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QUALITY AND ACCEPTABILITY OF PROCESSED CHEESE SPREADS MADE FROM TOTAL MILK PROTEINATE AND CASEIN CO-PRECIPITATE

BY

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SUMMARY

Processed cheese spreads (PCSs) were made by replacing the hard cheeses in the base blend with total milk proteinate (TMP) or casein co-precipitate (CCP), at ratios of 0 (control), 25, 50, 75 and 100%. The base blends were standardized to contain 55% moisture and 50% fat in dry matter in the resultant spreads. The PCSs were evaluated for chemical, physical and sensoric properties during storage at 7°C for 3 months. The results revealed that addition of TMP and CCP in the base blend resulted in PCSs with higher total nitrogen contents, as compared with the control cheese spread product ($p< 0.05$). However, the control treatment had the highest contents of soluble nitrogen, ash, salt in moisture and total volatile fatty acids as well as pH values, as compared with the other treatments ($p < 0.05$). On the other hand, PCSs treatments made with different levels of TMP had the highest values for penetration, meltability and whiteness, but lowest oil separation values than the other treatments ($p < 0.05$). Moreover, sensory evaluation scores revealed significant differences ($p < 0.05$) between all treatments. Furthermore, PCSs made with CCP had granular texture that increased by increasing CCP added. Also, PCSs made by incorporation of 25 and 50% TMP in the base blend gave the best organoleptic and improved the chemical and physical properties as compared with the other treatments during storage. The total costs for manufacturing PCSs was reduced by 13.48 and 25.61 % when hard cheeses in the base blend were replaced by TMP at the levels of 25 and 50%, respectively, than the control spread.

Key words: - Processed cheese spreads- total milk proteinate- casein co-precipitate- chemical properties- physical properties - sensory quality

INTRODUCTION

Processed cheese is generally manufactured from a mixture of various types of natural cheeses with the following selection criteria: type, flavour, ripening stage, texture and acidity (Chambre and Daurelles, 2000) Other

raw materials of dairy origin are used in the manufacture of processed cheese, among these are milk protein concentrates (MPCs) (Bailey, 2003). New technologies have enabled the integration of the whey proteins and different milk constituents into the cheese matrix, in order to improve its nutritive value as well as its economic effectiveness (Kessler, 1996 and Hinrichs, 2001). Whey proteins (WPs) may be incorporated in principle both in a native form and in a denatured state into cheese (Lawrence, 1989 and 1993) e.g. pasteurized processed cheese products (PCPs) (Gupta & Reuter, 1993; Abd El-Salam *et al.*, 1996, 1997 & 1998; Fayed and Metwally, 1999); acid or rennet caseinate and /or co-precipitates (Thomas, 1970;Gouda *et al.*, 1985 and Savello *et al.*, 1989); milk ultrafiltered retentate (Sood & Kosikowski, 1979 and Anis & Ernstrom, 1984); cheese base (concentrated fermented ultrafiltered milk retentate) (Gouda & El-Shibiny, 1987; Tamime *et al.*, 1990 and Park *et al.*, 1992) or cheese with high level of whey protein e.g. UF cheese or acid –heat coagulated curd (Kalab and Modler,1985;Collinge & Ernstrom, 1988 and Kala *et al.*, 1991) or accelerated ripened cheeses (Abd El-baky *et al.*, 1987 and El-Neshany *et al.*, 1987).In addition, Chambre and Daurelles (2000) reported an improvement in the spreadability and stability of the processed cheese by addition of MPC. However, MPC's should not be added in too high quantities to avoid affecting the consistency of the product or the formation of a browning reaction (Kelly, 1986; Metwally, 1992; Abd El-Salam *et al.*, 1996 and Mulvihill & Ennis, 2003).

Recent techniques for milk protein separation have resulted in a product known as total milk proteinate (TMP), that have much improved solubility over that of traditional casein co-precipitates (CCP) (Morr, 1985; Metwally, 1992 and Mulvihill & Ennis, 2003). TMP exhibits excellent emulsification and foaming potential when compared with CCP. However, in food product applications such as cream liqueurs TMP was inferior to CCP (Kelly, 1986). Replacement of caseinate by TMP in a processed cheese formulation gave product of excellent flavour and water binding characteristics.

