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NON-FAT NATURAL CHEESE
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- (57) Claim

1. A method for making a non-fat milk solids substrate suitable for manufacture of natural cheese, including the steps of:
 - (a) acidifying a first non-fat milk solids source to a pH below the isoelectric point of casein;
 - (b) providing a blend of the acidified non-fat milk source and a gum, the gum being present in amounts to provide a ratio of gum solids to protein in the range from about 0.1:1 to 0.5:1;
 - (c) subjecting the blend to high shear, high energy mixing to provide a dispersion of the gum in the casein of the non-fat milk solids source; and
 - (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.
2. A method for making a non-fat milk solids substrate for manufacture of natural cheese, including the steps of:

- (a) providing a blend of a gum and water;
 - (b) subjecting the blend to high shear, high energy mixing;
 - (c) combining the blend, after the mixing step, with a first liquid non-fat milk solids source which has been acidified to below the isoelectric point of casein to provide a dispersion of the gum in the casein of the non-fat milk solids source; and
 - (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids source substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.
19. A method for manufacture of a non-fat natural cheese, as hereinbefore defined, including the steps of:
- (a) providing a non-fat solids source in accordance with the method of either claims 1 or 2;
 - (b) inoculating the non-fat milk solids source with a culture system consisting of a coccus culture and a rod culture;
 - (c) forming a coagulum from the inoculated non-fat milk solids source and cutting the coagulum to provide curd and whey;
 - (d) stirring the curd in the whey;
 - (e) recovering the curd from the whey and curing the curd to provide a natural cheese.

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(21) International Application Number: PCT/US91/05789 (22) International Filing Date: 14 August 1991 (14.08.91) (30) Priority data: 567,281 14 August 1990 (14.08.90) US 639,990 11 January 1991 (11.01.91) US (71) Applicant: KRAFT GENERAL FOODS, INC. [US/US]; Kraft Court, Glenview, IL 60025 (US). (72) Inventors: KERRIGAN, Gary, L. ; 1428 Chippewa Trail, Wheeling, IL 60090 (US). HETH, Alice, A. ; 404 Lee Street, Evanston, IL 60202 (US). HAMANN, Alan, C. ; 2270 Greenview Road, Northbrook, IL 60062 (US).		(74) Agents: MELLER, Michael, N. et al.; Meller & Associates, P.O. Box 2198, Grand Central Station, New York, NY 10163 (US). (81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> 659999
(54) Title: NON-FAT NATURAL CHEESE (57) Abstract The present invention is directed to a non-fat natural cheese which is made from a first non-fat milk solids substrate which is made into cheese by various known methods. In the method for making the substrate, a non-fat milk solids source, such as skim milk, is acidified to a pH below the isoelectric point. A blend of the acidified non-fat milk solids source and gum is then prepared. The blend is then subjected to high pressure homogenization to provide a dispersion of the gum in the casein of the non-fat milk solids source. Alternatively, the gum may be dispersed in water and be subjected to high pressure homogenization prior to blending the gum with the acidified skim milk. In this embodiment, only mild low shear mixing is required to provide a dispersion of the gum in the casein of the non-fat milk solid source. The casein/gum dispersion is then combined with a second non-fat milk solids source to provide a non-fat milk solids substrate. The substrate can then be used to prepare non-fat natural cheese by various known methods.		

NON-FAT NATURAL CHEESE

Introduction

The present invention relates to the manufacture of natural cheese from a non-fat milk source. More particularly, the present invention relates to a process for the manufacture of non-fat natural cheese from a non-fat milk solids source, such as skim milk, wherein a portion of the skim milk is blended with a gum and treated under conditions conducive to forming a uniform dispersion of the gum throughout the casein of the skim milk. The treated portion of skim milk is combined with additional untreated non-fat milk solids source, such as skim milk, to provide a non-fat milk solids substrate suitable for the manufacture of natural cheese.

Background of the Invention

Natural cheese is the term used in the cheese making art to describe varieties of cheese which are made from various milk sources, such as whole milk and milk adjusted to various fat levels with cream, wherein the milk source is set, either by microorganisms alone or by a combination of microorganisms and a milk coagulating enzyme, such as rennet, and which involves a whey drainage step. Well known examples of natural cheese are Swiss cheese, American-type cheeses, such as Cheddar cheese, Colby cheese, stirred curd cheese, washed curd cheese and the Pasta filata cheeses, such as Mozzarella, Provolone and Scamorze.

