meat. It is also possible to cut the meat into pieces, but it is difficult to reproduce elongate pieces of meat, such as a beef steak or escalope.

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Fibrous products with improved characteristics, which closely imitate the texture and the structure of natural meat, have now been found according to the present invention.

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The present invention provides a food product comprising a coherent body of fibres which are obtained by spinning proteins of vegetable and/or animal origin and are held together by means of an edible binder, characterised in that the unidirectional protein fibres form a closed web containing an edible binder in the core.

The present invention also provides a process for the preparation of the said food products consisting in conveying the roving of protein fibres and in impregnating it with an edible binder, in shaping the impregnated web, that is to say in joining the longitudinal sides of the web in a circular movement in order to envelop the binder inside the web of fibres, and in coagulating the binder.

It is preferable to open the roving of protein fibres before the impregnation, thus facilitating the penetration of the binder inside the bundle.

According to this invention, the equipment used comprises means for impregnating the roving with a binder, means for shaping the impregnated web and means for coagulating the binder.

The expression "means for impregnating the roving" is to be understood as meaning a coating support and a device for applying the binder.

If appropriate, means for opening the roving of protein fibres can be provided.

The process of this invention makes it possible to obtain a food product based on vegetable and/or animal proteins, which closely reproduces the texture and the fibrous characteristics of a meat product, because the fibres are aligned and orientated parallel to one another, as in natural meat.

Furthermore, as the binder is covered with the protein fibres, it does not tend to be released during subsequent culinary treatments, as a result of which the food products withstand heating and retain their initial shape and their similarity to the natural products much better.

Another advantage is that the invention enables one to produce a strand of proteins which does not have the compact appearance of an impregnated and generally flattened roving of fibres.

Also expensive equipment is not required in order to carry out the process of the invention; this accordingly leads to a reduction in the cost of the product obtained.

The equipment is preferably designed to work continuously.

The present invention will now be described, merely by way of example with reference to the accompanying drawings, in which:

Figure 1 is a view in perspective of a product of the present invention,

Figure 2 is a schematic representation of the equipment which can be used to carry out the process of the invention,

Figure 3 is a view in perspective of a means which is used, according to Figure 2, for depositing the binder on the web, and which is referred to as an applicator,

Figure 4 is a view in perspective of a modified embodiment of the applicator of Figure 3,

Figure 5 is a view in perspective of a means which is used, according to Figure 2, for shaping the web,

and which is referred to as a converger,

Figure 6 is a section along the line AA' in Figure 5, and

Figure 7 is a view in perspective of a modified embodiment of the converger of Figure 5.

The spun proteins used in the present invention can be any protein filaments obtained in accordance with known spinning processes, such as those described in French Patent No. 1,048,464 and U.S. Patents Nos. 2,730,447 and 2,730,448. Thus, a wide variety of proteins can be used, in particular isolates of vegetable proteins, such as soya, sunflower, horsebean, pea, groundnut, maize, rapeseed, lucerne, oats, barley and wheat, or animal proteins, such as lacto-proteins (casein, caseinate and seroproteins), gelatin, blood proteins and fish meals. The isolates of soya, sunflower, horsebean, pea and milk casein are preferred raw materials.

To prepare the spun fibres the protein should be dispersed in an alkaline medium. The concentration of protein in the aqueous suspension can vary within wide limits, generally from 5 to 40% by weight, preferably from 10 to 25% by weight.

The alkaline solution used to prepare the protein gel is advantageously an aqueous solution of sodium hydroxide and/or potassium hydroxide, having a concentration such that the weight ratio base/protein is from 0.02 to 0.35:1. The pH of the resulting mixture is generally from 9 to 13.5. The protein gel can be prepared at a temperature from 2 to 25°C, preferably 5 to 15°C, in a homogeniser fed with the aqueous suspension and the alkaline solution, which are preferably located in separate reservoirs.