In Egypt the consumption of PCPs increased markedly during the last decade. PCPs represented about one quarter of the total cheese imports in 1997. The production reached about 10 thousand tons either in spreadable or block form (Awad, 2003). The PCPs mainly manufactured from blends containing imported Cheddar and Gouda cheeses as well as locally produced Ras cheese. The locally produced Ras cheese requires a ripening period of about 4 months to develop the desired flavour and body characteristics which in turn increase the total capital costs of production (El-Neshany *et al*, 1987). Also, biogenic amines may be formed and steady increased during the maturation of cheeses (El-Sonbaty *et al.*, 1998). Biogenic amines content in Cheddar, Gouda and Ras cheeses have been determined in several studies. Therefore, using matured cheeses rich in biogenic amines for production of PCPs can give rise to food intoxication (Joosten and Standhouders, 1987).

The objective of this study was to investigate the influence of replacing the

hard cheeses in the base blend by varying amounts of total milk proteins, as well as, casein co-precipitate; individually; on the chemical, physical and sensory properties of the resultant processed cheese spreads.

MATERIALS AND METHODS

Materials

Ras cheese (one month old) was obtained from Arabic Food Industrial Co. (Domety) 6th October city, Egypt. Also, matured Cheddar cheese (8 months old) and Kasomel emulsifying salt K2394 (Rhone-Poulenc Chimie, France) were obtained from International Dairy & Foods Co. (Milky Land), 10th Ramadan city, Egypt. Low heat skim milk powder and butter were procured from Irish Dairy Board, Grattan House, Lower Mount St., Dublin, Ireland. The chemical compositions of the ingredients used in the manufacturing of processed cheese spreads are presented in Table (1).

Methods

1.Preparation of total milk proteinate (TMP) and casein co-precipitate (CCP)

Fresh raw buffaloe's milk was obtained from the herd of the Fac. Agric., Ain Shams Univ., Cairo, Egypt. Skim milk was used for preparation TMP (casein and undenatured whey proteins) and CCP (casein and denatured whey proteins) according to the methods described by Morr (1985) and Metwally (1992). For preparation TMP, skim milk was adjusted to pH 10 by addition of 1 N NaOH and heated to 50 ±1°C to solubilize casein micelles. After that, pH was adjusted to 3.5 at 40°C using 1 N HCl to form a complex between the whey proteins and casein. The pH was raised again to 4.6 by 1 N NaOH to precipitate the complex proteins. The proteins were removed from the whey using cheese-cloth, and then washed 3 times by warmed (30 – 40°C) acidified (pH = 4.6) distilled water. The curd was pressed and suspended in distilled water by addition of 1 N NaOH to bring the pH to 7.5. The CCP preparation was done by heating skim milk in the water bath to 90°C for 15 min, following by cooling to 40°C. The pH was adjusted to 4.5 with1 N HCl. The precipitate was then processed through steps similar to that previously mentioned for TMP. The chemical compositions of the TMP and CCP prepared are presented in Table (1).

2. Manufacture of processed cheese spreads (PCSs)

Control processed cheese was made of young Ras and matured Cheddar cheeses as a base blend according to the method of Meyer (1973). Processed cheese treatments were manufactured, by replacing the hard cheeses in the base blend with TMP and CCP, individually, at ratios of 25, 50, 75 and 100%. Cheeses were weighed, minced, ground and placed into the processing batch type kettle of 10 kg capacities, a pilot machine locally made in Egypt (Mohamed, 2004) at the National Research Center. Simultaneously required amount of emulsifying salts (2.5 %), butter, skim milk powder and water were added. The composition of each batch of processed cheese treatments were adjusted to contain a final product, containing 55 ± 1 % moisture and 50 ± 1% fat in dry matter according to the Egyptian Standards (2001). All

blends were cooked with controlled agitation for 8 min at 85-90°C using direct injection steam at pressure of 1.5 bar. The agitation time of PCSs blends with CCP were low much increased. The hot product of PCSs was packaged into 150 ml sterilized glass jar and also covered with aluminum foil and their covers, then rapidly cooled at 7 ±1°C. The resultant PCSs were analyzed when fresh and after 1& 3 months. The compositions of different blends of PCSs are shown in Table (2). Three replicates of each treatment were manufactured and subjected for analysis.