In accordance with the present invention, a treated non-fat milk solids substrate is provided which can be used in any of the well known natural cheese make procedures to provide a non-fat natural cheese with



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texture, taste and organoleptic properties similar to that of natural cheese made with milk containing fat. Typical examples of natural cheese processes are those for Swiss cheese, stirred curd Cheddar cheese and

5 Mozzarella cheese, which are described hereinbelow.

In the manufacture of Swiss cheese, three species of bacteria have conventionally been used as starters during a fermentation period: these being a coccus culture, a rod culture and a propionic acid

10 forming microorganism. Usually, Streptococcus thermophilus is used as the coccus culture; Lactobacillus bulgaricus or Lactobacillus helveticus is used as the rod culture; and Propionibacterium shermanii is used as the propionic acid-forming microorganism. A

15 milk clotting enzyme, such as rennet, is also used and added in an amount such that curd firm enough to cut is formed in about 30 minutes. The fermentation proceeds at a temperature of from about 88° F. to about 94° F. Curd is cut and worked for about 30 minutes to an hour. The

20 curd is then heated over a period of about 30 minutes to a cooking temperature of between 120° F. and 128° F. The curd is stirred at the cooking temperature for about 30 minutes to an hour. The curd is pressed under the whey, and the whey is then removed. The curd is pressed into

25 blocks for curing to produce Swiss cheese with typical eye formation. The time required for fermentation, working and cooking is usually less than 3 hours.

In the manufacture of Cheddar cheese by the stirred curd method, milk is pasteurized at a temperature

30 of 162-164° F. for a holding time of 16 to 18 seconds. The milk is introduced into a cheese vat and a lactic starter, such as S. lactis, is added to the vat. Fermentation and ripening takes place at a temperature of 87° to 88° F. for a period of about 60 minutes. Rennet

35 is added and coagulation occurs in a further 30 minutes. The curd is cut into particles over a period of about 15

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minutes and is then cooked at a temperature of 38°C. to 39°C. (101°F. to 103°F.) for 30 minutes. The curd is stirred out in the whey for a period of 30 to 75 minutes. The curd and whey are then transferred to a drain table, where the whey drains over a period of about 30 minutes. The curd on the drain table is sprayed with water at a temperature of 41°C. (105 °F.) for a period of 2 to 4 minutes. Salt is added and the curd is allowed to rest on the drain table for a period of about 10 minutes. The curd is then transferred to a container, usually a 290 kg. (640 lbs.) container, where the curd is pressed under vacuum for a period of 75 minutes. The 290 kg. (640 lbs.) block of Cheddar curd is then transferred to a cooler after a resting period of about 24 hours. The curd is held in the cooler at a temperature of 5°C. (40°F.) for 10 days and is then cured an additional period of 21-45 days at a temperature of 5°C. to 7°C. (40°F. to 45°F.).

Pasta filata cheeses, such as Mozzarella, have traditionally been made by a process wherein the curd is pulled or stretched under hot water or hot whey by use of a paddle or by hand. Modern high production techniques for manufacture of such cheeses, however, utilize an inclined twin auger screw for transporting and stretching the curd under hot water to produce the cheese. In a typical process for manufacture of Mozzarella cheese, milk or partially skimmed milk at a temperature of about 31°C. (88°F.) is acidified to a pH of 5.2-5.5, usually by the addition of acetic acid. The milk is then set to provide coagulum by the addition of rennet and calcium chloride. The coagulum is cut to provide curd and whey and the curd can be cooked in the whey at a temperature of up to 44°C. (110°F.). The curd is usually stirred in the whey for a period of 15 to 45 minutes. The curd is allowed to settle and the whey is drained. The curd is then milled and transferred to an inclined, twin auger conveyorcooker, where it is



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transported and worked under hot water maintained at a temperature of 55°C. to 71°C. (130°F. to 160°F.) over a period of from 30 seconds to 2 minutes. The worked curd is molded into desired shapes, which are then placed in brine for a period of 1-12 hours to provide the Mozzarella cheese. The Mozzarella cheese is then packaged for distribution.

The term "natural cheese" is to be distinguished from the term "processed cheese". Processed cheese generally refers to a class of cheese products which are produced by comminuting, mixing and heating lots of natural cheese into a homogeneous plastic mass. The comminuted cheese is blended and set to cookers or the like which commonly heat the mass to a temperature of 74°C. to 85°C. (165°F. to 185°F.). During cooking, fat is stabilized with the protein and water by the addition of emulsifying salts, such as citrate or phosphate salts, usually at about a 3% level. The salts cause the protein to become more soluble. Under these circumstances, a stable emulsion of protein, fat and water occurs to provide a smooth, homogeneous mass. The hot mass is packaged directly or formed into slices and packaged. In the United States, Standards of Identity apply to classes of processed cheese and are established by the Food and Drug Administration (FDA). Certain of these classes can contain various additives, such as cream, skim milk, buttermilk, cheese whey and skim milk cheese. The moisture content of processed cheese under the Standards of Identity may range from less than 40% to 60%, and the fat content may range from 20% to 35%. The pH range for processed cheese products typically is between 5.0 and 6.5.