The duration of the operation varies according to the equipment (which is advantageously a twin screw or a static malaxator) from, say, 3 to 4 minutes up to, say, 30 minutes. In a discontinuous modified embodiment of the preparation of the protein gel, the overall duration for which the gel is kept does not generally exceed 60 minutes. However, it is advantageous to use a continuous procedure which eliminates storage. However, the gel must mature to a certain extent in order to reach the viscosity desired for spinning. The viscosity of the gel is generally from 500 to 1,500 poises.

The protein gel is advantageously filtered in known manner in order to remove the insoluble materials, the presence of which would be troublesome during spinning.

The resulting gel is then extruded through one or more spinnerets. The spinnerets used are normally of the type employed for spinning artificial or synthetic textiles. They generally possess from 1,000 to 10,000 holes and preferably from 3,000 to 6,000 holes, the diameter of which is generally 30 to 200 microns, preferably 100 to 150 microns.

The resulting filaments are usually collected in a coagulating medium, in which the spinneret is immersed.

An organic liquid can be used as the coagulating agent, but it is preferred to use an aqueous solution of an acid, such as hydrochloric acid, acetic acid, lactic acid, nitric acid, sulphurous acid, sulphuric acid, citric acid or phosphoric acid, or an aqueous

solution of a salt, such as sodium chloride, calcium chloride or sodium acetate, or an aqueous solution of an acid and a salt, such as those mentioned above.

- 5 The concentration of acid in the bath is suitably from 0.5% to 10% by weight, but is preferably from 2 to 5% by weight. The concentration can also vary greatly in the case of the salts, typically from 0.5 to 20% by weight, but is preferably from 5 to 10% by weight. One of the preferred coagulation baths is a 4% by weight aqueous solution of acetic acid.

- 10 The temperature at which the coagulation is carried out can vary within wide limits, generally from 5 to 80°C, but is preferably in the region of ambient temperature, that is to say 20 to 25°C.

- 15 The filaments are then usually subjected to drawing; this can be achieved by a difference between the outlet speed, that is to say the speed at which the threads leave the coagulating medium, and the take-up speed, it being possible for the latter to be 20 to 200% greater than the outlet speed. The drawing causes the more or less thorough orientation of the protein chains and thus makes it possible to influence the toughness or the tenderness of the final fibre. In this way, it is possible to imitate the desired type of flesh.

- 25 The pH of the filaments leaving the coagulation bath is generally 1.0 to 4.0, this being undesirable because the food products obtained have an acid taste and are normally too dry and tough.

- 30 It is for this reason that the pH of the bundle of filaments is generally brought to a pH value from 4.5 to 6.5, preferably about 5.5, either by simple washing with water or by neutralisation with a basic agent.

- 35 The choice of the composition and of the concentration of the neutralisation bath is determined by the acidity of the coagulating bath. The neutralisation bath used can be an aqueous solution of a base, such as sodium hydroxide or potassium hydroxide, an aqueous solution of a salt, such as sodium chloride, calcium chloride, sodium bicarbonate, potassium bicarbonate, sodium carbonate or potassium carbonate, or an aqueous solution of a base and a salt, such as those mentioned above. The concentration of the neutralisation bath can vary within wide limits, typically from 1 to 10% by weight in the case of the basic compounds and from 1 to 20% by weight in the case of the neutral compounds.

- 45 Washing with water is then generally carried out in order to remove the residual inorganic salts and to complete the "neutralisation", if necessary. This washing can be carried out by, for example, passage through a bath or by trickling onto rollers. Depending on the acidity of the coagulation medium, a single washing with water can suffice, without a neutralisation stage being necessary.

50 The resulting moist fibres usually contain 50 to 80% of water.

- 55 A preferred embodiment of the invention consists in starting from protein fibres which are neutralised but which contain fat in the core of said fibres, the fat being introduced before spinning is carried out.

- 60 The fat incorporated into the proteins can be any edible fat, used singly or as a mixture; the following are most commonly used: various oils, such as

groundnut oil, olive oil, maize oil, sunflower oil, soya oil, nut oil, coconut oil, sesame seed oil, cottonseed oil, safflower oil, fish oils or palm oil, and /or animal or vegetable fats, such as butter, margarine, beef suet, lard or chicken fat.

