Chemical , Reheological and Organoleptic Properties of Processed Cheese Analogs (Partial and Whole Replacement of Cheese)

Tarek Mourad El-Nemr
Dairy Science and Technology Department, Faculty of Agriculture (chatby), Alexandria University, Egypt

ABSTRACT

Effect of replaced cheddar cheese with a ratio of 45, 76 and 100 % in processed cheese analogs by using skim milk powder, whey protein powder and casein on chemical, rheologigal and organoleptic properties of processed cheese were studied. There were no differences in moisture, fat, salt levels and pH between all trails. The protein content was related to that in base materials used. Addition of casein increased hardness, while addition of skim milk powder and whey protein concentrate increased softness. The cohesiveness was lower in cheese made using whey protein concentrate and milk powder than in cheese made with casein. On the other hand, springiness and gumminess were lower in processed cheese made by replacing cheddar with skim milk powder, whey protein and casein. A sharp decrease in chewiness was observed in processed cheese made from whey protein concentrate and skim milk powder compared with whey protein concentrate and casein. Organoleptically, the cheese trails using whey protein concentrate were much softer than processed cheese made using casein. Addition of casein increased firmness and fracturability and decreased in mouth smoothness, cohesiveness and adhesiveness.

INTRODUCTION

Processed cheese is the famous, popular and widely used in many countries. It is manufactured from cheeses with different characteristics and ages to have a mild flavour and melt when cooked (Templeton and Sommer 1930 and 1932; Arnott et al., 1957; Magdoub et al 1984 and French et al., 2002).

Processed cheese-like products, called processed cheese analogs, are produced with a partial or whole replacement of natural cheeses by milk protein concentrates, MPC, (Gouda and El-Shibiby 1987, Gupta and Reuter 1992, Mleko and Foegeding 2001). Replacement of cheese or rennet casein with whey proteins has been evaluated for nutritional and economical benefits. The use of the cheap whey protein concentrate to replace the expensive cheese or rennet casein would reduce the cost of production. Increased amounts of whey proteins improve the firmness of processed cheese but have a highly significant effect on melting quality. On the other hand whey protein concentrates improved the nutritional value and modify the functional properties of the product for variable uses (Abd

El-Salam et al., 1998 and Al-Khamy et al 1997). Polymerization of whey proteins by heating 80 °C for 30 min at pH 8 increased yield stress of processed cheese analogs compared with unpolymerized whey proteins (Mleko and Foegeding 2001).

Texture plays an important role in the quality of cheese ,but the textural measurements of cheese are complicated and confusing .Most measurements have dealt only with one or two texture characters e.g., hardness and chewiness (Friedman et al 1963)

Most previous researches dealt with process cheese from a manufacturing standpoint. The finished product usually was evaluated subjectively (Harvey et al 1982) . Body and texture ratings were used as major factors in judging quality. Body is a complex physical characteristic that includes hardness , springiness and smoothness (Davis 1937) .Currently "texture" is defined by most people in the food industry as the overall physical sensations perceived about a food during mastications (Prentice 1972) .

The present investigation aiming to examine the possibility of using skim milk powder and whey protein concentrate in a formula (partial and whole substitution of cheese) flavoured with enzyme modified cheese (EMC) for reducing the production cost with acceptable product by Egyptian consumers. On the other hand, to study the textural and sensory characteristics of processed cheese analogs.

MATERIALS AND METHODS

Cheddar cheeses ,4 months old (N.Z.Board, U.S.A);Commercial enzyme modified cheese (EMC) from Chr. Hansen Lab, Milwaukee, WI, USA ;Skim milk powder (Belgium);Anhydrous milk fat (AMF) (U.S.A); Casein (Bebgum-Germany) ;Whey protein (Domo- Holland); Tri-Sodium phosphate and Lactic acid, Food Grade(BDH) .

Processed cheese made in pilot processing machine(Wolf – Germany) RPM 1400, homogenization 200 bar, total time of acidification-2 min.and heating 85 °C / 6 min.Fifty percent of total amount of water was added before heat treatment, the rest of water amount added when temperature reached 98 °C and then dropped to 86 °C, the cheese was filled at 74 °C

Processed cheese making

Five spread process cheese treatments were employed in this study (Table 2). The control cheese (C) was made using Cheddar cheese without adding skim milk powder and whey protein concentrate. Treatment 1 (T1)

was made by replacing 45 % of Cheddar cheese with skim milk powder, Treatment 2 (T2) was made by replacing 76 % of Cheddar cheese with skim milk powder, Treatment 3 (T3) was made by replacing all cheese with skim milk powder and whey protein concentrate. Treatment 4 (T4) was made by replacing all cheese with casein and whey protein concentrate.

