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Effect of Fat Replacers on the Quality of Low-Fat Munster-Like Cheese

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ABSTRACT

The effect of two fat replacers Simplesse®100 (as protein based fat replacers) and Slendid®200(as carbohydrate fat replacers) on the chemical composition ,rheological, microbiological and sensory qualities of low-fat Munster-like cheeses was investigated throughout the ripening period . The low fat cheese samples made with fat replacers were compared with full and low fat cheeses counterparts as controls. Cheeses were evaluated at 0, 30 and 60 days of ripening. The yield, moisture content and titratable acidity of the cheeses made with fat replacers were higher than those of low fat control cheese, whereas protein and total solids contents were lower. The used fat replacers had no effect on the proteolysis during cheese ripening, but enhanced the lipolysis. The use of fat replacers increased lipolytic bacteria and decreased yeast and moulds counts. Using of fat replacers decreased the hardness, adhesiveness, cohesiveness, gumminess and chewiness, and increased springiness. The sensory properties of low fat Munster-like cheese were improved by addition of fat replacers to the cheese milk.
Keywords: Low fat Munster-like cheese, fat replacers.

INTRODUCTION

Munster is a semi-soft French type cheese processed from whole cow's milk and originated from the Alsacian Village of Munster. Munster cheese is characterized by colorful orange rind, slicing with a mild, sweet cream flavor and smooth texture. Like most cheeses in France, Munster has a long tradition behind it. Many centuries ago this cheese was made by Benedictine monks who had migrated to the Alsace region of France. Eventually the savoir-faire for creating this cheese was passed on to the local population. According to Fox (1993), Munster cheese is one of the bacterial surface ripened cheeses. For which the development of desirable microorganisms on the surface and effect, the formation of viscous red orange (various shapes) smear necessary in determining the organoleptic properties of that cheese. Ripening is carried out from the surface to the interior, mainly through the participation of enzymes secreted by microorganisms present in the smear. Munster is normally made in large disc shapes, about 20 cm (8 in) in diameter and 5 cm (2 in) thick. Smaller cheeses, 10 cm (4 in) in diameter are also made.

In recent years there is a great interest for manufacturing low-fat dairy products particularly reduced-fat cheese to meet consumer demand. Consumers wish to reduce dietary fat intake for numerous health benefits .without sacrificing desirable textural and flavour attributes of cheese (Sakr & Mehanna 2011) .To eliminate the negative effects of removing fat in low-fat cheese production, three main approaches have been followed, including (1) modification in cheese making procedure, (2) use of adjunct starter culture and (3) use of fat replacers (Drake&Swanson**,** 1995 ; Mistry, 2001) . The use of fat replacer in the manufacture of dairy products is still novel. Fat replacers which decrease the calorific value of food , can be used to solve some physical and organoleptic problems originating from low-fat levels in the final products by bulking effect associated with moisture retention and give a sense of lubricity and creaminess .Fat replacers consist of mixtures of lipid-originated fat substitutes , protein- or carbohydrate-originated fat mimetics or their combinations (Huyghebaert *et al.* 1996 ; Romeih *et al.* 2002).The objective of this study was to investigate the possibility of using slendid®200 and simplesse®100 in the manufacture of low –fat Munster cheese and their effect of on chemical , microbiological ,reological and sensory properties of cheese during storage.

MATERIALS AND METHODS

Materials:

Fresh cow's milk samples were obtained from El-Serw Animal Production Research Station, Animal Production Research Institute, Agriculture Research Center. Standardized low-fat milk (SLFM, 1.5% fat) was prepared from the collected cow's milk samples. Fat replacers of commercial names Simplesse®100 and Slendid®200 were obtained from Co.Kelco, Denmark. Lyphoilized mesophilic starter cultures consisting of *Lactococcus lactis subsp.lactis ,Lactobacillus lactis subsp.cremoris ,Streptococcus thermophiles, Lactobacillus delbrueckii subsp.bulgaricus , Lactobacillus helveticus* and *Lactobacillus casei subsp,casei* were obtained from Ch.Hansen's Laboratories, Denmark. Liquid rennet was purchased from the local market.