- 70 A technique which makes it possible to introduce fat inside the fibres is described in French Patent Application No. 2,380,359, which consists in sending, separately and at suitable relative rates, the fat, kept in the liquid state, and the protein gel obtained as described above, into the feed circuit of the foremost spinneret or into a mixing device, in intimately mixing the two constituents by any mechanical means for a duration, up to spinning, of not more than 2 minutes, and in spinning the mixture prepared in this way.

- 75 The proportion of fat added to the protein gel can vary, according to the type of flesh which it is desired to imitate, from, say, 0.5 to 40% preferably from 5 to 30% by weight, relative to the proteins.

- 80 The filaments formed in this way undergo the same coagulation, drawing, neutralisation and washing treatments as described above.

- 85 A particular procedure for incorporating the fat consists in passing predetermined amounts of the protein gel and the fat, by means of metering pumps, into a gear pump, for example, in which the mixture is homogenised for a contact time of not more than 2 minutes.

- 90 It is also possible to introduce one or more lip-soluble adjuvants into the fat in accordance with the technique described in, for example, French Patent Application No. 2,415,674. Examples of adjuvants which may be mentioned are:

- 95 natural flavourings or aromatising agents, which are generally protein hydrolysates, such as ham flavour, beef flavour, pork flavour, onion flavour and fish flavour, and products extracted from the various types of meats or vegetables, insofar as they can be mixed homogeneously with the fats;
- 100 lipsoluble edible artificial flavours;
- lip-soluble antioxidants, such as ascorbyl palmitate, thioldipropionic acid, dialauryl thiopropionate and distearyl thiopropionate;
- 105 lipsoluble vitamins, such as vitamin A, pro-vitamin A or β -carotene, vitamin D and vitamins B1 and B12; flavour boosters or taste boosters; emulsifiers; and lipsoluble colourings.

- 110 The normal proportions of lipsoluble adjuvants in the fat should be such that they satisfy two conditions. Firstly, the mixture of fat and lipsoluble adjuvant should be homogeneous. Secondly, the weight ratio lipsoluble adjuvant/proteins should be from 0 to 0.15:1. Preferably, the weight ratio lipsoluble adjuvant/proteins is 3 to 6%.

115 The lipsoluble adjuvant or adjuvants are suitably dissolved in the fat before the latter is dispersed in the protein gel.

- 120 Other ingredients can be added during the steps preceding the impregnation operation, such as colourings or taste correctors or agents for modifying the resulting texture. For example, if they are water-soluble, the colourings can be added to the protein dispersion or to the neutralised fibres.

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Consequently, the process of the invention can be applied to a roving of filaments which may or may not contain the various abovementioned additives, but which have been brought to the desired pH at the outlet of the coagulating bath. As the fibres have a high water content, which can be 80% or more, part of this is preferably removed before processing is continued. The fibres can in this case be passed between squeezing cylinders to bring their moisture content down to, say, 60 to 70%.

On leaving the squeezing cylinders, the roving of fibres is generally in the form of a flat strip, the dimensions of which depend on the number and the characteristics of the fibres. The thickness of a roving containing from 3,000 to 6,000 fibres having a diameter of 50 to 100 microns is preferably from 0.5 to 5 mm and its width is from 20 to 60 mm.

The roving of fibres is then impregnated with an edible binder. However, the roving of fibres is preferably "opened" beforehand in order to facilitate their contact with the binder. Any system which makes it possible to render the roving less compact, by separating the fibres under the action of a stress or under the action of a stream of inert gas, can be used.

The binder is applied to the roving in order to bind the individual fibres and to ensure the resemblance between the fibrous texture of the resulting product and that of a meat. It is chosen according to the final characteristics of the product which it is desired to imitate, and according to the purpose for which it is intended, namely whether the final product is to be consumed hot or cold.

The edible binder may be any edible substance which can be applied to the fibres and which is capable of being hardened in order to bind the fibres in the form of a coherent mass.

Various suitable binders have been described in the literature. In order to reproduce the texture of meat more closely, it is preferable to use substances which can coagulate, such as the various albumins, such as egg albumin, fish albumin, soya albumin or wheat albumin, or cereal glutes, such as wheat gluten or rye gluten, blood plasma or cellulosic ethers.