Table (1): Chemical composition (%) of the ingredients used in manufacture of processed cheese spreads.

Ingredients	Composition (%)							
	Total solids	F/DM[1]	Total nitrogen	Soluble nitrogen	S/M[2]	Ash	pH	TVFA[3]
Cheddar cheese	65.80 ±0.16	52.90 ±0.10	3.99 ±0.09	1.20 ±0.99	4.46 ±0.13	5.42 ±0.19	5.02 ±0.05	29.10 ±1.87
Ras cheese	54.81 ±0.18	45.20 ±0.12	3.49 ±0.12	0.67 ±0.87	5.91 ±0.11	5.76 ±0.13	5.35 ±0.05	24.65 ±1.00
Skim milk powder	96.00 ±0.05	1.04 ±0.02	5.82 ±0.06	0.83 ±0.03	ND	7.89 ±0.10	6.40 ±0.06	ND
Butter	84.00 ±0.02	97.61 ±0.06	ND[4]	ND	ND	ND	ND	ND
Total milk proteinate	39.14 ±0.91	ND	5.92 ±0.95	ND	ND	1.80 ±0.59	4.90 ±0.10	ND
Casein co-precipitate	43.47 ±0.87	ND	5.83 ±0.99	ND	ND	2.15 ±0.39	4.90 ±0.10	ND

[1] Fat in dry matter. [2] Salt in moisture.
[3] Total volatile fatty acids, ml 0.1 N NaOH/100g. [4] N.D.,Not determined.

3.Methods of Analysis

3.1. Chemical analysis

The PCSs samples were analyzed for fat content (using Gerber method), total nitrogen (TN) and soluble nitrogen (SN) contents (using micro-Kjeldahal method), and also pH values (using pH meter model Cole-Armer Instrument Co., USA) as described in Ling (1963). The salt content was determined as described by Bradley *et al.* (1992). Total volatile fatty acids (TVFA) were determined by the method of Kosikowski (1970), values were expressed as ml 0.1N NaOH / 100g. Also, the moisture and ash contents were determined according to the method in AOAC (1990).

Table (2): Composition (kg/100kg) of different blends used in manufacture of processed cheese spreads made by replacing the hard cheeses with different ratios of total milk proteinate (TMP) and casein co-precipitate (CCP).

Ingredients	Control	Ratios of replacement (%)			
		TMP			
		25	50	75	100
Cheddar cheese	12.80	9.08	5.74	2.74	-
Ras cheese	38.44	27.26	17.20	8.20	-
Skim milk powder	5.12	4.84	4.58	4.38	4.20
Butter	10.26	15.22	19.72	23.64	27.16
TMP	-	12.12	22.94	32.82	41.90
CCP	-	-	-	-	-
Emulsifying salt	2.50	2.50	2.50	2.50	2.50
Water	30.88	28.98	27.32	25.72	24.24
Total	100	100	100	100	100
	CCP				
Cheddar cheese	12.80	8.90	5.52	2.58	-
Ras cheese	38.44	26.70	16.54	7.72	-
Skim milk powder	5.12	4.76	4.42	4.12	3.86
Butter	10.26	15.38	19.86	23.74	27.18
TMP	-	-	-	-	-
CCP	-	11.86	22.06	30.92	38.62
Emulsifying salt	2.50	2.50	2.50	2.50	2.50
Water	30.88	29.90	29.10	28.42	27.84
Total	100	100	100	100	100

3.2. Physical analysis

The PCSs firmness was measured using a penetrometer (Kochler Instrument Co. Inc., USA) as described by Gupta and Reuter (1993). The penetrometer cone was adjusted to touch the sample surface the released to skim into the sample for 5 sec. The penetration depth was recorded in units of 0.1 mm. Penetrometer reading is related inversely to the firmness of PCSs. Meltability of the PCSs samples was measured as described by Olson and Price (1958) with the slightly modification by Savello *et al.* (1989). After the PCSs samples were melted, the distance to which they spread, was measured in millimeters (mm) and used as criteria for the meltability. Oil separation was determined according to the method outlined by Thomas (1973). The diameter of the spread oil was measured in mm using an index of oil separation according to the following equation:

$$OSI = (D2 - D1) / D1 \times 100$$

Where: OSI = Oil separation index.