Methods:

Cheese manufacture

Munster like cheese was made mainly as described by El-Metwally (2013) from the prepared milk. The following flow chart describes the manufacture procedure from the prepared milk samples including standardized cow's milk (3% fat ,T1), low-fat standardized milk (LFSM,1.5%) without (T2) or with adding 0.2% Slendid®200 (T3)0r 0.2% Simplesse®100 (T4) or with adding Slendid®200 and Simplesse®100 (T5).Three replicates of each treatment were carried out.

The prepared milk
↓
Heating at 63°C
↓
Cooling to 34°C
↓
Lipholized powder starter addition (0.7% at 32C)
↓
Incubation at 32°C/40 minutes
↓
Renetting by animal liquid rennet (30 ml/100l.Whole milk in 40 minutes)
↓
Coagulation in 40 minutes
↓
Cutting into small cubes
↓
Scalding for 45 minutes
Raising the temperatures up to 38°C
↓
Drainage of the whey (pH 6.2)
↓
Hooping in round moulds (Capacity 3kg)
↓
Salting (Saturated brine solution for 24 hours)
↓
Ripening (18°C, 85%RH for 60 days)

Fig. A. Flow Chart of Munster like cheese

Methods of analysis

Chemical analysis

Total solids, fat and TN contents of milk, whey, and cheese samples were determined according to AOAC (2000). Ash content of milk and whey were measured as Ling (1963). Lactose content was colorimetrically determined as described by Lawrance (1968). Titratable acidity of milk, whey and cheese was estimated as lactic acid according to Ling (1963) . pH of the sample was measured using a glass electrode pH meter. Water soluble nitrogen (WSN) and non-protein nitrogen (NPN) of cheese were estimated according to Ling (1963). Total volatile fatty acids (TVFA) were determined according to Kosikowiski (1978).

Microbiological Analyses

Cheese samples were analyzed for total viable bacterial count (TBC), lipolytic bacterial count, coliform bacterial count, moulds and yeast counts according to the methods described by the American Public Health Association (1992).

Rheological Analyses

The texture properties of 60 days old cheese samples were evaluated using Texture analyzer (Sher force) . Control and experimental cheese samples were taken after 60 days ripening. The texture profile parameters were obtained and calculated as describe by Bourne (1982).

Organoleptic evaluation

Samples of cheese were organoleptically scored by the staff of the El-Serw Animal Production Research Station, Ministry of Agriculture. The score points were 15 for colour and appearance, 35 for body and texture and 50 for flavour.

RESULTS AND DISCUSSION

Table (1) shows that as a result of removing some fat from cow's milk to prepare standardized low-fat milk (SLFM) a pronounced decrease in TS and fat was recorded with the corresponding increase in protein , lactose and ash . Acidity and pH were not affected. It seems from Table (1) that the use of fat replacers (T3-T5) had no pronounced effect in this respect. Such replacers increased rennet coagulation time (RCT) of the SLFM, but had no pronounced effect on curd tension (CT) of the renneted milk (Table 2). A gradual decrease in curd syneresis (CS) was detected in Table (2) at any given syneresis time, as affected by the use of fat replacers (T3-T5). In all cases, standardized control milk (T1) had less CS as compared to non-treated SLFM (T2) or fat replacers treated SLFM (T3-T5). Calvo and Balcones (2000) demonstrated that decreased milk fat in milk caused an increase in rate of CS. Types of mechanism of CS as given by Walstra (1993). Included: A decrease in water bunding of the material making up the gel, shrinkage of the building blocks of the gel and rearrangement of the network of (para) casein micelles. In cheese whey the loss of some milk constituents was found to be affected by the applied treatments. Table (3) reveals that when Munster cheese was made from standardized control milk (SCM, 3% fat), the collected whey contained less TS, protein and lactose (T1), as compared to whey from the rest of treatments (T2-T5). Acidity value was also less and pH was higher in case of T1. This was expected since the composition and properties of cheese curd are greatly affected by milk composition and by the procedure of cheese making. It was also reported that the amount of fat in the whey decreased and the moisture content of the cheese increased linearly with the increase in the cutting time. The loss of fat from soft curd was explained by the inability of poorly –developed network to retain it and the retention of moisture by the difficulty of a very rigid highly cross –linked curd subsequently forming sufficient cross-links to expect the required amount of whey (Green and Grandison, 1993).

