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IMPACT OF SOME CARBOHYDRATE-BASE FAT REPLACERS ON THE LOW FAT MOZZARELLA-LIKE CHEESE CHARACTERISTICS

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ABSTRACT

Two carbohydrate-base fat replacers were used to study the chemical and physical properties of low- fat Mozzarella cheese being made by using 1.5% fat cow's milk. The obtained curd was divided into seven equal parts, the first one was used as a control while the rest parts were treated with 4, 6 or 8% (w/w) of maize starch or rice starch such effects on the cheese properties were followed during storage of cheese at 4^{o}C for six weeks . Only 4% of maize or rice starch treatments improved cheese meltability after one week of storage as compared with control cheese (82%and 23%), and the increases steadly continued as storage period advanced to reach the maximum after six weeks (177% and 105%) . Addition of 6% or 8% maize or rice starchs had bad or no impact on cheese meltability during the first two weeks of storage. All treatments had significant effect on the cheese contents of total solids, fat, protein and acidity .

INTRODUCTION

Manufacture of Mozzarella needs to please consumer not only searching for flavor, variety, pleasant chew and mouth feel, but also a population segment concerned with fat and calories. Fat reduction in the diet is important based on the scientific evidence linking diets high in fat to coronary heart disease and certain types of cancer (Woteki and Thomas, 1993). On the other hand, fat is a major multi-tusker, it provides nutrition, determines the physical structure of the food during processing, packing and storage, shapes and sensory characteristics of the food, including: appearance, texture, flavor and mouth feel. Functionally, fats affect the melting point, viscosity and spreadability of many foods .The removal of fat in Mozzarella cheese can result in cheese that is low in moisture ,giving the cheese hardness, rubbery and poor meltability (Poduval and Mistry, 1999). Cheese meltability is defined as the ease and extent at which cheese will flow upon heating (Gunase-Karam and Ak, 2003). Some carbohydrates have been developed for low-fat cheeses, such as Novagel (cellulose microcrystalline-guar), stellar (starch),salatrim'ae, Dairy Lo and Simples (Rudan *et al.*, 1998 ; Yun *et al.*, 1998 and Abd El-Hamid *et al.*, 2001).This study was carried to follow the effect of some fat replacers on the characteristics of low- fat Mozzarella cheese.

MATERIALS AND METHODS

Low fat Mozzarella cheese was made as described by Kosikowski (1982). Whole milk was standardized to 1.5 % fat and pasteurized at 72^{o}C for 20 sec, cooled immediately then treated with 0.02% $CaCl_2$ and cooled to 4^{o}C.

Citric acid solution (10%) was added gradually to the cold pasteurized milk up to pH 6.0 then warmed to 30°C. Calf rennet was added, the resultant curd was cut to cubes 1 x 1 x 1 cm using 1cm knives, the cut curds were remained undisturbed for approximately 15 min then the temperature was raised to 41°C in 35 min, until PH was reached to 5.25-5.30. The obtained curd was divided into seven equal parts, the first one was used as a control and 4, 6 or 8% of maize or rice starchs were added to the rest of the seven portions after cheddaring process and before cooking or scalding then immersed in hot water at 80±2°C (2 liter/1kg curd), molding and stored at 4°C for six weeks.

- **Chemical analysis**

Cheese samples were taken at zero time (after one day of refrigeration) then weekly until six weeks. The samples were analysised for acidity, total solid (TS) , fat, total protein (TP), water soluble nitrogen (WSN) and non protein nitrogen (NPN) were determined according to Ling (1963). TVFA's was determined according to Koskowski (1982). Meltability (tube) was measured using a modified method of Olson and Price (1958).

- **Statistical analysis :**

Results were presented as means ± SD. Data were subjected to statistical analysis as given by SPSS 10 for windows (SPSS, 1999) with on way ANOVA.

RESULTS AND DISCUSSION

1. Total solids content (TS %):

Data in (Table 1) illustrated that control cheese had the lowest TS content at zero time (38.92%),while the addition of fat replacers increased TS content. These increases were more noticeable with the addition of 8% rather than 6%, and with rice than maize starch and this is mainly because of the addition of fat replacers at higher rates. During storage period, TS contents of all treatments gradually increased to reach the maximum values at the end of the storage. Such increase might be due to the loss in moisture content during cold storage. These results are in accordance with the results of Perry *et al.* (1998) and Rudan *et al.* (1998), who reported that the TS of low fat Mozzarella cheese increased as storage period advanced. The values at the end of storage period were 42.03, 43.78, 47.02, 47.55, 45.68, 47.35 and 47.60%, for control, maize starch (4, 6 or8 %) and rice starch(4, 6 or 8%) cheeses respectively,. Statistical analysis showed highly significant TS differences between treatments and during storage periods (Table 2).

