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(54) Titre : FROMAGE NATUREL ET METHODE DE FABRICATION DE FROMAGE NATUREL A CARACTERISTIQUES DE TEXTURE PRECISES
(54) Title: NATURAL CHEESE AND METHOD FOR MAKING NATURAL CHEESE WITH SPECIFIC TEXTURE ATTRIBUTES

(57) Abrégé/Abstract:
The invention provides natural cheese and a method for making natural cheese with specific texture attributes.

1 ABSTRACT

2 The invention provides natural cheese and a method for making natural cheese with
3 specific texture attributes.

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1 **NATURAL CHEESE AND METHOD FOR MAKING NATURAL CHEESE**
2 **WITH SPECIFIC TEXTURE ATTRIBUTES**

3 CROSS-REFERENCE TO RELATED APPLICATIONS

4 **[0001]** The application claims the benefit of Provisional Application No. 63/056,821,
5 filed 7/27/2020.

6 FIELD OF THE INVENTION

7 **[0002]** The invention relates to the field of natural cheese and a method for making
8 natural cheese with specific texture attributes.

9 BACKGROUND OF THE INVENTION

10 **[0003]** Typical natural cheeses have well known texture attributes. Processed cheese,
11 such as American cheese, is a food product made from natural cheese with the
12 addition of other ingredients such as emulsifiers, sodium citrate, calcium
13 phosphate, sorbic acid, enzymes, cheese culture, vitamin D3, milk fat, extra
14 salt, saturated vegetable oils, whey and/or artificial food colorings. Processed
15 cheese has several advantages over natural cheese including resistance to oiling
16 offs when heated and a uniform look and physical behavior. Disadvantages
17 include an elevated amount of sodium and artificial ingredients.

18 SUMMARY OF THE INVENTION

19 **[0004]** The present invention includes a method for accumulating milk from which to
20 make natural cheese including the steps of adding concentrated acidified skim
21 milk, adding re-blended acidified skim milk, adding cream with greater than
22 25% milk fat and adding homogenized milk having between 3-18% milk fat.

1 [0005] The present invention includes a method for producing natural cheese with a
2 calcium reduction as compared to a standard natural cheese made without said
3 method including the steps of producing a calcium reduced stream by
4 acidifying milk and by ultrafiltration to concentrate the acidified skim milk,
5 producing a controlled homogenization stream by separating milk to produce
6 cream and to produce homogenized high fat milk, combining the two streams
7 and making natural cheese from the combined streams wherein the natural
8 cheese has a 35-50% calcium reduction as compared to a standard natural
9 cheese made without said method.

10 [0006] The present invention includes a method for producing natural cheese with
11 specific texture attributes including the steps of creating a stream of
12 concentrated acidified milk by adding an acidulant to skim milk to reduce the
13 milk pH and ultrafiltrating the acidified milk, creating a mineral reduced milk
14 stream by re-blending a portion of the concentrate acidified milk with a
15 diluent, creating a stream of cream having greater than 25% milk fat, creating a
16 stream of one of raw milk and skim milk, creating a stream of homogenized
17 milk having between 3-18% milk fat, combining the five streams and making
18 natural cheese from the combined streams.

19 [0007] The present invention includes a natural cheese made from a natural cheese
20 make process with an ingredient statement as that of a Standard of Identity
21 cheese and having the following characteristics: moisture 42-47 %, fat 24-
22 35%, FDB 41-61%, salt 1.5-2.7%, pH 5.1-5.45, calcium 350 to 500 mg/100
23 grams of cheese and lactose <0.02%.

24 [0008] The present invention includes a cheese made from a natural cheese make
25 process with an ingredient statement as that of a Standard of Identity cheese

1 and having the following characteristics: less stringiness, less oiling off,
2 controlled melt behavior, smooth melt, and homogeneous melt.

3 BRIEF DESCRIPTION OF THE DRAWINGS

4 **[0009]** Preferred exemplary embodiments of the invention are illustrated in the
5 accompanying drawings in which like reference numerals represent like parts
6 throughout, and in which:

7 **[0010]** FIG. 1 is a flowchart relating to a cheese make process;

8 **[0011]** FIG. 2 is a flowchart relating to a second embodiment of a cheese make
9 process;

10 **[0012]** FIG. 3 are photographs showing melting and oiling-off behaviors of cheeses;

11 **[0013]** FIG 4 is a graph of heating rheology data; and

12 **[0014]** FIG. 5 is a graph of cooling rheology data.

13 **[0015]** FIG. 6 illustrates the relative thickness of oil and oiling off results for Vats 1-4
14 of Example CT2.

15 **[0016]** FIG. 7 illustrates the oiling-off of cheeses from Example CT2.

16 **[0017]** Before any embodiments of the invention are explained in detail, it is to be
17 understood that the invention is not limited in its application to the details of
18 constructions and the arrangement of components set forth in the following
19 description or illustrated in the drawings. The invention is capable of other
20 embodiments and of being practiced or of being carried out in various ways.

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1 DETAILED DESCRIPTION

2 **[0018]** The invention relates to natural cheese and the production of natural cheese
3 with specific texture attributes. The invention utilizes processes within the
4 boundaries of conventional cheese make technology which allow for the tuning
5 of natural cheese texture while maintaining an ingredient statement as that of a
6 Standard of Identity cheese.

7 **[0019]** With reference to FIG. 1, an embodiment of one method for making natural
8 cheese with specific texture attributes is shown. The method is divided into
9 split streams relating to calcium reduction for melt behavior for example and
10 relating to controlled homogenization for restricted oiling off for example. As
11 shown in FIG. 1, for example, a total of five streams are produced and
12 recombined, however, other numbers of streams can also be utilized.

13 **[0020]** In stream 1, raw milk is separated and an acidulant, such as lactic acid, is
14 added to reduce the skim milk pH. Other acidulants, such as using a CO₂
15 injection, can also be utilized. The pH is reduced to between 5.5 and 6.5, more
16 particularly reduced to between 5.7 to 5.9 and, more particularly reduced to
17 5.9. Following pH adjustment, the acidified skim milk is ultra-filtrated, as is
18 known in the art, to concentrate the acidified skim milk to 3-5-fold, more
19 particularly to 4-5 fold, and more particularly to 4.5.

20 **[0021]** In stream 2, a portion of the concentrated acidified milk is re-blended with
21 water to produce a mineral reduced milk stream. The resultant stream will
22 have reduced mineral contents such as calcium and phosphorus.

23 **[0022]** In stream 3, the raw milk is separated to produce cream with greater than 25%
24 milk fat, more particularly in the range of 25-42%, and more particularly 35%.

1 [0023] Stream 4 includes raw milk.

2 [0024] In stream 5, raw milk is standardized to between with between 3-12% milk fat,
 3 more particularly to between 3-8% milk fat, and more particularly to 4% milk
 4 fat. After the desired milk fat is obtained, the stream is then homogenized, as
 5 is known in the art.

6 [0025] In FIG. 1, the streams can be combined in equal or differing percentages to
 7 form a unified stream that enters the pasteurization step as will be set forth in
 8 more detail below.

9 [0026] Turning now to FIG. 2, a second embodiment of a method for making natural
 10 cheese with specific texture attributes is shown.

11 [0027] Streams 1, 2 and 3 are the same as described above with respect to FIG. 1.
 12 Stream 7 is composed of skim milk. In stream 6, raw milk is standardized to
 13 between with between 12-18% milk fat, more particularly to between 13-16%
 14 milk fat, and more particularly to 15% milk fat. After the desired milk fat is
 15 obtained, the stream is then homogenized, as is known in the art.