Table 1.Gross chemical composition (%), acidity (%) and pH of the control and fat replacers-treated cheese milk (Average of 3 replicates)*.

Treatments	T.S	Fat%	Protein	Lactose	Ash	Acidity	pH
T1	12.08	3.10	2.85	4.50	0.75	0.16	6.70
T2	10.75	1.60	3.16	4.85	0.78	0.17	6.63
T3	10.98	1.60	3.15	4.83	0.77	0.16	6.65
T4	10.97	1.65	3.17	4.82	0.78	0.16	6.66
T5	10.99	1.65	3.17	4.82	0.78	0.16	6.68

***T1: Standardized control milk 3% fat**
T2: Standardized low-fat milk 1.5% fat = SLFM
T3: SLFM + 0.2 % (w/v) Slendid®200
T4: SLFM + 0.2 % (w/v) Simplesse®100
T5: SLFM + 0.1 % Slendid®200 + 0.1 % Simplesse®100

As expected, yield of fresh cheese was greatly affected by the fat content of the milk used. Table (4) shows that the maximum yield of fresh cheese (18.0%) was recorded for fresh cheese from SCM (T1), whereas the minimum (16.25%) was for fresh cheese from SLFM (T2). Fat replacers seem to have some effect on the increase of the fresh yield of cheese, since the values were 17.35, 17.05 and 17.20% for T3, T4 and T5, respectively. This could be attributed to the corresponding increase in moisture content as shown in Table (4). The recorded moisture content was 43.25%in fresh cheese from T2 and increased to be 45.68, 48.38 and 49.51 % in fresh cheese from treatments T3, T4 and T5 ,respectively. The same trend was noticed during cheese ripening with corresponding less value for yield that proportional , with the decrease in moisture content also during cheese ripening.

Table 2. Some physical properties of renneted cheese milk as affected by using fat replacers (Average of 3 replicates)*

Treatments	RCT(sec)	Curd Tension(gm)	Syneresis (gm/15gm of curd)				
			10	30	60	120	Total
T1	220	31.25	2.96	4.88	5.37	5.50	18.71
T2	182	35.57	3.19	5.27	6.89	7.12	22.47
T3	196	35.20	3.15	5.20	6.86	7.08	22.29
T4	192	35.00	3.10	5.15	6.78	7.00	22.03
T5	190	34.95	3.11	5.13	6.70	6.93	21.87

***See legend to Table (1) for details.**

Table 3. Gross chemical composition (%) , acidity (%) and pH of the collected whey during cheese making as affected by applying some treatments (Average of 3 replicates)*

Treatments	pH	Acidity	T.S	Fat	Fat/TS	T.P	P/TS	Ash	Lactose
T1	5.90	0.32	5.97	0.50	8.38	0.61	10.22	0.35	4.21
T2	5.60	0.37	6.15	0.25	4.07	0.83	13.49	0.34	4.38
T3	5.70	0.35	6.18	0.20	3.24	0.81	13.11	0.35	4.40
T4	5.72	0.35	6.18	0.20	3.24	0.80	12.94	0.37	4.40
T5	5.68	0.36	6.21	0.20	3.22	0.78	12.56	0.38	4.42

See legend to Table (1) for details. *

It is clear from Table (4) that the moisture content of low fat Munster- like cheese increased by replacing milk fat with either Simplesse®100 or Slendid®200. These results agree with the results of El-Sonbaty *et al.* (2002) and Kebary *et al.* (2002) of Edam cheese, Kebary *et al.* (2009) of Domiati cheese, El-Sonbaty and El-Sisey (2010) of Gouda cheese. The increased moisture content of low-fat cheeses produced by using fat replacers indicated that curd syneresis was retarded during cheese making. It was suggested that water can bind directly to fat replacers and such fat replacers can interfere with the shrinkage of the casein matrix.