Moisture and fat were standardized to 55 % and 22 % respectively in all treatments. Processed cheese was packaged and stored at 4°C for 2 days before analyses.

Chemical composition of cheese

All ingredients and processed cheeses were analyzed for moisture by the oven method (AOAC, 2000), salt (Ling 1963), and total protein by macro-Kjeldahl (AOAC, 2000). The pH was measured in slurry prepared by macerating 20 g of grated cheese in 20 ml of deionized water.

Texture profile analysis (TPA)

Cheeses were cut into cubes samples of 30 x 30 x 30 mm, placed in plastic bags, sealed, and stored at 20 °C for 1 h. A two-bite compression test was performed using the Texture Analyzer. A 25 % compression test was used and the crosshead speed was 50 mm/min. Hardness, cohesiveness, gumminess, chewiness, and adhesiveness were determined in triplicate from the texture profile curve as described by Bourne (1978).

Sensory evaluation

Six experienced panelists graded coded samples of cheese. Samples were presented in identical containers labeled with a random three digit number. Samples were cut into cubes 30 X 30 X 30 mm and presented at refrigerated temperature in plastic sample cups sealed with plastic lids to minimize moisture loss. Hand firmness, hand springiness, first bite firmness, first bit fracturability, chewdown degree of breakdown, chewdown cohesiveness, chewdown adhesiveness, chewdown smoothness and residual smoothness of mouth coating were evaluated as described by Brown et al., (2003). Flavor scores of 1 indicated lack of flavor, 5 definite and 9 pronounced flavors.

RESULTS AND DISCUSSION

Processed cheese formulations and actual chemical composition

The chemical composition of different ingredients used in processing trails is shown in Table 1.It was clear that they differ in their chemical composition, and their concentrations in the various blend varied. The processed cheese formulations are shown in Table 2. Anhydrous milk fat (AMF) was used to adjust the fat level to 22 % in all treatments. Enzyme modified cheese (EMC) was used at a level of 0.6 % in processed cheeses made without added Cheddar cheese. Table (3) shows the actual chemical composition of processed cheese. No differences in moisture, fat, salt levels and pH values were noticed between different treatments .

Protein percentage was higher in treatment 4 made using casein and whey protein concentrate, while it was lower in T3. The results showed that protein content of process cheese was related to that in base materials used.

Textural characteristics of process cheese:

Hardness

The differences in hardness values between treatments are shown in Table 4. Cheese made using casein were harder than cheese made using Cheddar cheese. Although having the same moisture level, T1, T2 and T3 cheeses were softer than control cheese. These results suggested that replacing of cheddar cheese with skim milk powder and whey protein concentrate soften the process cheese. However, since there were no differences in fat, moister and pH among all treatments, the differences in hardness should be related only to protein level and the characteristics of the base materials. The type, characteristic and age of the natural cheese play a major role in controlling the textural, viscoelastic, functional, microstructural and sensorial properties of process cheese (Bowland and Foegeding 2001, French et al., 2002, Glenn et al., 2003, Acharya and Mistry 2005). The differences in hardness between process cheese made from 100 % Cheddar and 55 % Cheddar are due to the reduced firmness of cheese by adding milk powder. The increase in hardness of process cheese made using casein (T4) is related to high protein content and casein structure (Table 3).

Cohesiveness

Cohesiveness was lower in process cheese made with Cheddar and skim milk powder (T3) than in all other treatments (Table 4). The protein content is lower in that cheese than in all other treatments (Table 4),

and the cohesiveness seems to be related to protein content in process cheese. The nature and the content of the protein matrix and the extent of fat dispersion contribute to cohesiveness or the tendency of cheese to adhere to it-self. Proteolysis disrupts the structural integrity of the protein matrix, leading to reduced cohesiveness (Irudayaraj et al., 1999), and the cohesiveness was lower in cheese made using whey protein concentrate and milk powder than in cheese made with casein.

Adhesiveness

There was an increase in the adhesiveness of process cheeses when cheddar was replaced by casein.