16 [0028] The streams can be combined in the same or differing percentages to form a
 17 unified stream that enters a pasteurization step. Examples of various
 18 percentages for the seven streams described in FIGS. 1 and 2 is as follows:

19 [0029] **Table A.** Cheese Milk Formulations (data given are parts per 100 m/m)

	CT5				CT7				CT4				CT3			
	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4	V1	V2	V3	V4
Stream 8					0.9	0.9	0.9	0.9								
Stream 7	47.2			47.2					46.8	46.8	46.8	46.8	51.1	52.6	48.5	48.4
Stream 4		19.75	19.75	0	19.2	19.2	19.2	19.2								

Stream 5		39.7	39.7	0	40.4	40.3	40.3	40.3								
Stream 2	29.75	30.1	30.1	29.75	29.8	29.8	29.8	29.8	29.6	29.6	29.6	29.6	16.7	17.2	25.8	25.8
Stream 1	5.3	5.2	5.2	5.3	4.9	4.9	4.9	4.9	6.00	6.00	6.00	6.00	10.6	9.2	6.3	6.3
Stream 3	7.05	5.25	5.25	7.05	4.8	4.9	4.9	4.9	7.00	7.00	7.00	7.00	9.7	9.45	8.6	8.6
Stream 6	10.7	0	0	10.7					10.6	10.6	10.6	9.2	11.8	11.5	10.8	10.8
Stream 10	0.76	0.76	0.76	0												
Stream 9												1.4				

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2 **[0030]** The total amount demineralized protein prior to milk standardization is
 3 preferably in the range of 30-50%, and more particularly in the range of 45-
 4 47%, of total proteins in the vat. The total amount of homogenized fat is
 5 preferably in the range of 20-40%, and more particularly 35%, prior to milk
 6 standardization. The milk concentration factor is preferably approximately 1-
 7 1.5, and more particularly 1.15. The target protein:fat ratio in the final milk is
 8 preferably around 0.70-0.95, and more preferably 0.77-0.85. Preferably, these
 9 are the parameters that determine the ratios of each stream to the vat.

10 **[0031]** Unacidified skim milk concentrates can also be utilized to satisfy the
 11 standardization requirements such as amount of demineralized proteins,
 12 protein: fat ratio, and milk concentration factor as can be seen in example CT 7
 13 (stream 8). Lactose powder (Stream 10) is added to compensate the lactose
 14 removal as a result of ultrafiltration as well to aid in acid development during
 15 the cheesemaking (CT5 V1 to V3). Portion of cream is added with lipolytic
 16 enzyme prior to homogenization to generate lipolytic flavor in the final cheese
 17 (Stream 9 in CT4 V4).

1 [0032] After pasteurization, the cheese make process proceeds as is known in the art.
2 Additional lactic acid can be added after pasteurization to bring the pH of
3 cheese milk down in the range of 6.1-6.5, and more specifically around 6.2-6.3.

4 [0033] The results of the method shown in FIGS. 1 and 2 include tailored texture
5 attributes including controlled breakdown of the cheese structure and
6 controlled melting and oiling off in particular. Further attributes include
7 reduced stringiness, reduced oiling off, smooth melt, slightly adhesive, mild
8 flavor, creamy, less acidic, and slightly lipolytic.

9 [0034] The natural cheese produced from the method disclosed herein preferably has
10 the following compositional characteristics:

Moisture	42 - 47%
Fat	24 – 35%
FDB	41 - 61%
Salt	1.5 - 2.7%
pH	5.1-5.45
Calcium	350 to 550 mg/100 grams of cheese
Lactose	<0.02%

11 [0035] The cheese made according to FIGS. 1 and 2 can also be tuned to add flavors.
12 For example, a flavor can be added by blending a flavor ferment into the curd
13 after salting and prior to pressing.

14 [0036] Examples CT1-CT5. An overview of five different example formulations for
15 making a natural cheese is set forth in Table 1 and Table 2.

1 [0037] Table 1. Cheese Make Parameters

Cheese	% of fat hom.	% of fat lipase-treat	cf	[% of prot] demin.	Lactic acid bacteria (U/100 L)	Lactobacillus helveticus (U/100 L)	t/T (h/°C) milk ripening	CaCl ₂ [g/100L]	Lactose [g/100L]	pH at salting	Ripening Temperature (°C)
CT1											
<i>vat 1</i>	0	0	1	0	10	0	1.5 (32)	23		5.54	6
<i>vat 2</i>	0	0	1	0	10	0	1.5(32)	23		5.65	6
<i>vat 3</i>	0	0	1	25	10	0	1(32)			5.62	6
<i>vat 4</i>	20	0	1	25	10	0	1(32)			5.64	6
CT2											
<i>vat 1</i>	0	0	1	35	10	0	0.5(32)			5.5	6
<i>vat 2</i>	0	0	1.25	43	10	0	0.5(32)			5.5	6
<i>vat 3</i>	35	0	1	35	10	0	0.5(32)	11.5		5.6	6
<i>vat 4</i>	35	0	1.25	43	10	0	0.5(32)			5.5	6
CT3											
<i>vat 1</i>	35	0	1.25	45	10	0	0.5(32)		480	5.55	6 /10
<i>vat 2</i>	35	0	1.25	45	10	2	0.5(32)		480		6/10
<i>vat 3</i>	35	0	1.15	45	10	0	0.5(32)		760	5.35	6
<i>vat 4</i>	35	0	1.15	45	10	0	1.5(32)		760	5.3	6
CT4											
<i>vat 1</i>	35	0	1.15	47	25	2	1.0(32)		760	5.25	6
<i>vat 2</i>	35	0	1.15	47	25	2	1.0(32)		760	5.3	6/10
<i>vat 2</i>	35	0	1.15	47	25	2	1.0(32)		760	5.3	6/10
<i>vat 3</i>	35	0	1.15	47	25	2	0.5(32)		760	5.45	6
<i>vat 4</i>	35	4.6	1.15	47	25	2	0.5(32)		760	5.4	6
CT5											
<i>vat 1</i>	35	0	1.15	47	25	2	1.0 (32)		760	5.3	6
<i>vat 2</i>	35	0	1.15	46	25	2	1.0 (32)		760	5.24	6

<i>vat 3</i>	35	0	1.15	46	25	2	1.0 (32)		760	5.35	6	
<i>vat 4</i>	35	0	1.15	47	25	2	1.0 (32)		0	5.37	6	

Abbreviations: hom. = homogenized, cf = concentration factor, demin. = demineralized, t = time, T = temperature

1 **[0038] Table 2. Cheese Milk Formulations (data given are parts per 100 m/m)**

CT1					
	Stream 7	Stream 2		Stream 3	Stream 6
Vat 1 REF	78.8			21.3	
Vat 2 REF	78.8			21.3	
Vat 3 25 demin	53.7	25		21.3	
Vat 4 25 demin 20 homog.	53.7	25		17	4.3

2

CT2					
	Stream 7	Stream 2	Stream 1	Stream 3	Stream 6
Vat 1 35 demin	58.3	32.8		8.9	
Vat 2 cf 1.25# 35% demin*	64.4	16.3	8.2	11.1	
Vat 3 35 demin 35% homog.**	52.2	33.2		5.7	8.8
Vat 4 cf 1.25 35+ demin 35% homog	55.9	17.3	8.4	7.3	11.1

3

CT3					
formulation per 100 w/w					
	Stream 7	Stream 2	Stream 1	Stream 3	Stream 6

vat 1 cf 1,25	51.1	16.7	10.6	9.7	11.8
vat 2 cf 1,25	52.6	17.2	9.2	9.45	1.5
vat 3, cf 1,15	48.5	25.8	6.3	8.6	10.8
vat 4, cf 1,15	48.4	25.8	6.3	8.6	10.8