The binder is preferably egg albumin, alone or in a mixture with other substances, in particular gluten and milk seroproteins. A binder of this type is described in French Patent Application No.

2,389,334. A preferred composition comprises from 1 to 5% by weight of albumin, calculated in terms of dry product, from 10 to 20% by weight of wheat gluten and from 10 to 20% by weight of milk seroproteins. An edible liquid, which is most frequently water, is used in a sufficient amount to make up the binder composition to 100%. These proportions are, of course, given by way of indication only.

Any ingredient can also be added to the binder, for example flavours, spices, colourings, preservatives, vitamins, emulsifiers and, if appropriate, fat.

It is desirable to add flavourings to give the final product a good meat taste. Various flavours with a taste of meat, beef, chicken, fish, crustaceans and the like, and also synthetic flavours with a taste of salt pork or smoked pork, are commercially available.

The colour of meat can be reproduced by incorporating permitted food colourings. Colourings which may be mentioned are carotenoids, canthaxanthine, cochineal, carmine, caramel and pigments.

The binder can therefore contain flavours, spices and colourings in various proportions which are given below by way of indication; up to 4% by weight of flavours, up to 4% by weight of natural or artificial colourings and up to 2% by weight of spices.

The binder can be present in a liquid composition or in an emulsion, which usually contains from 20% to 70% of solids.

It is used in an amount such that it produces a product having fibres which are bound to one another in a structured and stable manner, in order to acquire a cohesion which withstands the subsequent treatments, such as the various methods of cooking or preparation. The weight ratio of the moist spun proteins to the binder is typically from 4/ to 1/ and is preferably about 1/1. This ratio corresponds to protein fibres containing from 60 to 70% by weight of water.

The roving of fibres can be impregnated by circulating the roving of fibres in a bath containing the binder, but it is preferable to apply or spray the binder onto the roving of fibres.

Impregnation is suitably carried out at a temperature from 10°C to 30°C, depending on the nature of the binder.

The impregnated roving of fibres constitutes what has been referred to as a "web". The process of the invention consists in joining the longitudinal sides of the web in a substantially circular movement in order to envelop the binder inside the web of fibres. This gives a strand of fibres containing the binder in the core, and this is then generally subjected to coagulation.

The binder can obviously be coagulated using conventional heating techniques (oven or infra-red), but it is preferable to carry out a heat treatment of the microwave type in order to avoid hardening the roving of fibres on the outside.

The strand of fibres can be heated by means of electromagnetic waves. The treatment temperature is preferably at 80 to 100°C and the exposure time varies from 1 second to 5 seconds and is preferably about 2 seconds.

The protein fibres then generally contain from 60 to 70% of water.

The coagulated binder rigidifies the structure of the whole, both the protein fibres, and additives if present.

The resulting strand can then be chopped into sections of the desired length.

The bound fibres should then be conditioned in the customary manner. The resulting products can be deepfrozen, canned or alternatively dried in accordance with conventional techniques.

Suitable equipment or apparatus for carrying out the process will now be described with reference to Figure 2.

A roving of protein fibres 3 is initially squeezed, for example by being passed between two squeezing rollers 4 and 5, the separation of which is set so as to

give fibres having the desired moisture content.

The roving of fibres is then directed onto take-up roller 6, which makes it possible to convey the roving at the desired speed and which serves as a coating support. The roving should be conveyed along a generally horizontal path.

The take-up roller 6 can be a simple roller, the width of which is at least equal to that of the roving. It can be made of any material, such as stainless steel, nylon or polytetrafluoroethylene, but it is preferably provided with a flexible edible coating of the elastomeric type. It is driven at a set speed which depends on the movement which it is desired to impart to the roving 3. Its speed is therefore adjustable and can vary, for example, from 8 to 10 m/minute.

In a preferred embodiment of the equipment of the present invention, the take-up roller 6 possesses a central groove 7, the width of which is approximately equal to the width of the roving. The depth of the groove 7 is not critical and depends on the thickness of the impregnated roving. The groove provided in the take-up roller prevents any binder from overflowing.