While methods are known for making process cheese from skim milk, there has been substantial technical effort directed to methods for producing a natural cheese from a non-fat milk solids source, such as skim milk. It has been proposed to produce non-fat cheese from skim milk by subjecting the skim milk to

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membrane processes to increase the solids level of the skim milk, followed by evaporation processes to produce a substrate having the required level of solids to produce a natural cheese. The production of a natural cheese from skim milk, however, is complicated by the fact that the fat is no longer present in the protein matrix. Cheese has a protein matrix which is broken up by fat particles. When the fat particles are not present, the cheese protein matrix becomes very firm and the texture and feel of the cheese is completely different from that normally associated with natural cheese.

Summary of the Invention

According to the invention, there is generally provided a method for making a non-fat milk solids substrate suitable for manufacture of natural cheese, including the steps of:

- (a) acidifying a first non-fat milk solids source to a pH below the isoelectric point of casein;
- (b) providing a blend of the acidified non-fat milk source and a gum, the gum being present in amounts to provide a ratio of gum solids to protein in the range from about 0.1:1 to 0.5:1;
- (c) subjecting the blend to high shear, high energy mixing to provide a dispersion of the gum in the casein of the non-fat milk solids source; and
- (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.

The invention further provides a method for making a non-fat milk solids substrate for manufacture of natural cheese, including the steps of:

- (a) providing a blend of a gum and water;
- (b) subjecting the blend to high shear, high energy mixing;
- (c) combining the blend, after the mixing step, with a first liquid non-fat milk solids source which has been acidified to below the isoelectric point of casein to provide a dispersion of the gum in the casein of the non-fat milk solids source; and



- (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids source substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.

The invention also provides a method for manufacture of a non-fat natural cheese, as hereinbefore defined, including the steps of:

- (a) providing a non-fat solids source in accordance with either of the methods indicated above;
- (b) inoculating the non-fat milk solids source with a culture system consisting of a coccus culture and a rod culture;
- (c) forming a coagulum from the inoculated non-fat milk solids source and cutting the coagulum to provide curd and whey;
- (d) stirring the curd in the whey;
- (e) recovering the curd from the whey and curing the curd to provide a natural cheese.

Brief Description of the Drawings

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

Figure 1 is a microphotograph of the substrate made from the blend of non-fat milk solids sources and xanthan gum prior to high shearing high energy mixing;

Figure 2 is a microphotograph of the substrate made from the blend of a non-fat milk solids sources and xanthan gum after three passes through a high shear, high energy mixer;

Figure 3 is a photomicrograph of a thin section of a natural Cheddar cheese prepared from milk containing milk fat; and

Figure 4 is a photomicrograph of a thin section of a natural cheese made from the non-fat solids substrate of the information.

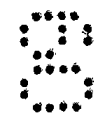
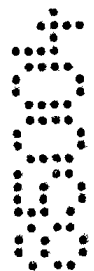
Detailed Description of the Invention

The present invention is directed to a method for making a non-fat milk solids substrate suitable for manufacture of non-fat natural cheese. In this connection, while the cheese products



of the present invention are characterised as being non-fat products, from a practical standpoint it is impossible to remove all butterfat from milk in ordinary commercial cream separation processes. Usually, a few tenths of a percent of butterfat remains in the skim milk after separating cream from the milk in the most efficient separators. When the skim milk is further concentrated, such as by removing whey during the cheese make procedures of the invention, the butterfat content is increased in proportion to the degree of concentration. The non-fat natural cheese products of the invention may contain up to about 1.7% fat. Therefore, the term "non-fat natural cheese product" as used herein, means natural cheese products which may contain up to about 1.7% butterfat.

10 Generally, in accordance with the invention, a non-fat milk solids source is acidified to a pH below the isoelectric point of casein. The non-fat milk solid source can be selected from skim milk, skim milk concentrated by evaporation, a skim milk retentate, reconstituted dried skim milk and mixtures thereof. Preferably, the non-fat solids are present in the non-fat milk solid source at a level of from about 5% to about 30%. All percentages used herein are by weight and
15 all temperatures are degree Fahrenheit unless otherwise indicated.



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The principal protein of non-fat milk solids, of course, is casein. Casein is a heterogeneous, phosphoprotein containing three electrophoretically distinct components designated, α , β and δ casein, in order of decreasing electromobility. These comprise, 80, 15 and 5% of whole casein, respectively, based on electrophoretic analysis. The casein components are colloidally distributed as polydispersed stable micellar aggregates in association with calcium and phosphate, and lesser amounts of magnesium and citrate. The total complex is generally referred to as the calcium caseinate, calcium phosphate complex. The casein micelles may be considered as a swollen, microscopic polyelectrolyte gel, containing an excess of 66% water, of which approximately $\frac{1}{4}$ is chemically bound. Micelle size dispersion is modulated by a generally reversible equilibrium with the calcium, phosphate, citrate and magnesium ions in the milk serum.