Table 4. The yield (%), gross chemical composition (%) and acidity (%) of cheese during ripening as affected by using fat replacers (Average of 3 replicates)*

Treatments	Ripening period (days)	Yield	Moisture	Fat	Fat/DM	Protein	Acidity
T1	Fresh	18.00	50.72	23.58	47.85	20.99	0.97
	30	17.15	46.90	23.71	44.65	21.31	1.45
	60	16.20	44.25	23.79	42.67	23.10	1.80
T2	Fresh	16.25	43.25	17.22	30.34	29.79	0.76
	60	15.30	39.00	17.82	29.21	30.18	1.20
	30	14.85	37.21	18.11	28.84	31.33	1.66
T3	Fresh	17.35	45.68	17.21	31.68	27.18	0.80
	60	16.20	42.35	17.82	30.91	27.82	1.32
	30	15.95	40.40	18.10	30.37	29.35	1.69
T4	Fresh	17.05	48.38	17.20	33.32	29.92	0.84
	60	16.10	45.83	17.80	32.86	30.31	1.41
	30	15.60	43.81	18.11	32.23	31.52	1.76
T5	Fresh	17.20	49.51	17.20	34.07	31.26	0.93
	60	16.35	48.08	17.61	33.92	31.84	1.43
	30	16.00	45.99	17.96	33.25	33.56	1.79

***See legend to Table (1) for details.**

Therefore, this lowers the driving force involved in expelling water from curd particles (McMahon *et al.*, 1996).One of the most important strategies for improving the properties of lower fat cheese is to increase its moisture content sufficiently to provide a ratio of moisture to protein in the lower fat cheese that is equal or higher than its full fat counterpart (Broadbent *et al.* 2001). Cheese treatment being made by adding simplesse®100 was more effective to increase the moisture content , thus it contained higher moisture content than the corresponding cheese made by adding slendid .On the other hand, moisture content of all cheese treatments decreased as ripening period progressed . These results agree with the Verachia (2005) and El-Sonbaty and El-Sisey (2010) of Gouda cheese. It could also be seen in Table (4) that the fat content of Munster-like cheese decreased as the fat content of milk reduced. On the other hand, fat content of cheese treatments increased markedly during storage periods. These results are in agreement with those reported by Abdalla *et al*. (2006); Taha et al.2007; abd Alla *et al*. (2008) and Mehanna *et al*.(2009) on Ras cheese and El-Sonbaty and El-Sisey (2010). This increased in fat content could be attributed to the reduction of moisture content throughout the ripening period (Kebary *et al*., 2006).

Total protein content of low fat Munster- like cheese treatments increased by replacing milk fat with Simplesse®100 or mixture of Simplesse®100 and Slendid®200 but decreased with slendid. On the other hand, as the ripening period progressed the corresponding total protein increased. The apparent increase is due to the loss of water and the increase in total solids of the cheese. Titratable acidity of all Munster-like cheese treatments increased during ripening period. These results are in agreement with those of El-Sheikh *et al*. (1999) for Ras cheese and El-Sonbaty and El-Sisey (2010), but the values were always higher in fat-replacers-treated cheese of different ages.

Proteolytic and lipolytic indices of cheese from different treatments are shown in Table (5) The recorded values of water soluble nitrogen (WSN) seem to be not affected by using the fat replacers (T3-T5) , but were greatly increased during ripening of cheese from all treatments. This also was noticed when WSN was calculated as percentage of TN (WSN/TN) .Values of non-protein nitrogen (NPN) or NPN/TN followed the same trend of WSN results being low in all fresh untreated cheese samples and gradually increased with advancing ripening. Using fat replacers also seem to have negligible effect in this respect. In all cases , cheese from SCM (T1) had always higher WSN , WSN/TN, NPN and NPN//TN at any given age as compared to cheese from the LFSM(T2) or the other treatments (T3-T5).

Lipolysis in cheese was affected by the applied treatments. Table (5) shows that the values of TVFA were always higher in the presence of fat replacers (T3-T5) as compared to T2. This was noticed in the fresh cheese or during ripening with more relatively values in case of T4 and T5. The recorded trends of results due to cheese ripening are in accordance with those given in the literature (El-Sonbaty *et al*. 2002;El-Zeini *et al*.2007 ;Mehanna *et al*.2009).

