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Preparation and Properties of Low Fat Processed Cheese Spreads

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Abstract: Low fat processed cheese spreads were prepared from mixtures of fully ripened Ras cheese and acid curd prepared from skim milk fermented with mixed culture of *Lactococcus lactis* sp. *lactis* and *Lactobacillus delbreukii* sp. *bulgaricus* (1:1). In addition to the cheese base, a commercial fat replacer (Samples), whey protein concentrate and oat, rice, Jursalium artichoke were also added (7 treatments). Also, low fat processed cheese spreads were prepared from the same formulations except that acid curd was replaced by rennet curd prepared by rennet coagulation of UF skim milk retentate (20% total solids). In addition to the cheese base, a commercial fat replacer (Samples®), whey protein concentrate, oat, rice, or Jursalium artichoke, were also added (7 treatments). In all treatments the emulsifying salt was added at the ratio of 3.25%. Cheese spreads were analysed for gross chemical composition, microbiological quality, colour parameters and sensory attributes. Also, the cheese microstructure was examined by electron microscopy. The total solids and fat content of the resultant low fat processed cheese spreads were in accordance of the Egyptian standards for half fat processed cheese spreads. However, the colour and organoleptic attributes of the obtained low fat processed cheese spreads made with use of acid curd were inferior to the control (full fat processed cheese spread). On the other hand the organoleptic properties of low fat processed cheese spreads from made with the use of rennet curd were comparable to the control. The treatments with the best organoleptic properties were that prepared from cheese base without other additives or with rice powder. Also, the colour attributes that spreads were comparable to the control. Differences in the microstructure of low fat spreads and control reflected the differences in its fat content.

Key words: Processed cheese spreads, chemical composition, skim milk curd, sensory attributes, microstructure, colour parameters

Introduction

The adverse effects of excessive dietary fat intake have been realized by the 80s of the last Century. High fat intake is associated with an increased risk for obesity and some types of cancer and saturated fat intake is associated with high blood cholesterol and coronary heart disease (Department of Health and Social Security, 1984; Visek, 1990).

The consumer demand for low/reduced fat products led to significant research efforts for fat replacement in traditional products as well developing new low fat products (Glicksman, 1995). However, this is not an easy gob as fats have several essential functions in respect to the texture, structure and sensory attributes of foods.

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Cheese varieties have received much attention with respect to fat reduction as cheeses have generally high fat contents (about 50% of cheese solids). The quality attributes of cheese (i.e., texture, mouth feel, flavour development) are greatly affected by its fat contents. Removal of fat from cheese yield cheese of inferior quality (Mistry, 2001).

Therefore, several attempts have been for the manufacture of low-fat versions of the processed cheeses and spreads. Methods developed for the preparation of these products included; the use of combinations of dairy ingredients (Salem *et al*., 1987; Strandholm *et al*., 1989; McGregor *et al*., 1995; Raval and Mistry, 1999; Awad *et al*., 2003), addition of starch and starch derivatives (Samodurov *et al*., 1991; Batz *et al*., 1994; Jackson *et al*., 1994), addition of polysaccharides other than starch (Brummel and Lee, 1990; Lee and Brummel 1990; Davison *et al*., 1993; Swenson *et al*., 2000) and addition of commercial fat replacers (Kebary *et al*., 1998, 2001). However, most of these additives, particularly fat replacers, increase the cost of cheese production. Therefore, it was thought desirable to search for inexpensive natural sources to be used in low fat cheeses.

In the present study, attempts were made for the use of some natural sources of starch, skim milk curd in the manufacture of low fat cheese spreads. The effect of used ingredients on the composition, quality and microstructure of low fat processed cheese spreads was also followed.