In contrast to the milk serum proteins, i.e., whey protein, and native proteins generally, casein is markedly insoluble at its isoelectric point of pH 4.6, a value determined by solubility and electrophoretic activity. Although, electrophoretically, the isoelectric point is rather sharply defined, coagulation of milk is usually initiated by acidification to a pH of 5.3 and is complete as the pH passes through 4.7 to pH 4.6. For practical purposes, it is more appropriate to refer to a region of isoelectric precipitation of casein. Consequently, acidification of milk to pH 4.6 yields a coagulum of whole casein, inclusive of the various casein components that comprise the micelle. In the isoelectric state, the oppositely charged groups in casein are balanced by equal dissociation and the net free charge is eliminated. On the alkaline side of the isoelectric point, the negatively charged groups of casein predominate, evidenced by its mobility toward the anode

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under an applied electrical field. The converse situation, i.e., predominance of positively charged groups, prevails in casein solutions acidic with respect to the isoelectric value.

5 In accordance with the invention, the non-fat milk solids source is acidified to a pH below the isoelectric point of casein, that is, to a pH below about 4.6. While a coagulum forms at the isoelectric pH, the non-fat milk solid source may be maintained in a fluid
10 condition by constant agitation as the pH is lowered through pH 4.6. The non-fat milk solids source is preferably acidified to a pH in the range of from about 3.8 to about 4.6, most preferably from about 4.1 to about 4.3. The pH may be lowered by fermentation with a lactic
15 acid producing culture, such as S. lactis or by addition of a suitable edible acid, such as acetic acid, lactic acid, glucono delta lactone, hydrochloric acid and phosphoric acid.

 In one embodiment of the invention, after the
20 non-fat milk solids source has been acidified, a suitable gum is blended with the acidified non-fat milk solids source under conditions of high shear. Preferably, the gum is added through a powder funnel connected to a pump provided with a centrifugal rotor. The gum is metered
25 into the acidified non-fat milk solid source as the source is pumped through the system. The gum is added at a level sufficient to provide a ratio of gum solids to protein in the range of from about 0.1:1 to about 0.5:1, preferably at a ratio of about 0.3:1.

30 The gum may be any of the edible hydrocolloid gums normally associated with the manufacture of food products. Suitable gums include xanthan gum, guar gum, the seaweed gums, such as agar and the various carrageenans, locust bean gum, tragacanth, pectin, gum
35 karaya and carboxymethyl cellulose. The preferred gum, for reasons of cost and availability is xanthan gum.

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Various aspects of the invention may, therefore, be described utilizing xanthan gum as the preferred gum of the invention.

By "xanthan gum" is meant the heteropoly-
5 saccharide produced by fermentation of the microorganism of the genus Xanthomonas. A discussion of the physical and chemical properties of xanthan gum may be found in Industrial Gums, R.L. Whistler, Ed., Academic Press, N.Y. (1973), p. 473.

10 Xanthan gum in aqueous solution with an appropriate counterion, such as sodium, is highly negatively charged because its side chains are composed of charged glucuronic acid, mannose and its pyruvate derivative. The structure of xanthan gum is set forth in
15 U.S. Patent 4,559,233 to Chen, et al.

In a subsequent step of the method of the invention, the gum/non-fat milk solids blend, after homogenization, is combined with a second non-fat milk solids source to provide the substrate of the invention
20 which is used to produce a non-fat natural cheese. It has been determined that if the gum is added to the entire amount of a non-fat milk solids source required to produce the non-fat cheese, that the gum inhibits subsequent clotting of the non-fat milk solids source to
25 provide a coagulum in the cheese make procedure. It is also not possible to use hydrated gum, i.e., a gum simply combined with water, prior to addition to the entire amount of non-fat milk solids source. Such hydrated gum passes out of the cheese make procedure with the whey
30 drainage step.

While not wishing to be bound by any theory, it is believed that the highly negatively charged gum is caused to react with the casein having a predominance of positively charged groups at the pH of the first non-fat
35 milk solids source during the subsequent homogenization step. In this connection, a particular type of

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homogenization is used to cause such interaction. It is believed that the interaction causes the complex gum structure to become dispersed in the casein network in much the same manner that fat particles are dispersed in the manufacture of cheese by conventional procedures using milk containing butterfat.

After the blend of xanthan gum and non-fat milk solid sources has been formed, the blend is subjected to high energy, high shear mixing. This step may be effected at ambient temperature. The blend, however, is preferably heated to a temperature of between about 32°C. to 66°C. (90°F. to about 150°F.), preferably from about 52°C. to 63°C. (125°F. to 145°F.). At temperatures higher than the indicated range, crosslinking of protein can occur during the subsequent homogenization step. At temperatures lower than the indicated preferred range, the dispersion of xanthan gum in the casein is more difficult to obtain.