It should be noted that it is sometimes necessary to add guide rollers on either side of the roving in order to hold it and introduce it into the groove. The rollers are not shown in Figure 2.

It is obvious that the take-up roller 6 can be replaced by any other device performing the same function. At the outlet of the squeezing rollers, it can be envisaged to collect the roving on a first conveyor belt driven by a second conveyor belt, which is conveniently an endless belt passing over two rollers, one of which is driven by a suitable control device. The first conveyor belt also acts as a coating support.

Upstream of a device, 9, for applying the binder, it is advantageous to place a system intended for opening the roving. A device 8 for opening the roving advantageously consists of a set of discs, which are applied to the roving and penetrate it so as to spread it out. Device 8 thus comprises discs mounted on a rotating axle and arranged in a plane perpendicular to the rotating axle. The discs are preferably independent of one another. The two faces of the disc can be chamfered, but the central portion should be blunt so as not to damage the roving. The number of discs mounted depends on the thickness of the discs and on the width of the roving to be opened.

Rather than one device 8, it is obviously possible to place several in succession.

It is also possible to open the roving by introducing it into a tube provided with openings which enable streams of gas, generally air, to be introduced from a source of supply, the said streams of gas thus being directed transversely relative to the roving. The nature of the device 9 used for applying the binder to the roving of fibres is not particularly critical provided it makes it possible uniformly to deposit, on the said roving, a fluid paste of the binder.

It is connected to a storage reservoir 10, containing the binder, via supply tube 11.

The reservoir 10 can also quite simply be a malax-

ating device for preparing the binder and which can be, for example, a planetary malaxator, a sigma malaxator, a ribbon mixer, a twin-paddle malaxator or a Hobart malaxator.

In order to regulate the flow rate of the binder, it is desirable to place a pump 12, preferably a metering pump, upstream of the device 9.

Figure 3 shows a device 9, hereafter referred to as an applicator, which is suitable for applying the binder. It consists of a flat central part 13 provided with an opening 14 at which a central tube 15, mounted on the supply tube 11, terminates. The shape of the opening can vary; for example, it can be circular or it can consist of a slot.

An improved modified embodiment of the applicator is shown in Figure 4 where the central part 13 is equipped with two sideplates 16 and 17, the shape of which is such that they match the radius of curvature of the take-up roller 6. In a simplified manner, they have a substantially triangular shape.

The dimensions of the applicator can easily be determined by those skilled in the art, with the knowledge that the width of the part 13 is approximately equal to the width of the roving. The material of which the devices of Figures 3 and 4 are made is chosen so that they are resistant to oxidation, for example stainless steel or an aluminium-based alloy.

At the outlet of the device 9, as shown in Figure 2, the roving of fibres is introduced into a device 18, which is also referred to as a converger, the function of which is to join up the edges of the roving in order to trap the binder, and to effect compression in order to cause the binder to penetrate into the roving.

The device 18 is generally a block of material having any external shape, for example a cubic, parallelepipedal or cylindrical shape. A cylindrical cavity is pierced over its whole length. However, the cavity 19 is preferably frustoconical, as shown in Figure 5, in order to reduce the number of points where the roving rubs on the internal walls of the cavity. As shown in Figure 6, orifice 20 for introduction of the roving is larger than its outlet orifice 21, but they both have a circular or elliptical shape, preferably a circular shape.

The size of the orifice 21 depends on the size of the roving which it is desired to obtain.

If the orifices 20 and 21 are circular, it is possible, for example, to choose the diameter of the orifice 20 to be 1.5 to 3 times greater than that of the orifice 21.

In an improved version shown in Figure 7, the converger, which possesses the same characteristics as those described above, is no longer monolithic but consists of two identical parts 22 and 23, joined by an articulated joining system 24 of the hinge type and by any closing system (clip or bolt, not shown).

The use of the device of Figure 7 permits a good positioning of the roving when the installation is being started up since it is simpler to pass the roving through the device if it can be opened up.

The convergers of Figures 6 and 7 are preferably made of a material having a low coefficient of friction, for example polytetrafluoroethylene, polyvinyl chloride or polyamide, or alternatively polished stainless steel or an aluminium-based alloy, for

example.