Table 5. Proteolysis and lipolysis occurring in Munster-like cheeses affected by the fat replacers durign ripening (Average of 3 replicates)*

Treatments	Storage period (days)	WSN%	WSN/TN%	NPN%	NPN/TN%	TVFA**
T1	Fresh	0.39	11.85	0.125	3.79	7.600
	30	O.53	15.87	0.173	5.18	16.20
	60	0.70	19.34	0.210	5.80	23.00
T2	Fresh	O.37	7.92	0.124	2.66	6.600
	60	0.50	10.57	0.166	3.51	11.00
	30	0.68	13.85	0.190	3.87	14.30
T3	Fresh	0.35	8.22	0.123	2.89	6.800
	60	0.48	11.01	0.159	3.65	11.89
	30	0.66	14.35	0.186	4.04	16.90
T4	Fresh	0.37	7.89	0.124	2.64	7.500
	60	0.51	10.47	0.166	3.41	17.60
	30	0.69	13.96	0.190	3.85	23.10
T5	Fresh	0.38	7.76	0.125	2.55	7.600
	60	0.53	10.62	0.169	3.39	17.90
	30	0.72	13.69	0.210	3.99	24.10

***See legend to Table (1) for details. **TVFA expressed as ml 0.1 N-NaOH per 10 g of cheese.**

Table (6) deals with the enumeration of total bacterial counts , lipolytic bacteria, coliform, and yeasts and moulds in all treatments .It is clear that cheese from LFSM + 0.1 % Slendid + 0.1 % Simplesse had higher TBC of 4.4 X 10^6 cfu/g .Addition of fat replacer to low-fat milk cheese increased lipolytic bacteria but decreased yeast and moulds counts in T3 and T4 treatments .It could also be observed that no coliforms were detected throughout the ripening time in any of cheeses .

Table 6. Microbiological quality (cfu/g) of Munster cheese during its ripening as affected by using fat replacers in cheese making (Average of 3 replicates)*

Property	Ripening Period (days)	Treatments T1	T2	T3	T4	T5
Total bacterial count	Fresh	2.3 X 10^6	1.5 X 10^6	1.8 X 10^6	2.2 X 10^6	4.4 X 10^6
	30	5.2 X 10^8	4.2 X 10^7	3.9 X 10^8	4.3 X 10^8	5.9 X 10^8
	60	4.7 X 10^9	3.5 X 10^8	5.5 X 10^9	6.8 X 10^9	1.2 X 10^9
Lipolytic bacterial count	Fresh	5.3 X 10^3	0.8 X 10^3	1.1 X 10^3	1.5 X 10^3	2.7 X 10^3
	30	6.5 X 10^4	1.2 X 10^4	2.6 X 10^4	2.2 X 10^4	2.9 X 10^4
	60	8.9 X 10^4	1.5 X 10^4	3.5 X 10^4	2.9 X 10^4	3.5 X 10^4
Coliform bacterial count	Fresh	ND	ND	ND	ND	ND
	30	ND	ND	ND	ND	ND
	60	ND	< 10	< 5	< 5	< 5
Yeast & mould count	Fresh	ND**	ND	ND	ND	ND
	30	1.5 X 10^2	1.8 X 10^2	1.2 X 10^2	1.6 X 10^2	2.2 X 10^2
	60	2.2 X 10^3	2.6 X 10^3	2.5 X 10^3	2.7 X 10^3	3.5 X 10^3

*** See legend to Table (1) for details. ** ND = Not-detected.**

Table (7) shows the calculated rheological parameters of 60 days old Munster-like cheese .Removing of fat from cheese- milk (T2) or even the use of fat replacers (T3-T5) greatly increased and decreased, respectively, the hardness of the resultant cheese . Morever ,cheese from T4 had the highest hardness among the fat-replacers containing cheese (T3-T5).This was not correlated with the moisture content , but correlated with type of fat replacer. (Awad *et al* (2003), El-Baz *et al*.(2011) , Mehanna and Pasztor – Huszar (2012) , Gwartney et al.(2002), and Rogers *et al*.(2010) .