After heating, the blend of xanthan gum and non-fat milk solids source is passed through a suitable high shear, high energy mixing device. A suitable homogenization device is a Rannie homogenizer, manufactured by the Rannie Manufacturing Company of Denmark. The Rannie homogenizer may be operated at homogenization pressures of from about 143567.5 g/cm² to about 1054605 g/cm² (2,500 psig to 15,000 psig). Preferably, homogenization pressures from about 632763 g/cm² to about 9491445 g/cm² (9,000 psig to 13,500 psig) are used. While high shear mixing step is described in terms of a homogenization step, any suitable high shear mixer capable of providing high shear, high energy properties may be used. For example, a commercial blender type mixer can be used, but long mixing times of 30 minutes to an hour are required to obtain the desired dispersion of the gum.

During passage through the high shear, high energy homogenizer at the preferred homogenization pressures, the temperature of the blend increases by an amount of from



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about -1°C . to 5°C . (30°F . to 45°F .). It is generally desirable to repeat the high shear mixing step at least twice and preferably from two to four times. Therefore, the blend after exiting from the high shear mixing step is preferably cooled to within the range that it entered the high shear mixing device, i.e. at a temperature of from about ambient to about 66°C . (150°F .). At homogenization pressures below about 632763 g/cm^2 ($9,000\text{ psig}$), more repetitions are desirable and the homogenization step may be repeated as many times as are found to be necessary to obtain desired dispersion of the gum.

In another embodiment of the invention, the gum may be blended with water and subjected to high shear, high energy homogenization, as described hereinabove, prior to blending the gum with the acidified non-fat milk solids source. In this embodiment, the gum is added to the water at a level of from about 0.8% to about 1.5%. After being subjected to high shear, high energy homogenization, the aqueous gum blend is added to the acidified non-fat milk source with mild low shear mixing, such as with a propeller mixer, to cause the gum to become dispersed in the casein network as previously described. The homogenized, aqueous gum blend is added to the acidified non-fat milk source at a level sufficient to provide a ratio of gum solids to protein in the range of from about 0.1:1 to about 0.5:1, preferably at a ratio of about 0.3:1.

As shown in FIGURE 1, the non-fat milk solids source, after addition to the xanthan gum, but prior to high shear, high energy mixing is a loose network of large casein micelles interspersed throughout the milk serum. During the high shear mixing step, a casein/gum dispersion is formed which is highly stable. As shown in FIGURE 2, after three passes through a Rannie homogenizer at 9491445 g/cm^2 ($13,500\text{ psig}$), the casein micelles are somewhat reduced in size and are uniformly dispersed throughout the milk serum,



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which is made highly stable by the presence of the gum. As shown in FIGURE 4, the appearance of cheese made from the dispersion is much the same as that made from milk-containing fat as shown in FIGURE 3. The method of the present invention for providing a casein/gum dispersion is to be distinguished from the methods described in U.S. patent No. 4,855,156 to Singer, et al. and in PCT Application US89/01813. Both the methods of the Singer patent and that of the PCT application are directed to providing microfragments of protein, in the case of the Singer patent, and microfragmented protein/gum fiber complexes, in the case of the PCT application.

The casein/gum dispersion obtained after the high shear, high energy mixing step of the invention is then combined with a second untreated non-fat milk solid source to provide a non-fat milk solids substrate which can be used to prepare non-fat natural cheese. The casein/gum dispersion is highly stable and can be held at refrigeration temperatures of 1°C. to 10°C. (35°F. to 50°F.) for a period up to about two weeks prior to being combined with the second non-fat milk solid source. The second non-fat milk solid source can be skim milk, skim milk concentrated by evaporation, a skim milk retentate, reconstituted non-fat milk solids and mixtures thereof. The substrate preferably has from 5% to about 30% total solids. Preferably, skim milk is used as the non-fat milk solids source for both the first acidified portion and for the second non-fat milk solids source which is combined with the casein/gum dispersion resulting from treatment of the first non-fat milk solids source. Skim milk has a total non-fat milk solids content in the range of about 8.25 to 9.3. A typical composition for skim milk is 90.5% water, 0.1% fat, 3.6% protein, 5.1% lactose and 0.7% ash.

The blend of dispersed gum and acidified non-fat milk solids source, whether obtained by homogenization of the gum in water or in the acidified non-fat milk solids



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source, is added to the second untreated non-fat milk solids source at a level sufficient to provide from about 0.05% to about 0.15% of gum in the non-fat milk solids substrate, based on the level of non-fat milk solids in the substrate.

The non-fat milk solids substrate of the invention can then be used to produce a non-fat natural cheese by any of the commonly used cheese producing procedures, such as those used in the manufacture of Swiss cheese, American-type cheese, such as Cheddar cheese, stirred curd cheese, washed curd cheese, Colby cheese and Monterey Jack, and by procedures used for the preparation of Pasta filata cheeses, such as Mozzarella.