Springiness

The springiness, which describes the height that the cheese sample recovers during the time elapsing between the end of the first bite and the start of the second bite, has a slight difference among all treatments except the cheese made from replacing 45% cheddar cheese with milk powder (T2). These results indicate that the ability of the processed cheese, made using cheddar and replacing the Cheddar cheese with whey protein concentrate, to recover its original height after removing the force is almost similar. Springiness was much lower in cheese made from replacing 76% cheddar cheese with milk powder than in all other cheeses (Table 4).

Gumminess

The gumminess in process cheese of 45 % Cheddar and skim milk powder (T2) was lower than other cheeses and the gumminess was higher in cheese made using casein and whey protein concentrate.

Chewiness

The results indicate that the energy required to masticate the cheese product to a state ready for swallowing 'Chewiness' is higher in the process cheese made using casein (T4). The same trend was also noticed for the energy required to disintegrate the cheese product 'gumminess'. Both chewiness and gumminess are related to the hardness.

A sharp decrease in chewiness was observed in process cheeses made from whey protein concentrate and skim milk powder compared to whey protein concentrate and casein. These indicated that the texture properties of process cheese mostly depend on the protein structure rather than the protein content.

Sensory Assessments

The sensory evaluation results are shown in Table 5. Hand firmness, hand springiness, first bite firmness and first bit fracturability were highly correlated. The firmness was correlated with fracturability, the process cheeses made using 76 % Cheddar and milk powder (T1) received

lower value of firmness and fracturability than cheeses made with 100 % Cheddar. In addition, the cheeses made using whey protein concentrate were much softer than process cheeses made using casein. The firmness and fracturability were negative correlated with certain chewdown terms (breakdown, cohesiveness and smoothness). All of the chewdown and residual terms were highly correlated with each other. Brown et al., 2003 reported that the highly cohesive cheeses were perceived as smooth and adhered to the mouth surfaces. The treatment 3 received higher degree of adhesiveness and residual smoothness of mouth coating. The mouth coating was expected to be high due to the high adhesion of the chewed mass, and the smoothness of the coating would also be expected to be high, since the original mass was perceived as smooth (Brown et al., 2003). Drake et al., 1999a,b and Brown et al., 2003 found that hand and mouth evaluated firmness were highly correlated; mouth cohesiveness, smoothness, and stickiness to the teeth were also correlated. The results of this study suggested that the process cheese made using casein was higher in firmness and fracturability and lower in mouth smoothness, cohesiveness and adhesiveness. Cheese flavor intensity was not different among the cheeses (Table5), and the panelists did not difference between cheese made with aged Cheddar and cheese made with EMC.

CONCLUSIONS

The results of this work suggested that the process cheese properties depend on the structure, chemical composition, age, functional properties and the additives used in process cheeses manufacture. The hardness and chewiness increased with decreasing the casein level, even if the moisture content is similar. There were no any differences in flavor between cheeses made using aged cheddar and EMC. The EMC will be the promising in making process cheese in the coming years, and the modifications of cheese texture are needed with replacing the nature cheese. It is possible to replace natural cheese with whey protein concentrate for modification the texture and cutting cost of process cheese. The process cheese analoge with acceptable flavor and low cost could produce in Egypt.

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Table 1.The chemical composition of different ingredients used in processed cheese

Ingredients	Moisture %	Fat %	Protein %	Salt %	pH
Cheddar cheese	34.1	33.6	25.7	1.78	5.4
Skim milk powder	4.0	0.64	36.9	-	-
Casein	7.0	0.10	92.0	-	
whey protein	4.00	0.10	34.00	-	
E M C*	38	32	23.90	1.54	
AMF**	-	99	-	-	

*Enzyme Modified Cheese
**Anhydrous Milk Fat

Table 2 . Formulation of different ingredients (%) in various processed cheese blends

	Treatments				
Ingredient %	**C**	**T1**	**T2**	**T3**	**T4**
Cheddar cheese	66.20	36.20	15.60	0.00	0.00
Skim milk powder	00.0	9.00	15.6	12.4	0.00
Casein	0.00	0.00	0.00	0.00	12.0
whey protein	0.00	0.00	0.00	7.4	8.0
EMC	0.60	0.60	0.60	0.60	0.60
AMF	0.60	10.20	17.00	22.00	22.00
Emulsifier Tri-Sodium phosphate	2.60	2.60	2.60	2.60	2.60
Condensate (water condensed from the steam using during processing)	8.00	8.00	8.00	8.00	8.00
Lactic acid	0.80	0.80	0.80	0.80	0.80
water	20.60	31.40	39.00	44.60	44.60
Salt	0.60	1.20	1.20	1.80	1.80
Calculated composition %					
Fat	22.00	22.00	22.02	22.00	22.00
Moisture	55.01	55.00	54.99	55.03	14.68
Salt	1.70	1.69	1.67	1.72	1.72