2. Fat content (%):

Results in (Table 1) showed that the addition of 6% maize or rice starch decreased fat contents in the resultant cheese at zero time (8.5% vs. 9%), however by increasing the concentration to 8% resulted in cheese of fat content equal the control cheese (9%). These results disagrees with those of Rudan *et al.* (1998), who found that cheeses made with fat replacers gained higher fat content than control cheese. As storage period advanced the fat contents increased, and that might be due to the loss of moisture. Statistical analysis showed highly significant ($P<0.01$) differences in fat content between treatments and during storage periods (Table 2) .

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Table (2): Analysis of variance of chemical and physical properties of low fat Mozzarella cheese as affected by addition of maize or rice starchs at different rates and during cold storage

Parameters	Between treatments		During storage	
	F- value	Sign	F- value	Sign
Total Solids (T.S) %	7.464	0.000 **	5.537	0.000 **
Fat %	4.463	0.001 **	7.280	0.000 **
Total protein %	17.148	0.000 **	2.256	0.050*
Acidity %	5.599	0.000 **	4.300	0.002 **
NPN %	5.764	0.000 **	3.317	0.007 **
WSN %	2.376	0.049 *	13.727	0.000 **
TVFA's (ml NaOH /100 g chesse)	2.158	0.070	5.167	0.000 **
Meltability (cm)	1.307	0.275	11.186	0.000 **

*** Significant at level < 0.05. ; ** Significant at level < 0.01.**

3. Protein content:

Data given in (Table 1) showed that control cheese had the lowest protein content at zero time (27.15%), while starch cheeses had higher values,which might be due to the higher TS contents of the examined cheeses compared with the control. These results came in agreement with the data obtained by Rudan *et al.* (1998) and Stevens and Shah (2002), who illustrated that low fat Mozzarella cheese being made with fat replacers contained higher protein content, however disagreed with those of Bhaskaracharya and Shah (2001), who stated that the protein contents of cheeses made with fat replacers were lower than those of control cheeses. As storage period advanced, protein content increased to reach the maximum values at the end of storage period for all treatments, except of 8% of maize starch cheese in which protein content reached the maximum after five weeks of storage, then slightly decreased. These increases are mainly due to the increases of TS contents. Protein content had highly significant differences between treatments ($P<0.01$), and significant differences ($P<0.05$) were detected during storage periods (Table 2).

4. Non protein nitrogen content (NPN, %):

Non protein nitrogen contents for all treatments at zero time were almost equal (Table1). As storage period advanced, NPN increased to reach the maximum at the end of storage. The contents at the end of storage period were 0.32, 0.1◦, 0.47, 0.31,0.34, 0.27 and 0.29%, respectively, for control, maize starch(4, 6 or 8%) and rice starch(4, 6 or 8%) cheeses. Generally, all treatments except 6% maize starch one contained lower NPN content through the storage periods. Highly significant NPN content differences were obtained between treatments and during storage period (Table 2).

5. Water soluble nitrogen content (WSN, %):

Results shown in (Table1) illustrated that 8% of rice starch had the highest WSN values (0.31%). WSN content were increased in all of the treated cheeses as storage period advanced and that might be due to the

activity of the residual rennet and of proteolytic activity of bacteria present in cheese. Cheeses made with 4%of maize or rice starch had the lowest WSN contents through out the storage periods, even less than control cheese . These results in accordance with those of Rudan *et al.* (1998) ; Hassan and Abdel-Kader (2000) and Badawi *et al.* (2004), who found that the soluble nitrogen of Mozzarella cheeses made with fat replacers were higher than control ones. WSN content (Table 2) showed significant differences between treatments and highly significant differences during storage ($P<0.01$).

6. Acidity content (%):

Addition of 4% rice starch sharply increased cheese acidity at zero time and during the storage period. (Table 3) On the other hand, 4% of maize starch cheese had the same trend, but after two weeks at lower values than 4% rice starch treatment. By increasing the addition rate of maize starch to 6% or 8% retarded the development of cheese acidity through out the storage periods. Acidity at the end of storage period were 2.23, 2.52, 0.88, 1.40 , 3.20, 1.60 and 2.10%, for control, (4,6 or 8%) maize starch and (4,6 or 8%) rice starch cheeses respectively,. These results in accordance with those of Hassan and Abdel-Kader (2000) and Badawi *et al.* (2004), who illustrated that cheese acidity increased as storage period advanced. Acidity differences between treatments were highly significant ($P<0.01$) and between storage period (Table 2) .