In an important embodiment of the invention, a modified Swiss make procedure is used to prepare a non-fat natural cheese utilizing the non-fat milk solids substrate of the invention. In this procedure, the non-fat milk solids substrate is inoculated with the usual rod and coccus cultures used in the manufacture of Swiss cheese. A propionic acid producing culture, however, is not used. In the method, the rod and coccus cultures are added to the substrate at the normal levels wherein the coccus culture is added at a level of about 1000 times that of the rod culture. A suitable culture is S. thermophilus. Suitable rod cultures are L. bulgaricus, L. lactis and L. helveticus. In accordance with the modified Swiss make procedure of the invention, the non-fat milk solids substrate is inoculated with the rod culture and the coccus culture and fermented for a period of about 30 minutes to an hour at a temperature of about 29°C. - 32°C. (84°F. - 90°F.). A milk coagulating enzyme, such as rennet and calcium chloride are then added and a coagulum forms in about 30 minutes.



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The coagulum is cut into 3,18mm (1/8th inch) to 27mm³ (1/2inch cubes). The cubes are stirred in the whey while the whey is heated to a temperature of from about 33°C to about 52°C (92°F to 126°F) over a period of about 30 minutes. The curd is stirred out at the elevated temperature for a period of 15 to 45 minutes. The curd and whey are then transferred to a universal cheese making apparatus (UCM) which is essentially a perforated drainer basket disposed within a solid wall container. The curd is pressed under whey for a period of about 15 to about 45 minutes. The whey is then drawn from the curd and the curd is retained in the UCM for a period of up to about 16 hours while pressure is applied to the curd. The curd block is then removed and transferred to a cold room maintained at a temperature of 2°C to 7°C (35°F to 45°F) and is held in the cold room for a period of up to about 30 days. The resulting cheese can then be further cured or can be cut and packaged into suitable size shapes at this point.

The resulting cheese has a mild, American-type cheese flavor and is a highly desirable cheese product having texture, flavor and organoleptic properties similar to that of natural cheese produced from fat-containing milk.

The following examples illustrate the present invention.

Example 1

A non-fat milk solids substrate was prepared in accordance with the invention. Skim milk was pasteurized and inoculated with an S. thermophilus culture. The skim milk was fermented to a pH of about 4.3. The acidified skim milk was blended with xanthan gum using a powder funnel feeding a centrifugal rotor pump. The xanthan gum was added to the skim milk at a ratio of 0.3:1 of active xanthan solids to protein in the skim milk. The blend of skim milk and xanthan gum was heated to a temperature of 60°C (140°F). The blend of xanthan gum and skim milk was then passed through a Rannie homogenizer three times at

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a pressure of 949.145kg/cm^2 (3,500psig). During each pass, the blend was heated by passage through the homogenizer from a temperature of 60°C (140°F) to a temperature of 80°C to 82°C (175°F to 180°F) and was cooled between each pass to 60°C (140°F) prior to the next passage through the Rannie homogenizer. A casein/gum dispersion was obtained after the three passes through the Rannie homogenizer.

The casein/gum dispersion was then combined with skim milk at a level of 12% of the casein/gum dispersion and 88% of pasteurized skim milk to provide a non-fat milk solids substrate having 9% total solids.

The non-fat milk solids substrate was used to produce cheese in accordance with the following procedures:

Example 2

The non-fat milk solids substrate of Example 1 was used to produce a cheese in accordance with the modified Swiss make procedure of the invention. 227kg (500pounds) of the non-fat milk solids substrate was inoculated with 3.40kg (7.5 lbs) of S. thermophilus and 10ml of L. bulgaricus. The substrate had been warmed to a temperature of 31°C (88°F). The inoculated skim milk was fermented for a period of 45 minutes and rennet was added at a level of 50ml of rennet. A coagulum formed in 30 minutes. The coagulum was cut into 3,18mm ($1/8$ th inch) to 1,27mm³ ($1/2$ inch cubes) to provide curd particles in whey. The curd cubes were stirred in the whey as the temperature was increased to 43°C (110°F) over a period of 30 minutes. The curd particles were then stirred out at the elevated temperature of 43°C (110°F) for 30 minutes. The curd and whey were then transferred to a UCM and the curd was pressed under the whey for a period of 30 minutes. The whey was drawn and the curd remained in the UCM for a period of 16 hours. The curd block was removed and transferred to a cold room maintained at 2°C to 5°C (35°F to 40°F). The curd remained in the cold room for a period of 30 days and was then removed and cut into



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consumer size blocks and wrapped for distribution.

The resulting cheese was full bodied and had a mild flavor associated with a natural full-fat Colby cheese. The cheese had no bitterness and the texture, flavor and organoleptic properties were similar to those associated with natural cheese produced from milk containing fat.