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CT4						
	Stream 7	Stream 2	Stream 1	Stream 3	Stream 6	Stream 9
vat 1 cf 1,15	46.8	29.6	6	7	10.6	0
vat 2 cf 1,15	46.8	29.6	6	7	10.6	0
vat 3, cf 1,15	46.8	29.6	6	7	10.6	0
vat 4, cf 1,15	46.8	29.6	6	7	9.2	1.4

2

CT5	Stream 7	Stream 2	Stream 1	Stream 3	Stream 6	Stream 5	Stream 4
vat 1 cf 1,15	47.2	29.75	5.3	7.05	10.7		
vat 2 cf 1,15		30.1	5.2	5.25		39.7	19.75
vat 3, cf 1,15		30.1	5.2	5.25		39.7	19.75
vat 4, cf 1,15	47.2	29.75	5.3	7.05	10.7		

3 **[0039]** The mineral composition of Stream 2 in the examples is given in Table 3. The
4 reduction of calcium and phosphorus achieved by ultrafiltration at pH 5.9 and

1 dilution to starting volume with water is approximately 39% and 46%
 2 compared to the starting skim milk.

3 **[0040] Table 3.** Total and serum Ca and P contents [mg/100g] in skim milk and
 4 demineralized split stream UFpH5.9dl in CT1-4. Serum Ca and P is defined as
 5 the fraction recovered in the permeate after ultracentrifugation (100,000 x g,
 6 1h/5°C). cf = concentration factor, dl = diluted

	cf	Skim Ca	Skim P	Skim serum Ca	Skim serum P	UFpH5.9 dl Ca	UFpH5.9 dl P	UFpH5.9 dl serum Ca	UFpH5.9 dl serum P
CT1	3	134	103	47.7	49.5	102	71	35.4	27
CT2	4.2	141	107	40.3	41.9	91.3	61.8	28.8	20.7
CT3	4.4	128	97.9	45.2	44.9	77.7	53.4	28.9	20.5
CT4	4.4	125	98.4	n.dt.	n.dt.	74.9	52.1	n.dt.	n.dt.
CT5	4.4	126	102	n.dt.	n.dt.	77	53.5	n.dt.	n.dt.

n.dt. = not determined

7 **[0041]** In Example CT1, the cheese make process was designed to achieve a
 8 composition and mimic processing for Monterey Jack type cheese as follows:

- 9 • pre-acidification of milk for 1.5 hours at 32°C using
- 10 mesophilic/thermophilic starter
- 11 • adding rennet
- 12 • cutting, stirring (10 min, 10 min)
- 13 • heating to 39°C at a rate of approximately 0.3°C/min
- 14 • cooking (10 minutes at 39°C)
- 15 • draining
- 16 • dry stirring
- 17 • washing (sprinkling of cold water (15°C) on acidified curds for
- 18 cooling, acidification and moisture control)

- 1 • dry salting at pH 5.6
- 2 • filling in molds
- 3 • pressing (0.5 hours at 3 bar, 1 hour at 4 bar)
- 4 • vacuum packing
- 5 • ripening at 6°C to 10°C

6 **[0042]** Processing times for Examples CT1-CT4 are set forth in Table 4.

7 **[0043]** **Table 4.** Processing Times

		Pre-ripen time [min]	pH at rennet	Rennet time [min/sec]	Make time [h]*	pH at salt
CT1						
REF vat 1		90	6.61	31	3	5.54
REF vat 2		90	6.6	30	3	5.65
vat 3		60	6.52	23'30"	2.75	5.54
vat 4		60	6.59	21'50"	2.75	5.64
CT2						
vat 1		30	6.45	40	3.8	5.5
vat 2		30	6.41	31'20"	3.8	5.5
vat 3		30	6.41	25'15"	3.6	5.63
vat 4		30	6.43	29'50"	3.9	5.5
CT3						
vat 1		30	6.4	31'55"	4	5.55
vat 2		30	6.28	19'25"	4.5	5.38
vat 3		30	6.26	20'25"	4.25	5.35
vat 4		90	6.25	22'10"	4.4	5.3
CT4						

vat 1		60	6.22	19'	2.8	5.22
vat 2		65	6.2	19'15"	2.9	5.3
vat 3		35	6.25	17'45"	2.8	5.4
vat 4		30	6.24	20'	3	5.4
CT5						
vat 1		60	6.20	19' 00"	3	5.3
vat 2		60	6.21	19' 00"	2.8	5.24
vat 3		60	6.22	24' 00"	2.9	5.35
vat 4		60	6.24	19' 00"	2.7	5.37

* make time = time from rennet addition to start salting

1 **[0044]** In the Examples, calcium and phosphorus reduction in cheese is obtained when
 2 using at total of 47% of demineralized split stream 1 and 2 to raise the
 3 concentration factor of the milk to 1.15, reducing milk pH prior to milk-
 4 ripening to pH 6.35 with lactic acid and at a starter dosage of 25U/100L. A
 5 pre-ripening time of 60 minutes and salting at pH of 5.22 contributed to the
 6 effective mineral reduction. In addition to the reduced mineral content in the
 7 split stream, the short make time and low pH in the final cheese contributed to
 8 additional calcium and phosphorus reduction. See Table 5.

9 **[0045]** **Table 5.** Composition of Cheeses from CT1-4 Determined after 14 days from
 10 Production. Calcium and phosphorus contents are also expressed as Ca, P per
 11 100g protein.

	[%]	[%]	[%]	mg/kg	mg/kg	[%]	[%]		[%]	[%]
CT1	moist.	fat	Protein*	Ca	P	NaCl	lactose	pH (end)	Ca/prot	P/prot
vat 1	40.9	30.5	24.6	726	505	1.31	n.d.	5.28	2.96	2.06
vat 2	41.2	30.5	24.0	727	508	1.47	n.d.	5.34	3.02	2.11

vat 3	41	30.6	24.2	741	511	1.45	n.d	5.44	<i>2.94</i>	<i>2.06</i>
vat 4	41	30.3	24.4	719	503	1.53	n.d	5.25	<i>2.99</i>	<i>2.08</i>
CT2										
vat 1	40.5	29	25.7	684	491	2.39	n.d.	5.50	<i>2.66</i>	<i>1.91</i>
vat 2	39.3	31	25.1	660	476	2.12	n.d.	5.46	<i>2.63</i>	<i>1.89</i>
vat 3	42.9	29.4	23.5	630	449	1.82	n.d	5.45	<i>2.86</i>	<i>1.91</i>
vat 4	41.3	30.5	23.9	620	446	1.78	n.d	5.36	<i>2.59</i>	<i>1.87</i>
CT3										
vat 1	39.6	30.7	25.4	624	454	1.76	n.d.	5.34	<i>2.45</i>	<i>1.78</i>
vat 2	38.3	32.1	25.4	583	442	1.9	n.d.	5.34	<i>2.30</i>	<i>1.74</i>
vat 3	38.3	31.5	25.9	581	447	2.1	n.d	5.40	<i>2.24</i>	<i>1.73</i>
vat 4	39.7	31.7	24.5	537	426	1.85	n.d	5.25	<i>2.19</i>	<i>1.74</i>
CT4										
vat 1	42.8	29.5	22.9	433	319	2.1		5.15	<i>1.89</i>	<i>1.39</i>
vat 2 SC	43.7	29.6	22.4			1.77		5.15		
vat 2 SC	44.3	29.1	22.3			1.87		5.14		
vat 3	42.2	30.3	22.9	490	352	2		5.26	<i>2.14</i>	<i>1.54</i>
vat 4	40.8	31.1	23.8	515	369	1.95		5.32	<i>2.16</i>	<i>1.55</i>
CT5										
vat 1	40.7	30.8	23.7	500	394	2.21	0.19	5.28	<i>2.11</i>	<i>1.66</i>
vat 2	46.6	27.3	21.4	444	349	2.12	n.d	5.16	<i>2.08</i>	<i>1.63</i>
vat 3	43.6	29.1	22.6	483	374	2.15	n.d	5.29	<i>2.14</i>	<i>1.66</i>
vat 4	42	29.8	23.1	393	511	2.09	n.d	5.30	<i>1.70</i>	<i>2.21</i>

* in *italics* approximate protein content calculated according to: protein [%] = dry matter [%] – (fat [%] + ash [%] + lactate [%]); n.d. = not detected

1 **[0046]** Cheese firmness is measured instrumentally under cold conditions
 2 (refrigerator, shredding/slicing temperature) and melting properties were
 3 measured by two empirical tests, modified Schreiber test for melt area and the
 4 extent of oiling-off. The data is summarized in Table 6.