Materials and Methods

Materials

- Ripened Ras cheese, obtained from Cairo market. The cheese was selected by the characteristic flavour of fully ripened Ras cheese.
- Simpless®100 obtained from Kelco Biopolymers (Dorset House, Regent Park, Kingston Road, Leatherhead,UK)
- Rice, oat and Jursalium artichoke were obtained from Cairo market. Each was dried and grounded to fine powders.
- Whey protein concentrate (WPC), imported by El-Sayed Awad Al-Amreety Co. (Cairo) from VRS Foods Ltd.
- Karish cheese (acid curd) was prepared by coagulation of skim milk by yoghurt starter and straining whey by cheese cloth. The different steps for the preparation of the acid curd are outlined in the following flow chart:

Fresh skim milk
↓heated up to 75°C
Cooled to 40°C
↓
Addition of 1% starter culture (*Lactococcus lactis* sp. *lactis* + *Lactobacillus delbreukii* sp. *bulgaricus* 1:1) and left over night
↓
Whey drainage
↓
Acid curd (~ 30% TS, pH 4.7)

- Sweet curd, prepared by rennet coagulation of UF-skim milk retentate as shown in the following flow chart:

Fresh skim milk (~ 10% TS)
↓
Heating up to 50°C and

Ultrafiltration up to 20% TS
↓
Skim milk retentate
↓
Heating up to 75°C and
Cooled to 40°C
↓
Addition of rennet (4 g/100 kg)
Coagulation within 30 min
↓
Whey drainage
↓
Sweet curd (~30% TS)

- Joha S9 emulsifying salt (BK Giulini Chemie GmbH , Landenburg, Germany) was obtained from the local market.

Methods

Manufacture of Processed Cheese Spreads

The amounts of ingredients for the manufacture of processed cheese spreads were calculated in order to fulfil the legal standard specification of the final product i.e., full-fat (~ 45%) and low-fat (~20%) fat/dry matter (F/DM). The ingredients were mixed, placed in the processing kettle (Stephans Universal machine, Switzerland) of 2.5 kg capacity and then heated by direct steam up to 90°C with continuous mixing at 1400 rpm for 5 min. Heating was discontinued, the hot cheese melt was packaged manually in wide-open screw capped glass bottles (100 mL capacity) and stored at 5°C until analysed. Table 1 shows the gross composition (%) of the above ingredients.

Chemical Analysis

Fat, moisture, ash, Total Nitrogen (TN) and Soluble Nitrogen (SN) contents were determined according to the methods described by International Dairy Federation (IDF, 1991), British Standard Institute (BSI, 1986), AOAC (1990) and Ling (1963), respectively.

Microbiological Analysis

The total viable, yeasts and moulds, coliform and aerobic spore-formers (mesophilic and psychrophilic) counts were determined according to IDF (1991, 1990), BSI (1987) and BSI (1986) in the same order. Anaerobic spore-formers count was determined by the method of BSI (1968). These organisms were divided into two main groups i.e., saccharolytic and proteolytic by their action on the used medium (Anonymous, 1982). The most probable number was calculated using Tables given by BSI (1991).

Table 1: The chemical composition of ingredients used in processed cheese spreads

Ingredients	TS (%)	Crude protein (%)	Fat (%)	Ash (%)	Carbohydrate*
Ras cheese	66.32	20.01	36.40	6.07	3.84
WPC	94.70	37.51	1.50	7.10	48.59
Samples®	95.60	44.77	2.30	8.06	40.47
Oat	93.95	11.12	-	3.33	79.50
Rice	91.74	6.32	-	1.85	83.57
Jursalium Artichoke	90.05	8.40	-	4.23	77.42
Rennet curd	30.72	11.45	3.00	3.33	6.95
Acid curd	30.00	11.45	3.00	3.33	12.22

* % Calculated by difference

Physical Analysis

The colour of the processed cheese spreads was measured using Hunter colorimeter Model D2s A-2 (Hunter Assoc. Lab.Inc. Va, USA) following the instruction of the manufacturer (Hunter Assoc. Lab, 1976). The instrument was first standardized using a white tile (top of the scale) and a black tile (bottom of the scale). A specimen of the cheese (flat layer) was placed at the specimen port; the tri-stimulus values of the colour namely; L, a and b were measured where:

L: value represents darkness from black (0) to white (100), a; value represents colour ranging from red (+) to green (-) and b value represents yellow (+) to blue (-).