Of course the device can have a different configuration, but it must make it possible to enclose the binder in the roving, such as an open converger consisting of a single element (22 or 23).

The converger 18 can be positioned either vertically, as shown in Figure 2, or horizontally in the case where the roving is kept horizontal. In all cases, the roving 3 enters through the orifice 20 in the form of a strip and leaves through the orifice 21 in the form of a strand 25. It is then introduced into device 26 where the coagulation of the binder takes place.

A microwave oven is preferably used. The power of this oven is generally from 5 to 50 Kw, depending on the amount of material used, the nature of the constituents and their electrical characteristics, and also on the speed of the impregnated roving. The frequency of the oven is usually $2,450 \text{ MHz} \pm 25$.

On leaving the oven, the binder has become coagulated.

The final product, shown in Figure 1 is in the form of a strand, the circular or elliptical cross-section of which shows 3 concentric zones; the peripheral zone 1 and the inner zone 2 consist essentially, and respectively, of protein fibres and coagulated pure binder, whilst the intermediate zone 1 bis groups consists of protein fibres and coagulated binder, which is referred to as "interpenetration binder". The existence of the zone 1 bis makes it possible to provide the assembly with good cohesion. The relative size of the zones can vary according to the desired cohesion; in particular, the zone 1 can be reduced to a minimum.

The products obtained according to the invention have a pleasant texture and have a structure which is generally sufficiently stable to withstand the various culinary processing operations.

These products can be presented in various ways, depending on whether the protein fibres are coloured, but not the binder, and vice versa, or whether the protein fibres and the binder are coloured with colourings which can be different.

Depending on the flavours, colourings, spices and fats which may be incorporated, these products can have the taste and the appearance of any animal flesh, that is to say either the flesh of mammals or that of fish, birds or crustaceans.

Animal meat substitutes can thus be provided which possess substantially all the qualities of the natural products whilst at the same time being less expensive than the latter.

The following Examples further illustrate the present invention. The percentages expressed in the Examples are given by weight.

EXAMPLE 1

The roving of fibres to be impregnated is a roving of vegetable proteins, consisting of 5,012 fibres having a diameter varying from 70 to 80 microns. The width of the roving of fibres is 50 mm.

The fibres are soya fibres obtained in accordance with a conventional process and having the following characteristics, given for 100 g:

water content after squeezing	70 %
soya isolate	25.5%
fat (sunflower oil)	4.5%

pH 5.6 Reference will be made to Figure 2 for the description of the equipment.

The roving of fibres is initially squeezed by being passed between two rollers 4 and 5 having a width of 200 mm and a diameter of 100 mm.

It is then directed onto the take-up roller 6 having a width of 150 mm and a diameter of 400 mm. This roller is provided with a rubbery coating and possesses a central groove 7 having a width of 50 mm and a depth of 5 mm, into which the roving is introduced. The roller 6 is connected to a motor set at a speed of 10 m/minute.

A device 8 for opening the roving bears on the roller 6. It consists of a set of 10 stainless steel discs arranged in a plane perpendicular to the rotating axle.

The discs are independent of one another and have a diameter of 40 mm and a thickness of 5 mm.

The device 8 is applied to the roving in order to spread it out.

When the roving has been opened, the binder is applied with the aid of an applicator 9, the said binder consisting of:

drinking water	62%
vital gluten	15%
milk seroproteins (obtained by ultra-filtration of milk)	18%
ovalbumin (dried egg white)	5%

The applicator used is symbolised by Figure 4.

This device is made of stainless steel and consists of a central part 13 having a length of 50 mm and a width of 40 mm, at which a central tube 15 for the introduction of binder, having an internal diameter of 14 of 6 mm, terminates. Furthermore, it possesses two sideplates 16 and 17 of triangular shape, the base of which is 10 mm.

The amount of binder deposited represents, by weight, an amount equal to that of the roving, the amounts being expressed as solids in both cases.

The roving is thus impregnated continuously with the binder and is then introduced, according to Figure 2, into the device 18, or converger, as shown in Figure 7. The said device is in a vertical position.