5 **[0047]** **Table 6.** Hot Functionality (oiling-off, melt area), as Measured by Modified
 6 Schreiber Test, and Texture (cold) as Measured by Uniaxial Compression
 7 (Texture Analyzer) of Cheeses from CT1-4 after 8-10 Weeks Ripening. Unless
 8 otherwise indicated (*), the cheeses were ripened at 6°C.

	Thickness oil layer [%]		[% of initial diameter]		[kPa]		[-/-]	
	oiling off	oil- off stdev	Melt area	stdev	fracture stress	stdev	frac strain	stdev
CT1								
vat 1(REF)	10.8	2.3	201.0	1.1	57.2	9.9	0.94	0.04
vat 2(REF)	12.8	1.6	196.2	1.8	52.7	7.6	1.04	0.06
vat 3	12.3	2.1	177.7	2.3	70.6	12.1	1.14	0.05
vat 4	9.3	1.6	173.7	4.5	70.4	10.8	1.23	0.05
CT2								
vat 1	18.3	1.6	186.0	2.6	103.7	10.1	0.83	0.07
vat 2	15.2	0.4	186.9	5.7	111.8	11.5	0.89	0.04
vat 3	4.2	1.1	180.4	3.8	59.3	7.4	1.17	0.07
vat 4	7.4	1.4	178.1	2.5	64.5	9.2	1.06	0.09
CT3								
vat 1	9	2	155.6	3.0	110.8	5.5	0.98	0.04
vat 2	11	1	169.7	3.0	130.1	13.8	1.03	0.06
vat 3	11	2	147.0	7.5	138.6	9.0	0.90	0.07
vat 4	10	1	168.8	3.5	77.6	3.1	0.99	0.06

vat 1/10*	10	2	173.1	3.3	76.4	8.9	0.82	0.08
vat 2/10*	11	2	169.2	2.5	100.3	9.7	0.86	0.1
CT4								
vat 1	9	1	178.8	6.9	41.8	10.1	0.7	0.07
vat 3	7	2	173.9	2.3	50.4	6.9	0.84	0.07
vat 4	14	3	164.8	2.1	68.6	3.3	0.97	0.06
CT5								
V1	10.1	1.3	175	n.d	n.d	n.d	n.d	n.d
V2	0.5	0.2	158	n.d	n.d	n.d	n.d	n.d
V3	1.2	0.5	152	n.d	n.d	n.d	n.d	n.d
V4	6.7	0.8	182					

* Vat 1 and 2, ripened at 10°C

- 1 **[0048]** The calcium content of the in the final cheese influences the hot functionality
2 of the cheese such as melt behavior. Despite higher extent of demineralization,
3 cheeses spread less upon melting than the reference cheeses with normal
4 calcium and phosphate content at near identical moisture content.
- 5 **[0049]** Partial homogenization is effective to reduce the extent of oiling-off, compared
6 to the reference cheese and to other variants without homogenized cream.
7 These results are illustrated in FIG 6 and FIG. 7. Vat 3 and vat 4 had 35% of
8 fat homogenized, vat 1 and vat 2 non-homogenized. FIG. 7 shows shreds
9 before heating and after heating. Oil exudation can be observed as dark zone
10 around the melted cheese.
- 11 **[0050]** To assess cold functionality, the firmness (stress at fracture) and shortness
12 (strain at fracture) is measured by uniaxial compression test. Data are given in
13 Table 6. Fracture stress is translated to firmness and fracture strain to

1 shortness. The firmness of the cheeses differed from around 50 kPa to 130 kPa
2 and it appeared to be most strongly correlated with moisture contents. The
3 level of calcium in cheese was not found to be related to firmness. Fracture
4 strain, shortness (= opposite to long/elastic) appeared to be correlated with
5 calcium content of the cheese while pH appeared not to influence the fracture
6 strain.

7 **[0051]** With respect to cold functionality, the results of the instrumental compression-
8 fracture measurement are in line with sensory perceived firmness of the
9 cheeses.

10 **[0052]** With respect to hot functionality, with regard to melt area (modified Schreiber
11 test), the amount of spread is comparable with that the targeted processed
12 cheese counterparts.

13 **[0053]** With respect to oiling-off, the effect of emulsion properties is pronounced in
14 the oiling-off behavior as shown in Fig. 3.

15 **[0054]** In one example, the cheese milk standardized with the various streams
16 according to the one process has the following characteristics: Protein:fat =
17 0.88, protein content = 4.16 % (i.e., concentration factor 1.15 compared to
18 normal milk with 3.6 % protein), lactose content = 3.2% (CT5/vat 4), i.e., a
19 dilution by 29 % compared to starting milk (4.5 % lactose), proportion of
20 demineralized protein (retentate + diluted retentate) is 47% of total protein in
21 the standardized cheese milk, and the proportion of homogenized fat is 35% of
22 total fat in the standardized cheese milk.

23 **[0055]** The natural cheeses produced had the following approximate composition:
24 moisture content 41 – 42%, NaCl content 1.8 %, fat content 30% and pH -

1 5.30. The calcium and phosphorus content of these cheeses is reduced by
 2 approximately 30% and 40% respectively, compared to a reference cheese.

3 **[0056]** To evaluate the cheese melting properties analytically, temperature sweeps by
 4 oscillating small strain rheology were conducted. This methodology relates to
 5 the dynamic changes in the ratio between a system’s elastic/solid and
 6 viscous/liquid behavior ($\tan \delta = G''/G'$), as function of temperature. For
 7 comparison purpose, a commercially procured sample of Monterey Jack was
 8 also evaluated against the cheeses. Parameters used for the evaluations are
 9 described in Table 7.

10 **[0057]** **Table 7.** Parameters to conduct oscillating small strain rheology

Manufacturer/Model	Anton Parr
Temperature Ramp	5°C - 80°C - 40°C
Temperature Ramp Speed	2°C/min
Frequency	1 Hz
Strain	0.1% strain
Sample Diameter	25 mm
Sample thickness	approx. 2 mm

11 **[0058]** The visco-elastic behavior upon heating to 80°C and cooling was markedly
 12 different from a standard natural cheese (Monterey Jack), and approached that
 13 of processed cheese. As can be seen in Table 8, the $\tan \delta_{\max}$ (heat) was highest
 14 in the natural cheese sample whereas, the $\tan \delta_{\max}$ (heat) was comparatively
 15 low for the processed cheese sample. The $\tan \delta_{\max}$ (heat) for all the test
 16 cheeses ranged from 1.65 to 2.01. CT5 cheeses are less fluid-like and

1 assumingly more cohesive than the natural cheese. The cross-over temperature
 2 was found to be typically higher for processed cheeses. The processed cheeses
 3 achieved liquid-like properties only at comparatively higher temperature,
 4 compared to the natural cheeses. See Figs. 4 and 5. Cheeses CT5 are closest
 5 to the behavior of the processed cheese, notably in the cooling trajectory
 6 between 70 and 50°C.