The hue (H*), chroma (C*) and browning index (B1) were calculated according to the method of Palou *et al*. (1999) as follows:

$$H^* = \tan^{-1}[b^*/a^*] \quad (1)$$

$$C^* = v\,[a^{2*} + b^{2*}] \quad (2)$$

$$B1 = [100\,(X - 0.31)]x\,10.72 \quad (3)$$

Where $X = (a^* + 1.75\,L^*)/(5.645\,L^* + a^* - 3.012\,b^*)$

Scanning Electron Microscopy (SEM)

Cheese samples were prepared according to the method of Caric *et al*. (1985) as follows: the sample was cooled to 4°C, cut into 1 mm^3, fixed with 2.8% glutaraldehyde solution for 24 h and post fixed with a 2% osmium tetroxide solution in 0.2 M cacodylate buffer pH 6.85 for 4 h. The fixed sample was dehydrated in a graded ethanol series and dried in a critical point dryer using liquid CO_2 and coated with gold in a S/50 Edwards sputter coater (Edwards Inc., England) and examined in JEOL, JXA scanning electron microscope (JEOL Inc., Japan).

Sensory Evaluation

All samples of processed cheese were evaluated organoleptically for the different sensory properties using a hedonic scale from 1 to 5 designed according to the hedonic scale provided by IDF (1997). Cheese scoring was carried out by a score panel of 12 personnel of the staff members of the Dairy Departments of the National Research Centre and Banha University

Experimental

Formulations of the different treatments (7 treatments) are shown in Table 2. Three replicates were made from each treatment and analysed each in duplicate.

Table 2: Formulation of ingredients (g) used in the preparation of low fat processed cheese spreads

Ingredients	1	2	3	4	5	6	7
Ras cheese	550	350	350	350	350	350	350
Skim milk curd**	350	550	550	550	550	550	550
Emulsifying salt	32.5	32.5	32.5	32.5	32.5	32.5	32.5
Oat		4.5					
Rice powder			4.5				
Jursalium artichoke				4.5			
Simpless R 100					4.5		
WPC*						4.5	
Added water	100	100	100	100	100	100	100
Condensed water	100	100	100	100	100	100	100

*WPC; Whey Protein Concentrates, SMR; ** Acid or rennet curd

Statistical Analysis

The obtained data were statistically analysed according to the methods described by Steele and Torrie (1960).

Results and Discussion

Chemical Composition

Table 3 shows that the composition of processed cheese spreads made with the use of acid curd which indicate that it can be considered as half-fat product according to the Egyptian Standards for processed cheese spreads (Egyptian Standards Organization, 2002a, b).

Table 4 shows the average chemical composition of processed cheese spreads based on rennet curd. The low fat processed cheese spreads from different treatments had a total solid contents that ranged from 34.65 to 35.45% and fat content that ranged from 29.90 to 32.23% fat/dry matter which satisfy the standard specifications of half fat processed cheese spreads (Egyptian Standards Organization, 2002a,b).

Microbiological Quality

Table 5 and 6 show the total bacterial count of low fat processed cheese from different treatments with the use of acid and rennet curd respectively in the formulation. Generally, spreads from different treatments had a low total bacterial counts that ranged from 140 to 323 cfu g^{-1}. The total bacterial counts of the control fall in this range. The low total bacterial count of spreads from different treatments can be attributed to the high heat treatment received during processing (~90°C/5 min) and good hygienic conditions during processing and handling (Abd Rabou *et al*., 2005). This was also apparent from the absence of coliforms and yeasts and moulds in all treatments. Also, Table 5 and 6 show low counts aerobic sporeformers in low fat processed cheese spreads prepared with the use of acid and rennet curd respectively as a cheese base. Differences between low fat spreads from different treatments and control were not significant ($p \leq 0.05$) indicating that the used ingredients had no noticeable effect on the aerobic sporeformers counts in the prepared spreads. Also, the anaerobic saccharolytic and proteolytic sporeformers of low fat processed cheese spreads from different treatments were low (Table 6) being comparable to that for control. These results suggests that the used ingredients had no probable effect on the microbiological quality of the product.