Example 3

A Mozzarella cheese was produced using the non-fat milk solids substrate of Example 1. In accordance with the method, the substrate pH was reduced to within the range of 5.2 - 5.5 by the addition of acetic acid. The substrate was set by the addition of rennet and calcium chloride while the substrate was maintained at a temperature of 31°C (88°F) 227kg (500 lbs) of the acidified substrate was used to which was added 10ml of rennet and 40mg of CaCl_2 . The coagulum was cut to provide curd and whey and the whey was heated to a temperature of 36°C (96°F). The curd was stirred out in the whey for a period of 30 minutes. The curd was allowed to settle and the whey was drained from the curd resulting in the formation of a curd block. The curd block was cut into pieces and the pieces were milled and transferred to a twin auger screw conveyor-cooker inclined at an angle of 7°C (45°F). Hot water was maintained in the lower portion of the cooker at a temperature of 54°C to 71°C (130°F to 160°F). The retention time of the curd as it was transferred and worked in the cooker-conveyor was about 1 minute. The worked curd exiting from the cooker-conveyor was run into a molding machine and formed into 454gr (1 pound) shapes of the desired size. The Mozzarella shapes were placed in a brine tank for a period of about 3 hours and were then removed and packaged.

The resulting Mozzarella cheese resembled part skim natural Mozzarella cheese in flavor, texture and organoleptic properties.



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Example 4

Xanthan gum was added to 45,4kg (100 pounds) of water at a level sufficient to provide a solution having 1% of xanthan gum. The xanthan gum solution was then subjected to high sheer, high energy homogenization as described in Example 1 starting at a temperature of 60°C (140°F) and using three passes through the homogenizer.

The homogenized aqueous solution of xanthan gum was then blended with skim milk which had been acidified to a pH of 4.2 with vinegar. The homogenized aqueous gum solution was added at a level to obtain 0.3 parts of gum to 1 part of protein to skim milk. The skim milk was stirred with a LightningTM propeller mixer as the aqueous solution of gum was added.

The mixture of xanthan gum and acidified skim milk was then added to pasteurized, non-acidified skim milk to provide a non-fat milk solids substrate having 0.008% of xanthan gum in the substrate 0.084% based on the weight of the non-fat milk solids in the skim milk.

The procedure of Example 2 was then used to produce a natural cheese which had substantially similar properties to the cheese produced in Example 2.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for making a non-fat milk solids substrate suitable for manufacture of natural cheese, including the steps of:
 - (a) acidifying a first non-fat milk solids source to a pH below the isoelectric point of casein;
 - (b) providing a blend of the acidified non-fat milk source and a gum, the gum being present in amounts to provide a ratio of gum solids to protein in the range from about 0.1:1 to 0.5:1;
 - (c) subjecting the blend to high shear, high energy mixing to provide a dispersion of the gum in the casein of the non-fat milk solids source; and
 - (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.

2. A method for making a non-fat milk solids substrate for manufacture of natural cheese, including the steps of:
 - (a) providing a blend of a gum and water;
 - (b) subjecting the blend to high shear, high energy mixing;
 - (c) combining the blend, after the mixing step, with a first liquid non-fat milk solids source which has been acidified to below the isoelectric point of casein to provide a dispersion of the gum in the casein of the non-fat milk solids source; and
 - (d) combining the casein/gum dispersion with a second, non-acidified non-fat milk solids source to provide a non-fat milk solids source substrate which can be used to prepare non-fat natural cheese, as hereinbefore defined.

3. A method as claimed in claim 2, wherein in providing the blend of a gum and water, the amount of gum used relative to the water is in the range from 0.8% to 1.5%.

4. A method as claimed in either of claims 2 or 3, wherein the blend is added to the acidified non-fat milk source at a level sufficient to provide a ratio of gum solids to protein in the range from 0.1:1 to 0.5:1.
5. A method as claimed in claim 4, wherein the ratio is 0.3:1.
6. A method as claimed in either of claims 1 or 2, wherein the gum is xanthan gum, guar gum, agar, carrageenan, locust bean gum, tragacanth, pectin, gum karaya or carboxymethyl cellulose, preferably xanthan gum.
7. A method as claimed in either of claims 1 or 2, wherein the first or the second non-fat milk solids source is selected from skim milk, skim milk concentrated by evaporation, skim milk retentate, reconstituted dried skim milk and mixtures thereof, preferably skim milk.
8. A method as claimed in either of claims 1 or 2, wherein the pH of the first acidified non-fat milk solids source is in the range of 3.8 to 4.6, preferably 4.1 to 4.3.
9. A method as claimed in either of claims 1 or 2, wherein the first non-fat milk solids source is acidified by fermentation with a lactic acid producing culture or by addition of an edible acid to the skim milk.
10. A method as claimed in claim 9, wherein the edible acid is acetic acid, lactic acid, glucono delta lactone, hydrochloric acid or phosphoric acid, preferably acetic acid or lactic acid.
11. A method as claimed in either of claims 1 or 2, wherein the blend of the acidified non-fat milk solids source and the xanthan gum is heated to a predetermined temperature prior to the mixing step.
12. A method as claimed in claim 11, wherein the predetermined temperature is in the range of from 32°C to 66°C (90°F to 150°F), preferably 52°C to 63°C (125°F to 145°F).
13. A method as claimed in either of claims 1 or 2, wherein the high shear, high energy mixing is by homogenization of the blend at a pressure of from 632.763kg/cm² to



1054.605kg/cm² (9,000 psig to 15,000 psig) and the temperature of the blend increases from 16°C to 25°C (40°F to 45°F).