The converger used is a "Teflon" cube having a side length of 50 mm, which is pierced with a frusto-conical passage constituting the cavity 19 into which the roving of fibres is introduced. The two orifices are thus circular, the orifice 20 for introduction of the roving having a diameter of 30 mm, whilst the diameter of the outlet orifice 21 is 13 mm.

The roving 25, which is then in the form of a strand, is passed into a microwave oven having a power of 5,000 watts, and resides in the oven for 2 seconds.

This gives a well-bound cylindrical roving having a diameter of about 12 mm.

The roving is then chopped into pieces having a length of 3 cm, the composition of which is as follows:

water content	65 %
soya isolate	16.07%
fat	2.87%
vital gluten	5.42%
milk seroproteins	7.60%

ovalbumin solids 3.04%

EXAMPLE 2

An experiment is carried out in the manner described in Example 1, but 15% of a beef flavour is introduced into the binder.

The application of the binder and its coagulation are carried out in an identical manner.

The strand obtained at the outlet of the microwave oven is chopped into pieces having a length of 14 cm.

These pieces can be moulded in order to reconstitute a piece of meat.

CLAIMS

1. A food product in the form of a coherent body of spun vegetable and/or animal protein fibres, adhered together with an edible binder such that the fibres are substantially unidirectional and form a closed web with a core of edible binder.

2. A food product according to Claim 1 in which the spun protein originates from an isolate of soya, sunflower, horsebean or pea or milk casein.

3. A food product according to Claim 1 or 2 in which the edible binder is capable of coagulating under the action of heat.

4. A food product according to any one of Claims 1 to 3, which is in the form of a strand, comprising a peripheral zone of protein fibres, an intermediate zone of protein fibres and coagulated binder, and an inner zone of coagulated binder.

5. Process for the manufacture of a food product as claimed in one of the preceding claims which comprises impregnating a roving of protein fibres with an edible binder, shaping the impregnated web by joining the longitudinal sides of the web in a substantially circular movement in order to envelop the binder inside the web, and coagulating the binder.

6. Process according to Claim 5, in which the roving of fibres is partially separated before impregnation.

7. Process according to Claim 5 or 6, in which the binder is applied uniformly to the web of fibres.

8. Process according to any one of Claims 5 to 7, in which the binder is coagulated under the effect of a heat treatment of the microwave type.

9. Process according to claim 5 substantially as described in Example 1 or 2.

10. Equipment suitable for the preparation of a food product as claimed in one of Claims 1 to 4 which comprises means for conveying a roving of protein fibres, means for impregnating the roving with a binder, means for shaping the impregnated web into a coherent body and means for coagulating the binder.

11. Equipment according to Claim 10 which comprises means for opening the roving of protein fibres.

12. Equipment according to Claim 10 or 11, in which the means for conveying the roving comprises a take-up roller possessing a central groove, the width of which is approximately equal to the width of the roving.

13. Equipment according to any one of Claims 10 to 12, in that the means for opening the roving comprises a set of discs mounted on a rotating axle and arranged in a plane perpendicular to the rotating

axle.

14. Equipment according to any one of Claims 10 to 13, in which the means for impregnating the roving with binder comprises an applicator consisting of a flat central part provided with an opening capable of receiving a supply of binder.

15. Equipment according to Claim 14 in which the said central part is equipped with two sideplates.

16. Equipment according to any one of Claims 10 to 15, in which the means for shaping the roving comprises a block of material provided with a frusto-conical cavity (9) passing through said block.

17. Equipment according to Claim 16 in which the block comprises two identical parts joined by an articulated joining system and by a closing system, said articulation being parallel to the axis of the cavity.

18. Equipment according to any one of Claims 10 to 17 in which the means for coagulating the binder comprises a microwave oven.

19. Equipment according to Claim 10 substantially as described with reference to Figures 2 to 7 of the accompanying drawings.

20. Process according to any one of Claims 5 to 9 carried out in equipment as claimed in any one of claims 10 to 19.

21. A food product as defined in Claim 1 whenever manufactured by a process as claimed in any one of claims 5 to 9 and 20.

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