Cheese Colour

Table 7 and 8 show the colour parameters of low fat processed cheese spreads from different treatments using acid and rennet curds in the cheese base, respectively. It is obvious from these results that all treatment had nearly similar values for different colour attributes being comparable to that for the control. Consequently the different ingredients used in low processed cheese spreads can be considered of no effect on the colour of the obtained cheese. This can be explained on the basis that the added ingredients did not increase the reducing sugars content in the mix which are responsible for the formation of the brownish colour in processed cheese products.

Organoleptic Properties

Low fat processed cheese spreads from different treatments using acid curd were generally ranked less scores (Table 9) for different organoleptic attributes than the control. They were characterized by aqueous phase separation indicating incomplete emulsification. Therefore, the use of acid curd was responsible for the low acceptability of the obtained low processed cheese spreads. The acid curd normally lacks the gel structure and contains less calcium than green cheese or rennet curd which may explain the low quality processed cheese spreads based on acid curd (Caric and Kalab, 1993). Therefore, the use of rennet curd instead of the acid curd in the processed cheese blends was studied.

Table 3: Chemical composition (g/100 g)of low fat processed cheese spreads from different treatments using acid curd (Average of 3 replicates)

Treatments No.	TS	Protein	SN	SN/TN	Fat	Fat/DM	Ash	Ash/DM	CHO
1	41.96	13.71	0.37	16.40	21.68	51.67	4.39	10.11	2.33
2	35.91	14.92	0.30	13.06	11.62	32.53	2.74	7.63	6.55
3	35.74	12.06	0.29	14.17	11.38	31.82	2.68	7.80	9.50
4	35.55	14.17	0.30	13.89	11.53	32.45	4.24	11.93	5.56
5	35.41	15.76	0.28	11.28	11.74	33.15	5.03	14.21	2.86
6	36.36	17.16	0.33	12.20	11.34	30.98	3.54	9.76	4.46
7	34.68	15.27	0.20	8.22	10.93	31.50	2.70	7.79	2.79

CHO, carbohydrate (calculated by difference)

Table 4: Chemical composition (g/100 g) of low fat processed cheese spreads from different treatments using rennet curd (Average of 3 replicates)

Treatments No.	TS	Protein	SN	SN/TN	Fat	Fat/DM	Ash	Ash/DM	CHO
1	42.40	12.64	0.31	15.15	24.16	56.98	4.14	9.76	1.46
2	34.65	11.76	0.31	16.71	11.17	32.23	3.67	10.61	8.05
3	34.98	12.22	0.26	13.69	10.99	31.42	3.68	10.53	8.09
4	35.07	12.22	0.22	11.56	10.79	30.78	3.97	11.33	8.29
5	34.94	13.02	0.27	13.27	10.92	31.25	3.94	11.27	7.06
6	35.01	12.66	0.25	12.76	10.32	29.48	4.48	12.80	7.55
7	35.45	12.43	0.27	13.11	10.49	29.60	4.22	11.93	8.30

CHO, carbohydrates (calculated by difference)

Table 5: Total bacterial count and aerobic and anaerobic sporeformers counts of low processed cheese spreads from different treatments using acid curd (cfu g^{-1})*

		Aerobic sporeformers		Anaerobic sporeformers	
Treatments No.	Total count	Mesophilic	Psychrophilic	Saccharolytic	Proteolytic
1	115	77	25.0	39.5	4.3
2	140	30	35.0	34.5	4.3
3	175	75	6.7	47.0	10.0
4	187	157	13.3	30.0	15.7
5	293	130	6.7	8.0	9.3
6	170	80	13.3	37.0	4.3
7	160	140	30.0	21.0	3.0

*Average of 3 replicates

Table 6: Total bacterial count and aerobic and anaerobic sporeformers counts of low processed cheese spreads from different treatments using rennet curd (cfu g^{-1})*

		Aerobic sporeformers		Anaerobic sporeformers	
Treatments No.	Total count	Mesophilic	Psychrophilic	Saccharolytic	Proteolytic
1	233	93	3.3	33	61
2	183	103	6.6	13	15
3	163	93	4.3	16	56
4	197	157	3.7	12	17
5	323	147	0.0	5	10
6	267	167	3.3	15	36
7	140	100	23.3	16	27