7. Total volatile fatty acids content ((TVFA's, ml NaOH 0.1 N/100 gm cheese):

Addition of maize or rice starches at different rates increased TVFA's content at zero time cheeses and during the first three weeks of storage, as compared with the control cheese (Table 3). The TVFA's values at zero time were 1.8, 0.8, 2.4, 2.4, 1.4,2.4 and 2.3 (ml NaOH 0.1 N/100 g cheese), respectively, for control, (4, 6 or 8%) maize starch and (4, 6 or 8%) rice starch cheeses. The results are in agreement with the results obtained by Hassan and Abdel-kader (2000) and Badawi *et al.* (2004), who noticed significant increases in cheese TVFA's contents during cold storage. Statistical analysis showed highly significant TVFA's differences during storage period, but insignificant differences between treatments (Table2).

8. Meltability measurements (cm):

Data given in (Table 3) illustrated that addition of 4% of maize or rice starches improved cheese meltability after one week by 82% and 27% in order since the meltability of 4% maize srarch after one week storage was higher than that of control cheese after six weeks storage (13.5cm vs. 10.6 cm). On the other hand , by increasing the concentration of maize starch to 6% drastically decreased the meltability of cheeses when fresh and during the first two weeks. These results are in accordance with those of Rudan *et al.* (1998), who reported that fat replacers cheese had the same meltability as control cheese processed without replacers. Generally, starch added improved cheese meltability after storage 2-3 weeks. Statistical analysis showed highly significant differences only during storage periods (Table 2). The above results, it could be recommended to add only 4% maize starch to the curd of Mozzarella cheese being made from 1.5% cow's milk because that economically low cost cheese and less time to get best quality.

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تأثير استخدام بعض بدائل الدهن كربوهيدراتية المصدر علي صفات الجبن الشبيه بالموزاريلا منخفض الدهن

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درس تأثير إضافة بعض بدائل الدهن كربوهيدراتية المصدر إلي خثرة جبن الموزاريلا منخفضة الدهن الناتجة من تصنيع لبن 1.5% دهن علي الصفات الطبيعية والكيماوية للجبن الناتج . الخثرة الناتجة قسمت إلي ٧ أجزاء متساوية ، أستخدم الجزء الأول للمقارنة وباقي الأجزاء أضيف إليها ٤% أو ٦% أو ٨ % (وزن / وزن) من نشا الذرة أو نشا الأرز وتم حفظ الجبن الناتج علي ٤ °م لمدة ٦ أسابيع . أوضحت النتائج أن المعاملة بإضافة ٤% نشا ذرة أو نشا أرز قد حسنت من درجة انصهار الجبن بعد أسبوع واحد من التخزين بمعدل ٨٢% ، ٢٣ % مقارنة بنتائج جبن الكنترول ، ولقد تزايدت نسب التحسن تدريجيا لتصل إلي أقصاها في نهاية فترة التخزين لتصل إلي ١٧٧%، ١٠٥% .

من ناحية أخري لوحظ أن إضافة ٦% أو ٨% من نشا الذرة أو نشا الأرز لم يؤثر أو خفض درجة انصهار الجبن خلال أول أسبوعين من التخزين .

كل المعاملات كان لها تأثيرا معنويا علي محتوي الجبن من المادة الصلبة الكلية ، الدهن ، البروتين ، الحموضة .

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(Table 1): Changes of total solids, fat, protein and degree of proteolysis of Mozzarella cheese made from 1.5% fat cow's milk as affected by addition of 4 or 6 or 8 % maize starch (MS) or rice starch (RS) during storage at 4ºc for six weeks .