Table 3.Gross chemical composition (%) and pH of processed cheese (Average of 3 replicates)

Treatments	Fat	Protein	Moisture	salt	pH	Dry matter
C	21.67	16.67	55.12	1.82	5.62	44.88
T1	21.85	12.29	54.79	1.78	5.65	45.21
T2	21.78	8.98	54.91	1.76	5.56	45.09
T3	21.75	9.53	55.08	1.8	5.68	44.92
T4	21.54	19.24	54.89	1.75	5.58	45.11

Table. 4. Texture profile analysis of processed cheese

Treatments	Hardness	Cohesiveness	Adhesiveness	Springiness	Gumminess	Chewiness
C	7.21	0.50	0.20	2.85	3.59	10.24
T1	5.66	0.52	0.18	3.28	2.93	9.61
T2	6.50	0.39	0.17	3.66	2.53	9.28
T3	5.32	0.50	0.23	3.12	2.66	8.28
T4	10.78	0.52	0.22	3.66	5.62	20.58

Table 5. Reheological and organoleptic properties of processed cheese

Tretments	Hand Firmness	Hand springiness	First bite firmness	First bit fracturability	Chewdown degree of breakdown	Chewdown cohesiveness	Chewdown adhesiveness	chewdown smoothness	Residual smoothness of mouth coating	Overall flavor
C	6.12	5.83	6.77	5.82	5.22	5.23	4.46	7.12	4.80	7.21
T1	5.29	4.88	4.89	5.42	5.22	5.46	4.35	5.93	6.24	7.62
T2	4.60	4.68	5.46	5.23	5.80	5.23	4.60	6.80	5.60	7.82
T3	4.29	5.57	4.29	4.14	6.14	6.23	5.14	7.32	7.14	7.43
T4	6.45	6.61	5.26	6.61	5.42	4.81	4.82	4.54	6.35	7.21

الملخص العربى

الخواص الكيماوية والريولوجية والحسية للجبن المطبوخ المشابه (الاحلال الجزئى والكلى للجبن)

طارق مراد النمر

قسم علوم و تكنولوجيا الألبان – كلية الزراعة (الشاطبي)

جامعة الاسكندرية – الاسكندرية – مصر

تم دراسة احلال الجبن التشيدر بنسب ٤٥ و٧٦ و ١٠٠ % فى مشابهه الجبن المطبوخ اللبن الفرز المجفف وبروتينات الشرش المجففة وكذلك الكازين المجفف على الخواص الكيماوية والريولوجية والحسية . ولقد اظهرت النتائج عدم وجود فروق فى رقم الحموضة والرطوبة والدهن وايضا معدلات الملح بين المعاملات المختلفة . كذلك اظهرت النتائج ان محتويات البروتين فى المعاملات ارتبطت بالمحتويات البروتينية فى مواد الاحلال فاضافة الكازين المجفف عمل على زيادة معدلات الصلابة hardness بينما اضافة اللبن الفرز المجفف ومركزات بروتينات الشرش المجففة عملت على زيادة الطراوة أو النعومة softness . اما التماسك cohesiveness لعينات الجبن المختلفة كان اقل عند استخدام مركزات بروتينات الشرش واللبن المجفف مقارنة بالكازين المجفف .وعلى نحو آخر فمعدلات المرونة والإلتصاقspringiness and gumminess بصفة عامة قلت عند احلال الجبن التشيدر باللبن الفرز و مركزات بروتين الشرش والكازين المجففين . بينما اللدانة chewiness انخفضت فقط عند الاحلال بمركزات بروتينات الشرش واللبن الفرز المجفف مقارنة بمركزات بروتينات الشرش والكازين .هذا ولقد اظهرت الصفات الحسية ان معاملات الجبن المطبوخ المشابه باستخدام مركزات بروتيبات الشرش كانت اكث طراوة عن تلك المستخدم فيها الكازين المجفف . وكذلك اضافة الكازين ازادت الثبات firmness والقدرة على التكسر fracturability وقللت فى النعومة داخل الفم mouth smoothness والتماسك cohesiveness والالتصاق .adhesiveness