*Average of 3 replicates

Table 7: Colour parameters (Hunter) of low fat processed cheese spreads from different treatments using acid curd (Average of 3 replicates)

Treatments No.	L	a	b	H	C	B1
1	85.4	-2.1	22.4	84.64	22.50	50.60
2	82.1	-2.6	22.3	83.35	22.45	51.82
3	84.4	-2.1	22.3	84.62	22.40	51.02
4	82.1	-1.9	22.5	85.17	22.58	53.63
5	78.4	-3.1	22.4	82.12	22.61	54.11
6	79.7	-2.8	22.8	83.00	22.97	54.84
7	84.4	-3.5	22.3	81.08	22.57	49.32

Table 8: Colour parameters (Hunter) of low fat processed cheese spreads from different treatments using rennet curd (Average of 3 replicates)

Treatments No.	L	a	b	H	C	B1
1	85.4	-1.4	22.6	86.46	22.64	52.33
2	82.6	-1.6	20.8	85.60	20.86	48.85
3	84.4	-2.5	20.5	83.06	20.65	45.31
4	83.6	-2.0	21.3	84.64	21.39	48.91
5	84.1	-1.9	21.8	85.02	21.88	50.15
6	84.5	-2.0	21.1	84.58	21.19	47.75
7	85.3	-1.7	21.2	85.41	21.27	48.00

Table 9: Average scores (10 panelists) of organoleptic attributes (out of 5 points) of low fat processed cheese spreads from different treatments using acid curd (Average of 3 replicates)

Attribute	1	2	3*	4**	5***	6***	7****
Appearance	4.5	4.0	4.0	3.0	2.5	3.5	3.5
Firmeness	4.5	4.0	3.5	2.5	2.0	2.0	3.5
Spreadability	4.5	4.0	3.5	3.0	1.5	2.5	3.5
Stickness	5.0	4.5	3.5	3.0	2.5	2.5	3.5
Smoothness	5.0	4.5	3.5	3.5	2.0	2.5	3.5
Breakdown	5.0	4.5	4.0	3.0	2.5	2.5	3.5
Chewiness	5.0	4.5	4.5	3.5	2.5	2.5	4.5
Gumminess	5.0	4.5	4.5	3.5	2.5	2.5	3.5
Oil separation	5.0	4.5	5.0	4.0	5.0	1.5	5.0
Flavour	4.5	4.0	3.0	3.0	3.0	2.5	3.0
Overall preference	5.0	4.0	3.5	2.5	2.5	1.5	2.5
Total scores	53.0	47.0	42.5	34.5	28.5	27.5	39.5

* Whey separation; ** Whey separation, insoluble substances; *** Whey and oil separation, insoluble substances; **** Oil separation, foeign taste

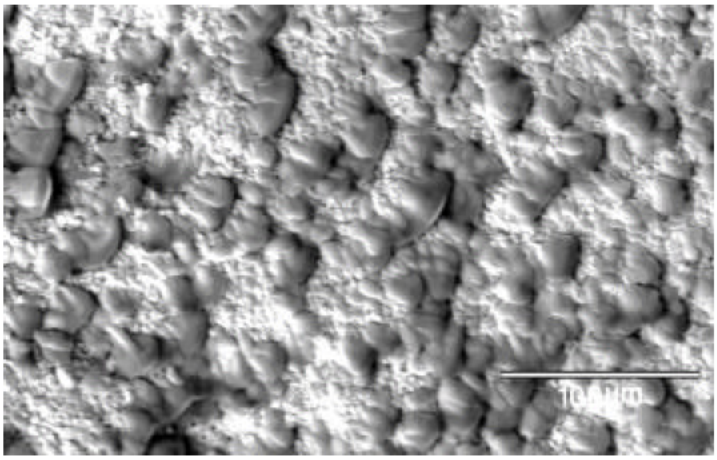
Table 10: Average scores (10 panelists) of organoleptic attributes (out of 5 points) of low fat processed cheese spreads from different treatments (Average of 3 replicates)