7 **[0059]** **Table 8:** Parameters deduced from heating-cooling curves

	T (Crossover) (°C) Tan δ=1 (Heat)	Tan δmax (Heat)	T (Crossover) (°C) Tan δ=1 (Cool)	Tan δmax (Cool)
CT5 Vat 1	53.8	1.92	60.81	1.89
CT5 Vat 2	55.88	1.65	60.81	1.42
CT5 Vat 3	53.85	1.71	62.91	1.62
CT5 Vat 4	53.85	2.01	60.81	1.98
Monterey Jack	53.85	2.90	58.70	2.88
Total Average PC	66.00	1.19	65.01	1.19

8 **[0060]** With respect to Fig. 4, temperature sweep experiment (from 5-80°C: Heating)
 9 of cheeses CT5 @10 weeks, processed cheese (3 different lots) and Monterey
 10 Jack (MJ) @ 10 weeks by small strain oscillating rheology. Tan δ (G''/G') is
 11 given as function of temperature (avg of n=3 for CT5 samples, average of 3
 12 lots n=9 for processed cheese, average of n=3 for Monterey Jack.

13 **[0061]** With respect to Fig. 5, temperature sweep experiment (from 80-40°C: Cooling)
 14 of cheeses CT5 @10 weeks, processed cheese (3 different lots) and Monterey
 15 Jack (MJ) @ 10 weeks by small strain oscillating rheology. Tan δ (G''/G') is

1 given as function of temperature (avg of n=3 for CT5 samples, average of 3
2 lots n=9 for processed cheese, average of n=3 for Monterey Jack). The box
3 indicates the temperature range during cooling which is relevant from
4 consumption point of view.

5 **[0062]** The rheological analysis indicates differences in molecular assembly of the fat-
6 filled protein matrix of the processed cheese and that of the texture-tuned
7 cheeses of CT6. The processed cheese attains fluid-like character at higher
8 temperatures (T crossover heating 12°C higher) and maximum Tan δ remains
9 approx. 35% lower (indicating a higher cohesivity).

10 **[0063]** The cheeses produced meets the desired chemical composition. Firmness and
11 specific melting properties (e.g., oiling-off, spread, low/no stringiness,
12 homogeneous melt) resembles those of the processed cheese benchmarks.

13 **[0064]** Various features and advantages of the invention are set forth in the following
14 claims.

15

CLAIMS

We claim:

1. A method for accumulating milk from which to make natural cheese, said method including the steps:
 - adding concentrated acidified skim milk;
 - adding re-blended acidified skim milk;
 - adding cream with greater than 25% milk fat; and
 - adding homogenized milk having between 3-18% milk fat.
2. The method of claim 1 and further including the step of adding one of skim milk and raw milk.
3. The method of claim 1 wherein the acidified milk has a pH in the range of 5.5-6.0.
4. The method of claim 1 wherein the homogenized milk has between 3-12% milk fat.
5. The method of claim 1 wherein the homogenized milk has between 12-18% milk fat.
6. The method of claim 1 wherein the re-blending uses water.
7. The method of claim 4 and further including the step of adding raw milk and wherein the concentrated acidified skim milk is approximately 4-11% of the accumulated milk, the re-blended acidified skim milk is approximately 15-30% of the accumulated milk, the cream is approximately 4-11% of the accumulated milk,

the homogenized milk is approximately 35-42% of the accumulated milk and the raw milk is approximately 15-20% of the accumulated milk.

8. The method of claim 5 and further including the step of adding skim milk and wherein the concentrated acidified skim milk is approximately 4-11% of the accumulated milk, the re-blended acidified skim milk is approximately 15-30% of the accumulated milk, the cream is approximately 4-11% of the accumulated milk, the homogenized milk is approximately 8-11% of the accumulated milk and the skim milk is approximately 45-60% of the accumulated milk.
9. A method for producing natural cheese with a calcium reduction as compared to a standard natural cheese made without said method, said method including the steps:
 - producing a calcium reduced stream by acidifying milk and by ultrafiltration to concentrate the acidified skim milk;
 - producing a controlled homogenization stream by separating milk to produce cream and to produce homogenized high fat milk;
 - combining the two streams; and
 - making natural cheese from the combined streams wherein the natural cheese has a 35-50% calcium reduction as compared to a standard natural cheese made without said method.
10. The method of claim 9 wherein the acidified milk has a pH of between 5.7-5.9.
11. The method of claim 9 wherein the acidified milk is concentrated 4-5 fold.
12. The method of claim 9 wherein the calcium reduced stream is added in a greater percentage than the homogenized stream when combining the two streams.

13. A method for producing natural cheese with specific texture attributes, said method including the steps:
 - creating a stream of concentrated acidified milk by adding an acidulant to skim milk to reduce the milk pH and ultrafiltrating the acidified milk;
 - creating a mineral reduced milk stream by re-blending a portion of the concentrate acidified milk with a diluent;
 - creating a stream of cream having greater than 25% milk fat;
 - creating a stream of one of raw milk and skim milk;
 - creating a stream of homogenized milk having between 3-18% milk fat;
 - combining the five streams; and
 - making natural cheese from the combined streams.
14. The method of claim 13 and further adding a flavor ferment during the cheese make process prior to salting.
15. The method of claim 13 wherein the natural cheese made includes at least one of the following texture attributes less stringiness, less oiling off, controlled melt behavior, smooth melt, homogeneous melt, increased opacity, controlled product breakdown and controlled proteolysis.
16. A natural cheese made from a natural cheese make process with an ingredient statement as that of a Standard of Identity cheese and having the following characteristics: moisture 42-47 %, fat 24–35%, FDB 41-61%, salt 1.5-2.7%, pH 5.1-5.45, calcium 350 to 500 mg/100 grams of cheese and lactose <0.02%.
17. A cheese made from a natural cheese make process with an ingredient statement as that of a Standard of Identity cheese and having the following characteristics:

less stringiness, less oiling off, controlled melt behavior, smooth melt, and homogeneous melt.