D1 = Diameter of cheese fat before heating.

D2 = Diameter of cheese fat after heating.

All PCSs samples were measured for whiteness (%) using a Hunter Colorimeter Model D25 A-2 (Hunter Assoc. Lab Inc. Va, USA) and the instruction of user manual (Hunter Assoc., 1976). The instrument was first standardizing using a reference with white surface.

3.3. Sensory evaluation

The sensoric properties of PCSs samples were evaluated according to the scheme of Meyer (1973) by 15 regular scoring panels of the staff members at the Food Science Department, Fac. Agric., Ain Shams Univ. and National Research Center. The scores consisted of flavour & aroma (40 points), body & texture (40 points) and appearance & colour (20 points).

4. Statistical analysis

The experimental data were analyzed using the general linear models procedure of the Statistical Analysis System (SAS, 1996). Significance of differences was defined at $p < 0.05$.

RESULTS AND DISCUSSION

Chemical composition

Table (3) reveals that there were no significant differences ($p > 0.05$) (Table, 6) among all treatments with respect the total solids (TS) and fat in dry matter (F/DM) contents of PCSs. The TS and F/DM ratios of the resultant fresh PCSs untreated and treated with TMP and CCP ranged from 44.64 to 44.99 % and 50.21 to 50.90 %, respectively. However, addition of TMP and CCP in the base blend resulted in PCSs of higher TN contents, as compared with control treatment ($p < 0.05$). Increasing the percentage of TMP and CCP added, increased the TN content in the PCSs. PCSs with TMP had slightly higher in TN content than the CCP treatments. El-Neshawy *et al.* (1988) reported that the addition of WPC to blends showed the products fine consistency and high protein content. Moreover, the control treatment made without TMP and CCP had the highest contents of ash, salt in moisture (S/M) and TVFA as compared with the other treatments ($p < 0.05$). However, treatments with CCP had slightly higher ash and SWP contents than the PCSs with TMP. The low ash, S/M and TVFA contents of PCSs treatments with TMP and CCP may be due to their low contents of these components. During the storage, no significant differences ($p > 0.05$)were found in the chemical composition of PCSs.

The chemical composition of PCSs were reported to be changed very slightly during storage at the refrigerator temperature (Abd El-Salam *et al.*, 1996; Hamed *et al.*, 1997; El-Sonbaty *et al.*, 1998 and Mohamed, 2004).

Table (3): Effect of replacing the hard cheeses with different ratios of total milk proteinate (TMP) and casein co-precipitate (CCP) on the chemical composition of processed cheese spreads during storage at 7 °C for 3 months.