14. A method as claimed in claim 13, wherein the homogenization step is repeated for from 2 to 4 times.
15. A method as claimed in claim 13, wherein the blend is cooled to a temperature in the range of the predetermined temperature after the homogenization.
16. A method as claimed in either of claims 1 or 2, wherein the casein/gum dispersion includes from 5% to 20% of the non-fat milk solids substrate.
17. A method as claimed in either of claims 1 or 2, wherein the ratio of the gum to the protein of the acidified non-fat milk solids source in the blend is from 0.2:1 to 0.4:1.
18. A method as claimed in either of claims 1 or 2, wherein the non-fat milk solids in the first and the second non-fat milk solids sources is from 5% to 30% by weight, preferably from 9% to 12% by weight.
19. A method for manufacture of a non-fat natural cheese, as hereinbefore defined, including the steps of:
 - (a) providing a non-fat solids source in accordance with the method of either claims 1 or 2;
 - (b) inoculating the non-fat milk solids source with a culture system consisting of a coccus culture and a rod culture;
 - (c) forming a coagulum from the inoculated non-fat milk solids source and cutting the coagulum to provide curd and whey;
 - (d) stirring the curd in the whey;
 - (e) recovering the curd from the whey and curing the curd to provide a natural cheese.
20. A method as claimed in claim 19, wherein the stirring step is conducted at a temperature of from 33°C to 52°C (92°F to 126°F).



21. A method as claimed in claim 19, wherein the curd is pressed under the whey prior to recovering the curd.
22. A method as claimed in claim 19, wherein the coccus culture is S. thermophilus.
23. A method as claimed in claim 19, wherein the culture is L. lactis, L. bulgarius or L. helveticus.
24. A method as claimed in claim 19, wherein a milk coagulating enzyme is added to the inoculated non-fat milk solids source prior to forming the coagulum.
25. A method as claimed in claim 24, wherein the milk coagulating enzyme is rennet.
26. A method as claimed in claim 19, wherein the non-fat milk solids source is a non-fat milk solids substrate produced by the method of claim 1.
27. A method as claimed in claim 19, wherein the non-fat milk solids source is a non-fat milk solids substrate produced by the method of claim 2.
28. A method for making a non-fat milk solids substrate suitable for manufacture of natural cheese, substantially as hereinbefore described and with reference to the examples given.
29. A method for making a non-fat milk solids substrate for manufacture of natural cheese, substantially as hereinbefore described and with reference to the examples given.
30. A method for manufacture of a non-fat natural cheese in accordance with claim 19, substantially as hereinbefore described and with reference to the examples given.

KRAFT GENERAL FOODS, INC.

7 February 1995

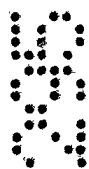
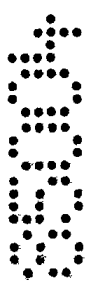




FIG. 1



FIG. 2



FIG. 3



FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 91/05789

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 A23C19/05; A23C19/028		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	A23C	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	FR,A,2 367 431 (CENTRALE LAITIERE DE HAUTE NORMANDIE) 12 May 1978 see page 10; claims 1.17-20 ---	1,5,6,7,8
A	JOURNAL OF FOOD SCIENCE. vol. 53, no. 6, 1988, CHICAGO US pages 1680 - 1683; M.CRADDOCK ET AL.: 'Evaluation of alternative methods to increase calcium retention in cottage cheese curd' see page 1680 ---	1,25,26,28
A	DE,A,2 122 905 (MILIFOMA GESELLSCHAFT) 23 November 1972 see page 7; claim 1 ---	1
A	US,A,4 749 584 (A.WIRCHANSKY) 7 June 1988 see column 2 - column 3; claims 1,11; example 1 ---	1,2
-/-		
¹⁰ Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "A" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
18 DECEMBER 1991	14.01.92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	DESMEDT G.R.A. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT

(CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,4 581 240 (G.SMITH) 8 April 1986 see column 8, line 12 - line 29; examples 1-5 ---	1,2,4
X	WO,A,8 203 971 (D.LAVERY & SON PROPRIETARY LTD) 25 November 1982 see page 4 - page 7; claim 1 ---	50-51, 53-56

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 18/12/91

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