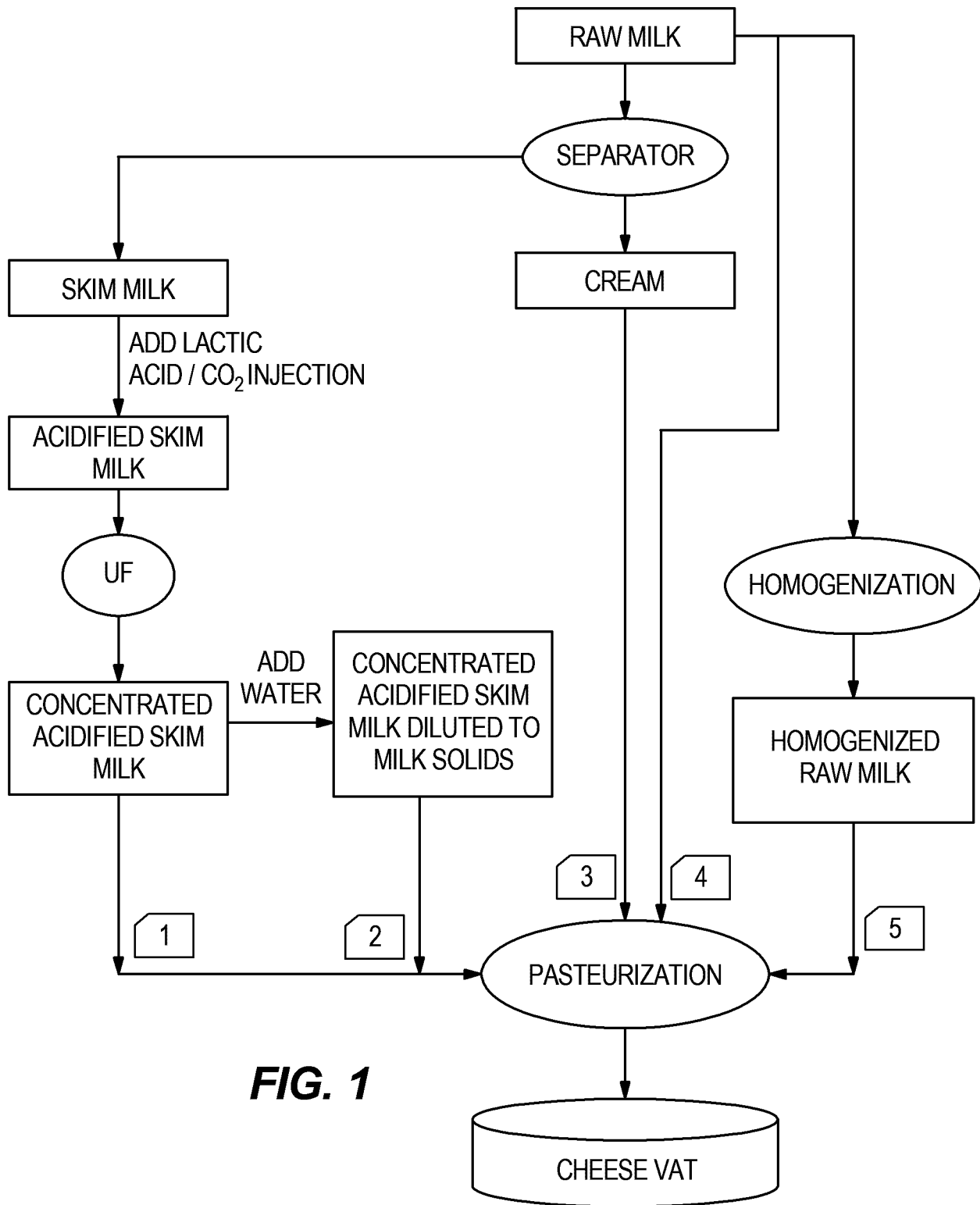


FIG. 1

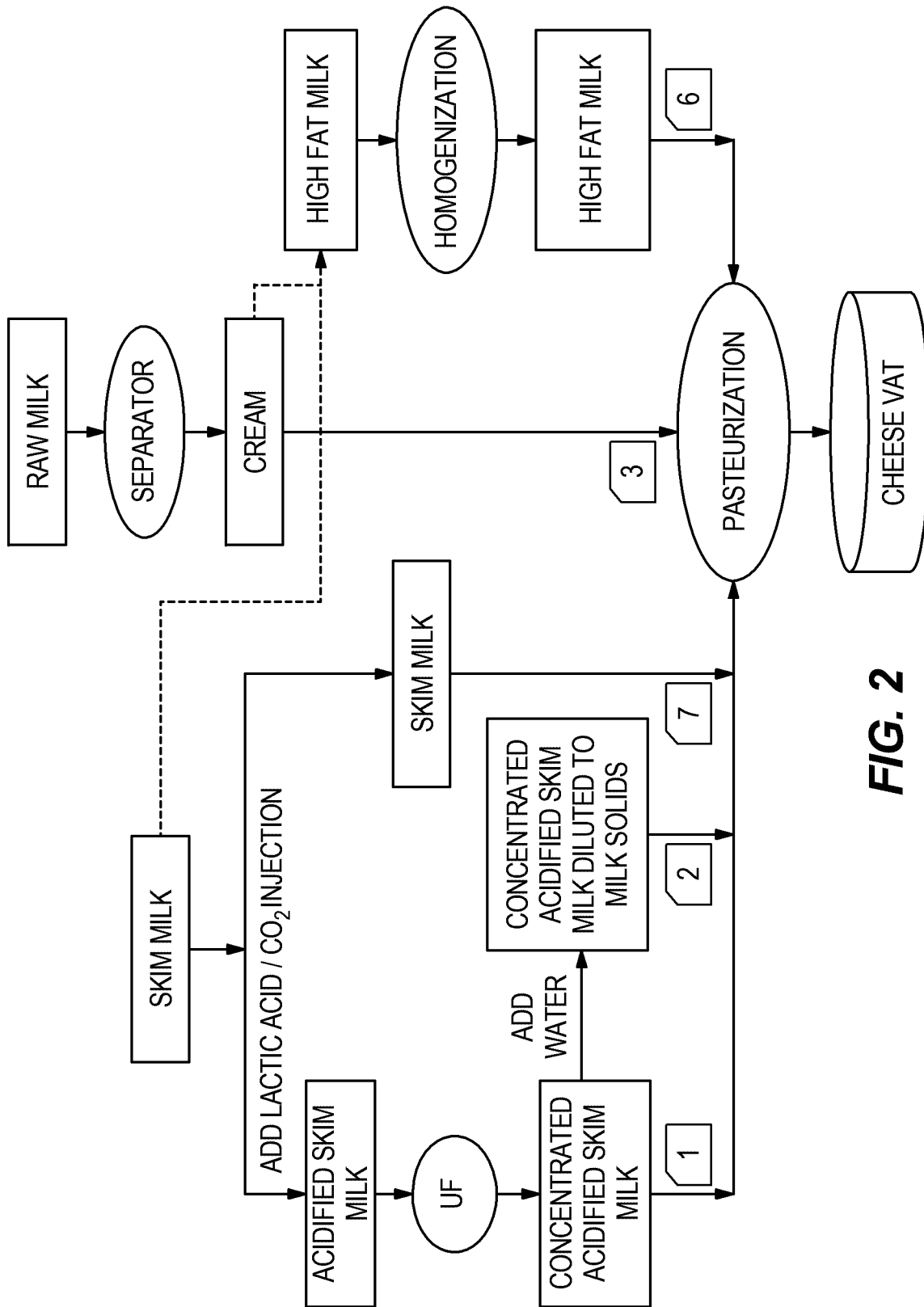
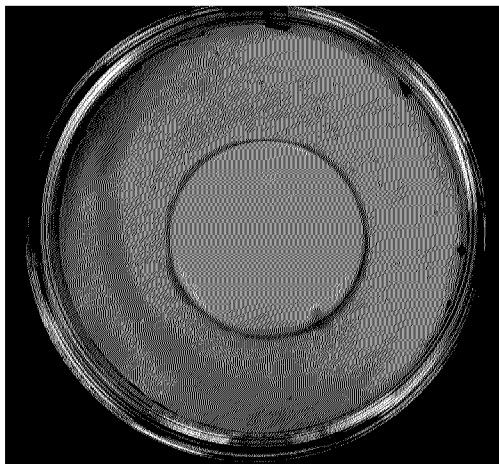