Table 7. Texture profile analysis (TPA) of 60 days old Munster cheese as affected by using some fat replacers in cheese making (Average of 3 replicates)*

Properties	Treatments				
	T1	T2	T3	T4	T5
Hardness (N)	7.90	42.20	16.50	26.60	22.30
Adhesiveness(mj)	0.54	0.83	0.21	0.38	0.29
Cohesiveness(Rati	0.71	0.79	0.74	0.76	0.73
Springiness (mm	5.75	4.37	5.93	4.95	5.66
Gumminess (N)	9.60	31.20	13.10	19.40	16.50
Chewiness (mj)	32.53	78.25	41.27	59.33	45.62

*** See legend to Table (1) for details.**

Table (8) deals with the scoring points of different cheeses through out 60 days of ripening. Organoleptic scores of all cheeses treatments increased as ripening period progressed these results are in agreement with the findings of Degheidiv(1996).Control cheese (T1) gained higher score than control low-fat cheese (T2) which made also without adding fat replacers .

Table 8. Organoleptic properties of the resultant Munster cheese as affected by using slendid® 200 0r simplesse®100 in the manufacture (Average of 10 panelists).

Treatments	Storage periods (days)	Colour (5)	Appearance (10)	Body& Texture (35)	Flavour (50)	Total (100)
T1		4	8	28	40	80
T2		3	9	25	35	72
T3	Fresh	4	9	27	37	77
T4		3	8	26	35	72
T5		4	9	27	36	76
T1		4	9	30	43	86
T2		3	9	27	37	76
T3		4	9	29	40	82
T4	30	3	8	28	38	77
T5		4	9	28	39	80
T1		4	9	33	46	92
T2		3	8	29	40	80
T3		4	9	32	45	90
T4	60	3	8	30	42	83
T5		4	9	30	43	86

*** See legend to Table (1) for details.**
****Values in parenthesis represent the maximum attainable scores.**

Similar results were reported by Badawi(1998) and Hussein (2000) . The low fat cheese containing slendid®200 was more acceptable than the low-fat cheese containing simplesse®100. Generally adding fat replacers improved the acceptability of cheese. These results might be due to the higher water activity of such cheese treatments which enhance the growth of proteolytic and lipolytic bacteria, proteases and lipases activities and subsequently formation of the proper flavour, body and texture .These results are in accordance with those reported for Ras cheese by Hussein (2000) and for Gouda cheese by El-Sonbaty and El-Sisey (2010).

CONCLUSION

It could be concluded that adding fat replacer such as slendid®200 and simplesse®100 in making Low-fat Munster- like cheese caused an increased in moisture and the values of ripening indices and scores of organoleptic properties . Overall, quality evaluation showed that it was possible to produce acceptable low-fat cheese with fat replacer by the conventional production techniques. The importance of this finding to the cheese industry is significant, owing to the great demand for a variety of low-fat food items by the consumic public.

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تأثير بدائل الدهون على جودة الجبن الشبيه بالمونستر المنخفض الدهن

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فى هذا البحث تم دراسة تأثير نوعين من بدائل الدهون ، Simplesse® 100(بديل دهنى ذو أصل بروتينى) و Slendid® 200(بديل دهنى ذو اصل كربوهيدراتى) على التركيب الكيماوى والخواص الريولوجية و الميكروبيولوجية والحسية لجبن المونستر المنخفض الدهن خلال فترة التسوية. وتم عمل مقارنة للجبن المنخفضة الدهن المصنعة باستخدام بدائل الدهون مع مثيلاتها من الجبن المنخفض الدهن والكامل الدسم ككنترول .أوضحت النتائج ان استخدام بدائل الدهون أدت الى زيادة تصافى الجبن الطازج والمسوى وزيادة نسبة الرطوبة والحموضة فى الجبن الناتج عن الجبن المنخفض الدهن الكنترول بينما انخفضت محتويات الجبن من المادة الصلبة والبروتين. كما انها ايضا ليس لها تأثير على تحلل البروتين فى الجبن أثناء التسوية ولكن حسنت من التحلل الدهنى.استخدام بدائل الدهون يؤدى الى زيادة البكتيريا المحلله للدهون فى الجبن بينما تخفض من محتواها من الخمائر والفطريات.كما أدى ايضا استخدام بدائل الدهون الى انخفاض الصلابة والتماسك والتلاصق واللزوجة والمضغ وزيادة المرونة وتحسين الصفات الحسية لجبن المونستر المنخفض الدهن .