Parameter (%)	Treatments %	Storage period (weeks)						
		0	1	2	3	4	5	6
TS	0	38.92±0.82	39.50±0.41	40.34±0.65	40.53±0.41	41.63±0.42	42.00±0.33	42.03±0.21
	4% MS	41.14±0.11	41.68±1.61	41.84±0.23	42.54±0.82	42.51±0.26	43.01±0.82	43.78±.015
	6 % MS	41.59±0.70	42.13±0.37	43.00±0.82	44.24±0.33	45.47±0.45	46.35±0.41	47.02±0.73
	8% MS	42.11±0.73	43.33±0.55	44.13±0.98	45.86±0.42	46.22±0.63	47.02±0.50	47.55±0.48
	4% RS	40.52±0.33	41.57±0.41	42.03±0.58	43.56±0.31	44.54±0.43	44.82±0.51	45.68±0.65
	6% RS	42.01±0.47	44.15±0.65	45.76±0.62	45.66±0.55	45.70±0.44	46.37±0.82	47.35±0.63
	8% RS	43.15±0.49	43.45±0.36	44.29±0.49	45.99±0.67	46.37±0.82	46.85±0.69	47.60±0.45
Fat	0	9.0±0.42	9.5±0.12	9.5±0.42	9.5±0.18	10.0±0.17	10.5±0.15	11.0±0.43
	4% MS	9.0± 0.30	9.0± 0.13	9.5± 0.41	9.5± 0.28	10.0±0.12	10.0±0.25	10.5±0.13
	6% MS	8.5±0.14	8.5±0.26	8.5±0.71	8.5±0.34	9.0±0.61	9.0±0.26	10.0±0.11
	8% MS	9.0±0.11	9.5±0.43	9.5±0.22	9.5±0.25	9.5±0.28	10.0±0.41	10.0±0.50
	4% RS	9.0± 0.33	9.5 ±0.45	10.0±0.14	10.0±0.25	10.5± 0.18	11.0±0.20	11.5 ± 0.43
	6% RS	8.5±0.45	8.5±0.33	8.5±0.18	9.0±0.14	9.5±0.31	9.5±0.41	9.5±0.33
	8% RS	9.0±0.15	9.0±0.24	10.0±0.11	10.0±0.41	10.0±0.71	10.5±0.21	10.5±0.41
Protein	0	27.15±0.12	27.58±0.33	28.29±0.14	28.33±.032	29.58±0.11	29.87±0.15	30.29±0.26
	4% MS	29.01±0.35	29.29±0.28	30.01±0.12	30.72±0.30	30.87±0.17	31.16±0.13	31.58±0.21
	6% MS	30.73±0.23	31.44±0.41	33.44±0.42	34.29±0.29	34.82±0.13	35.17±0.49	35.67±0.27
	8% MS	30.15±0.30	30.70±0.18	31.01±0.27	32.85±0.25	34.15±0.11	35.44±0.33	35.30±0.28
	4% RS	28.15±0.42	28.58±0.13	29.01±0.19	29.86±0.25	30.86±0.11	30.15±0.12	31.15±0.22
	6% RS	32.15±0.28	34.01±0.17	34.87±0.22	35.12±0.15	34.73±0.34	35.30±0.55	35.35±0.42
	8% RS	32.15±0.25	32.58±0.28	32.73±0.42	34.30±0.55	34.51±0.27	34.58±0.31	34.99±0.35
NPN	0	0.16±0.82	0.20±0.08	0.25±0.04	0.26±0.03	0.29±0.24	0.29±0.02	0.32±0.04
	4% MS	0.067±0.01	0.077±0.04	0.081±0.03	0.084±0.05	0.087±0.07	0.170±0.01	0.151±0.13
	6% MS	0.17±0.04	0.20±0.01	0.30±0.11	0.38±0.21	0.42±0.17	0.47±0.04	0.47±0.03
	8% MS	0.16±0.06	0.18±0.01	0.27±0.01	0.28±0.03	0.28±0.02	0.29±0.07	0.31±0.08
	4% RS	0.077±0.05	0.084±0.24	0.118±0.01	0.165±0.04	0.235±0.06	0.318±0.01	0.341±0.13
	6% RS	0.16±0.01	0.16±0.15	0.18±0.21	0.21±0.03	0.24±0.07	0.24±0.01	0.27±0.03
	8% RS	0.16±0.04	0.21±0.14	0.22±0.01	0.26±0.22	0.28±0.01	0.29±0.02	0.29±0.21
WSN	0	0.239±0.16	0.299±0.06	0.388±0.02	0.47± 0.05	0.522±0.04	0.597±0.01	0.600±0.01
	4% MS	0.210±0.04	0.232±0.01	0.260±0.02	0.202±0.02	0.298±0.05	0.394±0.08	0.410±0.02
	6% MS	0.24±0.01	0.34±0.04	0.52±0.05	0.52±0.02	0.64±0.05	0.67±0.01	0.65±0.04
	8% MS	0.28±0.15	0.33±0.02	0.39±0.01	0.46±0.08	0.48±0.14	0.56±0.11	0.56±0.01
	4% RS	0.172±0.05	0.216±0.10	0.290±0.01	0.296±0.07	0.334±0.03	0.463±0.01	0.455±0.15
	6% RS	0.28±0.02	0.29±0.13	0.36±0.11	0.38±0.03	0.43±0.01	0.53±0.15	0.66±0.04
	8% RS	0.31±0.15	0.33±0.01	0.35±0.01	0.41±0.04	0.57±0.03	0.62±0.01	0.57±0.02