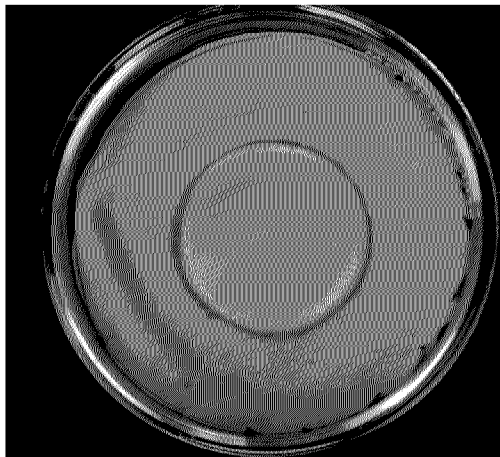
FIG. 2



PC Lot A CT5 10 Weeks



Sargento MJ CT5 10 Weeks



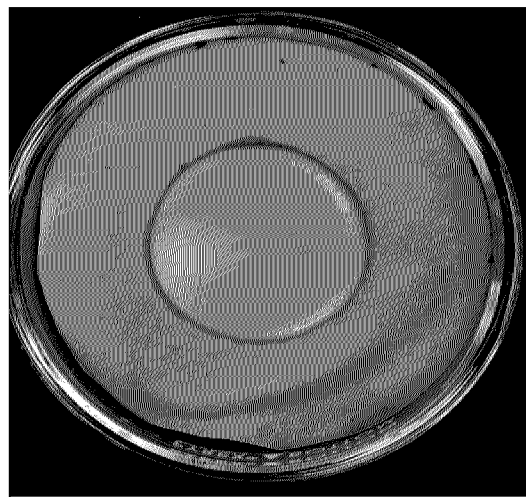
Vat 1 CT5 10 Weeks



Vat 2 CT5 10 Weeks



Vat 3 CT5 10 Weeks



Vat 4 CT5 10 Weeks

FIG. 3

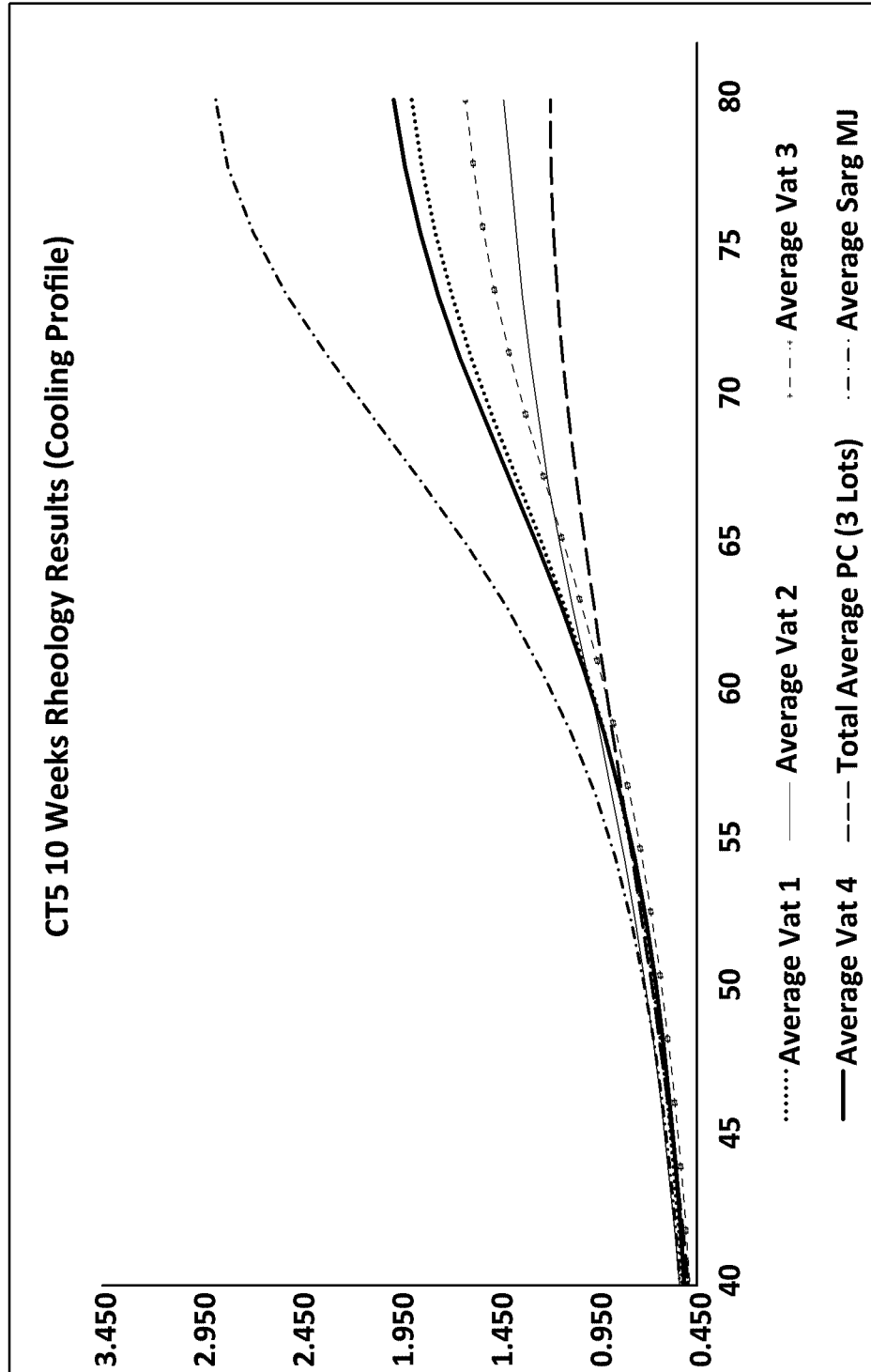
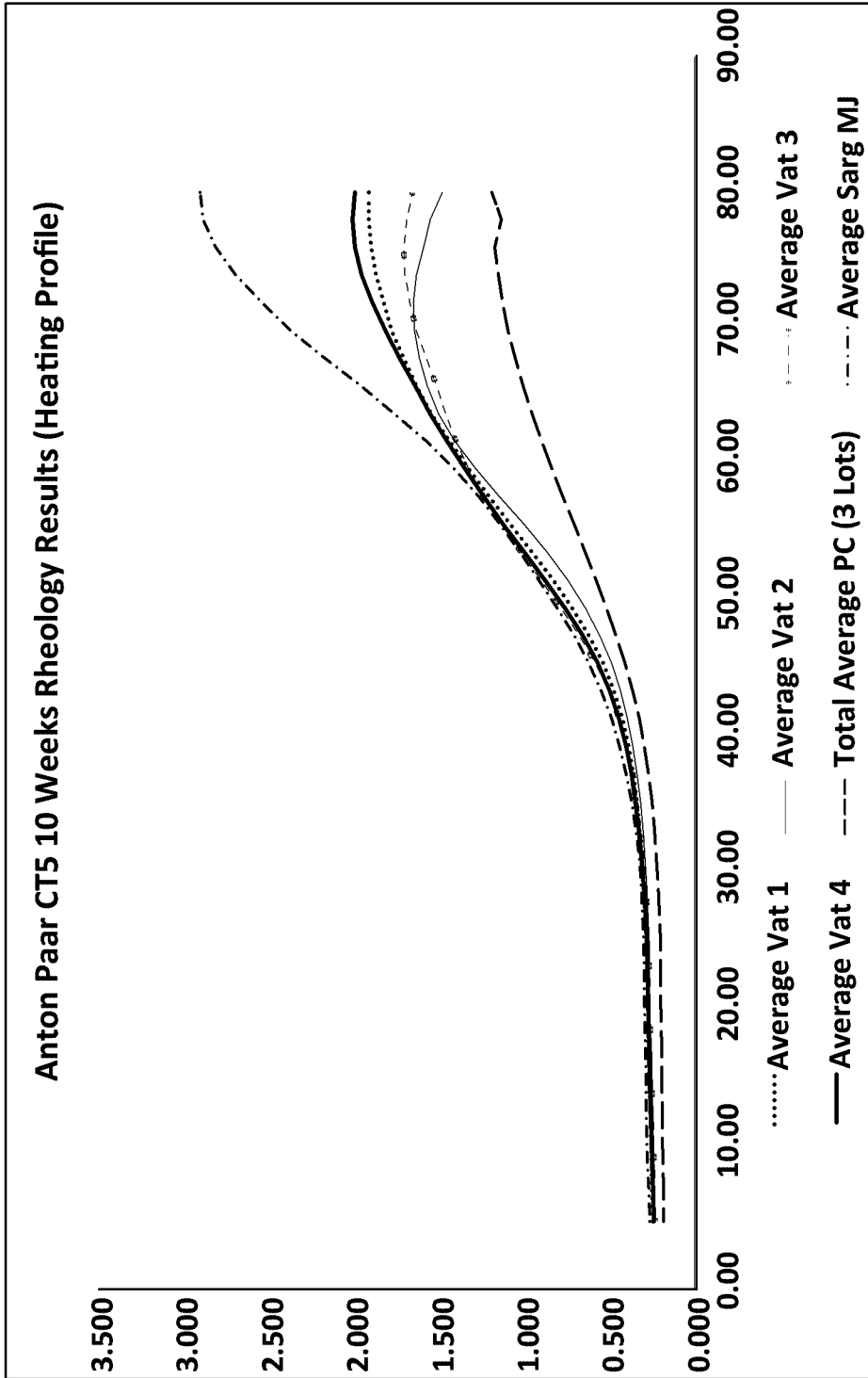