Attribute	1	2	3	4	5	6	7
Appearance	4.5	4.7	4.7	4.3	4.5	4.7	4.8
Firmeness	3.5	4.5	4.7	4.3	4.5	4.7	4.2
Spreadability	3.3	4.3	4.7	4.0	3.7	4.0	4.3
Stickness	3.8	4.5	4.5	4.3	4.7	4.3	4.8
Smoothness	3.8	4.3	4.5	4.0	3.8	4.3	4.3
Breakdown	3.8	4.3	4.5	4.0	4.3	4.3	4.3
Chewiness	4.3	4.3	4.5	4.3	4.8	4.5	4.8
Gumminess	4.3	4.3	4.8	4.5	4.5	4.8	5.0
Oil separation	5.0	5.0	5.0	4.7	4.7	4.7	5.0
Flavour	4.3	4.2	4.5	4.0	4.2	4.2	4.7
Overall preference	3.8	4.2	4.3	3.8	3.8	4.0	4.2
Total scores	44.4	48.6	50.7	46.2	47.5	48.5	50.4

The low fat processed cheese spreads made with the use of rennet curd were characterized by good texture and structure (Table 10). Phase separation observed in spreads prepared with the use of acid curd was not apparent in that spreads. Therefore, rennet curd can be considered more suitable for the preparation of low fat cheese spreads. Slight differences were found in scores for different attributes between low fat processed cheese spreads and the control (full-fat). Moreover, the total scores for low fat spreads from some treatments were higher than the control. Based on the total scores, low fat processed cheese made with Ras cheese and rennet curd only and that made with the addition of rice powder were considered as the best treatments for low fat processed cheese.

Microstructure

A comparison was made in this study between the microstructure control processed cheese spreads (full-fat) and low fat spread made with the use of rennet curd and rice (Fig. 1). Both spreads exhibited a matrix of fused casein molecules. Channels were apparent between the protein matrix probably reflect the location of the aqueous phase. Additional material was apparent that fill the



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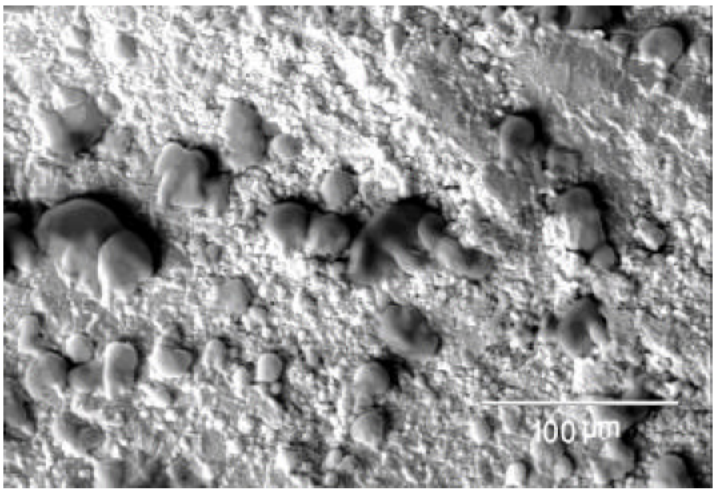

B

Fig. 1: Scan electron microscope for different types of spreadable processed cheese made with different fat substitutes (A) full-fat , (B) low-fat cheese with Rice (Magnification 350)

intracellular spaces. The presumption that this material was milk fat is consistent with the finding of Kerr *et al*. (1981) for Domiati cheese. The occurrence of more of this material in full-fat spread add to the assumption that it was milk fat. Apart from the difference in fat addition of rice seems to have no effect on the microstructure of processed cheese spreads. Similar results (not shown) was found with the use of oat and Jursalium artichoke. The present results are in accordance with that given by Abd Rabou *et al*. (2005).

Conclusions

Good quality low fat processed cheese (half-fat) can be made from mixed Ras cheese and rennet curd (35:55) with or without the addition of rice powder (4.5%). The cheese satisfy the legal specifications for half-fat processed cheese spread and had good microbiological quality. The organoleptic properties of the obtained cheese were better than full-fat processed cheese spreads.

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