(Table 3): Changes of acidity, TVFA and meltability of Mozzarella cheese made from 1.5% fat cow's milk as affected by addition of 4 or 6 or 8 % maize starch (MS) or rice starch (RS) during storage at 4ºc for six weeks .

Parameter	Treatments %	Storage period (weeks)						
		0	1	2	3	4	5	6
Acidity %	0	0.70±0.01	0.95±0.04	1.10±0.02	1.10±0.01	1.40±0.04	2.13±0.01	2.23±0.03
	4% MS	0.86 ±0.06	0.87 ±0.01	1.64 ±0.05	1.64±0.02	1.78 ±0.02	1.78 ±0.04	2.52 ±0.01
	6 % MS	0.60±0.06	0.70±0.08	0.71±0.03	0.81±0.03	0.86±0.01	0.97±0.33	0.88±0.10
	8% MS	0.73±0.16	0.80±0.01	0.80±0.15	0.73±0.06	0.99±0.02	1.40±0.10	1.40±0.14
	4% RS	1.11±0.03	1.12 ±0.04	2.19 ±0.02	2.55±0.01	2.62 ±0.05	2.64 ±0.01	3.20 ±0.02
	6% RS	0.73±0.21	1.22±0.30	1.20±0.06	0.85±0.10	0.95±0.02	1.40±0.12	1.60±0.07
	8% RS	0.75±0.02	0.92±0.11	1.07±0.41	0.64±0.02	1.03±0.32	2.06± 0.03	2.10±0.14
TVFA ml NaOH 0.1 N/100 g cheese	0	1.8±0.08	2.0 ±0.18	2.2±0.16	2.2±0.16	2.8±0.08	3.0 ±0.24	3.2 ±0.16
	4% MS	0.8±0.08	4.0±0.24	3.2 ±0.49	3.6±0.18	5.8 ±0.25	6.0 ±0.25	7.4 ±0.33
	6% MS	2.4±0.25	2.8±0.16	2.4±0.24	3.0±0.23	3.2±0.19	4.0±0.26	4.2±0.32
	8% MS	2.4±0.08	2.4±0.22	2.4±0.29	2.4±0.16	2.6±0.18	2.6±0.21	4.4±0.10
	4% RS	1.4 ±0.25	6.2 ±0.16	6.0 ±0.41	3.4±0.16	4.4 ±0.18	6.4± 0.16	5.0 ±0.16
	6% RS	2.4±0.33	3.2±0.32	3.4±0.25	2.6±0.13	2.6±0.49	2.6±0.30	2.6±0.12
	8% RS	2.3±0.12	3.6±0.41	3.6±0.39	3.6±0.01	3.4±0.18	2.8±0.33	2.8±0.14
Meltability (cm)	0	7.5±1.22	8.2 ±1.22	8.7± 1.41	9.9±1.31	10.0±1.22	10.5±2.50	10.6±1.30
	4% MS	7.4±1.14	13.5±1.31	14.3 ±2.90	16.2±1.63	16.1 ±1.50	18.3± 1.14	20.5 ±2.50
	6% MS	2.5±1.16	3.5±2.60	5.5±1.24	12.0±1.20	14.0±1.60	17.5±2.01	19.5±2.21
	8% MS	7.2±0.75	7.5±1.30	7.5±1.46	8.6±2.04	12.8±1.33	12.7±1.10	12.7±1.63
	4% RS	7.3±1.63	9.0±1.14	10.5±1.22	12.5±1.14	13.0 ±2.50	13.0± 1.06	15.0 ±1.63
	6% RS	4.1±1.28	6.0±1.50	7.5±2.50	9.6±1.14	11.6±1.64	13.1±1.25	13.1±1.20
	8% RS	2.6±0.90	3.5±1.63	6.0±1.10	8.0±1.23	14.1±1.70	20.1±1.30	22.0±1.36

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