FIG. 4



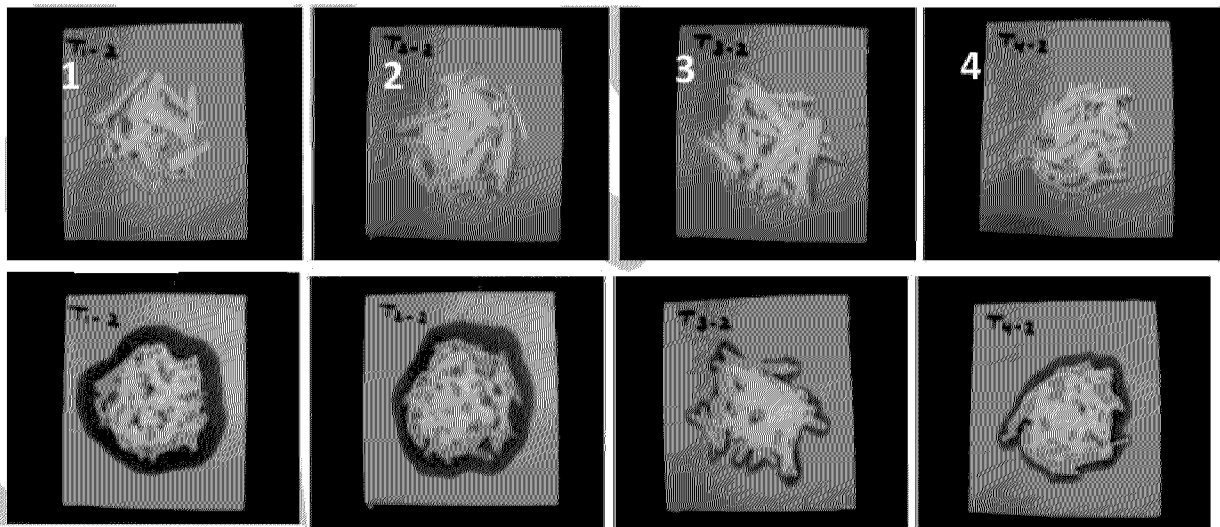
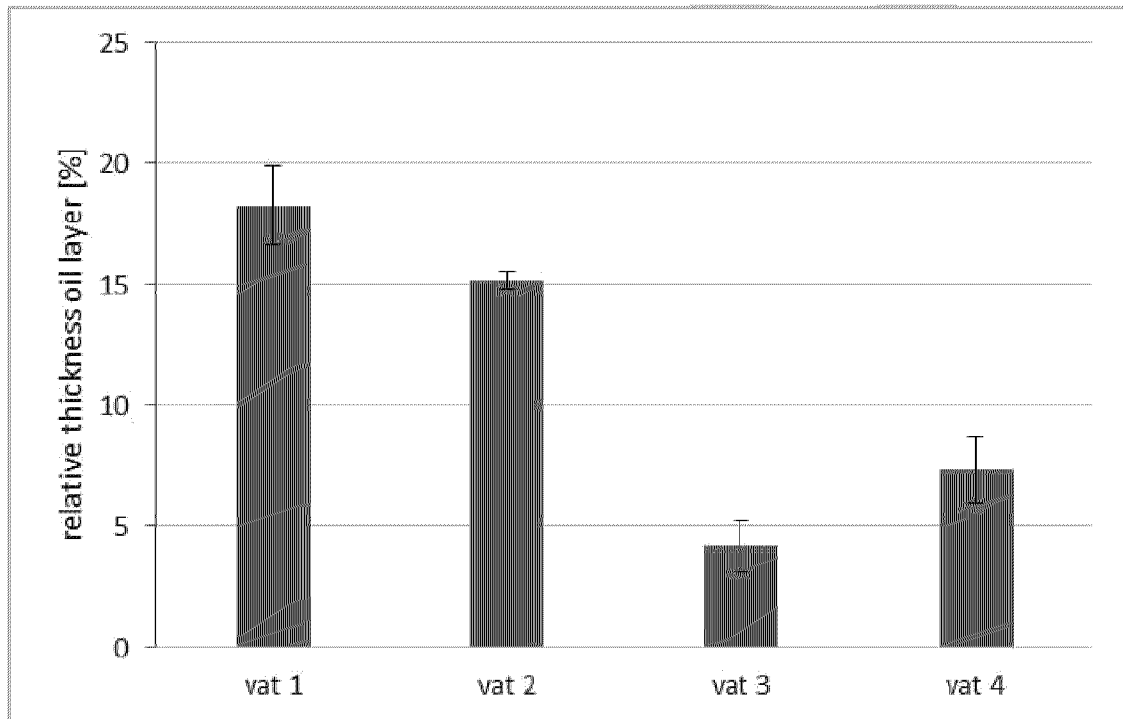
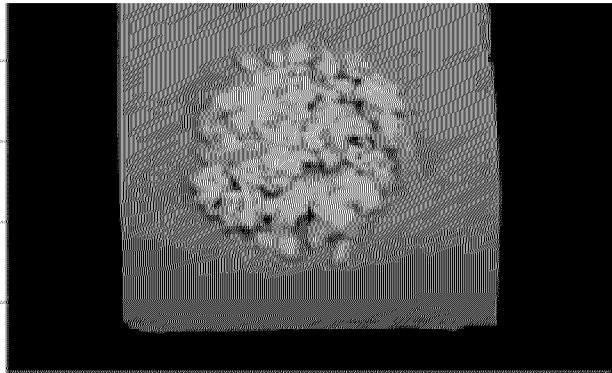
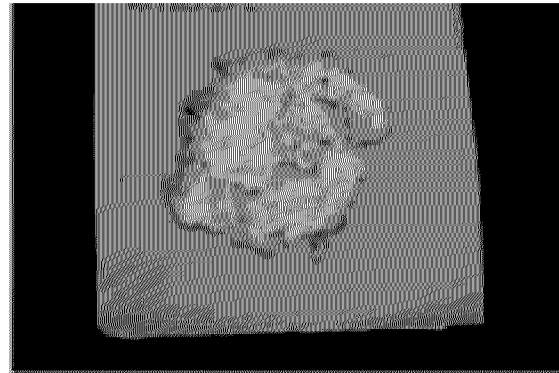


FIG. 6



Before Heating



After Heating

FIG. 7