Composition (%)	Storage period (month)	Control	Ratios of replacement (%)							
			TMP				CCP			
			25	50	75	100	25	50	75	100
Total solids	Fresh	44.64	44.83	44.85	44.91	44.95	44.90	44.92	44.99	44.96
	1	44.69	44.92	44.91	45.01	44.99	45.11	44.99	45.06	45.23
	3	44.79	44.95	44.97	45.21	45.05	45.20	45.11	45.30	45.30
Fat in dry matter	Fresh	50.90	50.53	50.50	50.31	50.22	50.45	50.44	50.33	50.21
	1	51.01	50.61	50.54	50.35	50.35	50.55	50.52	50.44	50.33
	3	51.11	50.66	50.65	50.45	50.39	50.55	50.60	50.56	50.39
Total nitrogen	Fresh	2.15	2.99	3.69	3.99	4.50	2.89	3.55	3.90	4.31
	1	2.18	3.01	3.71	4.00	4.55	2.99	3.58	3.91	4.45
	3	2.22	3.13	3.79	4.08	4.61	3.00	3.63	4.01	4.53
Ash	Fresh	5.01	4.20	4.29	4.30	4.32	4.25	4.31	4.40	4.45
	1	5.12	4.33	4.32	4.33	4.33	4.33	4.39	4.40	4.50
	3	5.21	4.31	4.40	4.41	4.43	4.36	4.44	4.55	4.57
Salt in moisture	Fresh	3.02	2.76	2.43	2.21	2.01	2.77	2.44	2.22	2.05
	1	3.13	2.77	2.48	2.22	2.09	2.80	2.49	2.25	2.12
	3	3.15	2.87	2.53	2.36	2.12	2.85	2.54	2.35	2.22
Total volatile fatty acids	Fresh	28.00	27.33	25.33	24.02	23.25	27.52	25.48	24.22	23.35
	1	28.12	27.53	25.55	24.22	23.32	27.55	25.54	24.52	23.55
	3	28.35	27.69	25.69	24.39	23.66	27.80	25.80	24.65	23.70
pH	Fresh	5.83	5.75	5.65	5.55	5.50	5.65	5.60	5.52	5.40
	1	5.80	5.72	5.65	5.55	5.50	5.65	5.62	5.50	5.40
	3	5.75	5.70	5.60	5.50	5.45	5.60	5.60	5.50	5.35
Soluble nitogen	Fresh	1.65	0.76	0.70	0.68	0.62	0.75	0.69	0.64	0.63
	1	1.66	0.78	0.70	0.70	0.65	0.76	0.70	0.68	0.65
	3	1.72	0.84	0.78	0.75	0.69	0.81	0.75	0.73	0.71

pH values

Replacing hard cheeses with either TMP or CCP in the base blend slightly lowered the pH values of the PCSs than the control cheese ($p < 0.05$) (Tables, 3 &6). Also, PCSs at replacement ratios of TMP and CCP 75 and 100 % had slightly lower in pH values than the 25 and 50 %. This could be due the low pH value of TMP and CCP as compared with pH of matured Cheddar and young Ras cheeses. During the storage period at 7°C for 3 months, there were slight decreases ($p < 0.05$) in pH values of PCSs untreated and treated with TMP and CCP. These decreases

were slightly increased with increasing the percentage of TMP and CCP added in the formula. The slight reduction in pH values during the storage period could be attributed to the limited growth and activity of resistant microflora and enzymes in the product. It could be also due to the hydrolysis of polymerized phosphate present in the emulsifying salts and their interaction with protein (Tamime *et al.*, 1990;Younis *et al.*, 1991a; Aly *et al.*, 1995 and Chambre &Daurelles, 2000).

Soluble nitrogen contents

The results revealed that the control spread had higher SN content than that of PCSs treatments with TMP and CCP (Table, 3) being significant differences ($p < 0.05$) (Table, 6) which could be due to the low SN content in TMP and CCP added in the formula. Also, the SN contents decreased by increasing the replacement ratios of TMP and CCP added in the base blend. The SN contents were slightly increased ($p < 0.05$) in all spreads during storage at 7°C, especially at the end of the 3 months. The change occurred in SN contents during storage might be due to the enzymatic activity of heat resistant proteinases or psychrotrophic spore forming bacteria present in the product (Tamime *et al.*, 1990; Younis *et al.*, 1991a and Aly *et al.*, 1995).

Penetration values

Fig. (1) shows that the penetration value of spread control made with matured Cheddar and young Ras cheeses was decreased significantly ($p < 0.05$) (Table, 6) than the PCSs made with different replaced ratios of TMP. A highly significant increase ($p < 0.05$) in penetration values (inverse firmness) were found irrespective of the addition of varying amounts of TMP. On the other hand, PCSs treatments with CCP had the lowest penetration values; especially when the level of added CCP was increased. The relatively low penetration values of PCSs with CCP, was probably due to its granular texture. After storage up to 3 months at 7°C, the penetration values of all treatments were slightly decreased. The differences in the penetration values during storage could be related to the interaction between emulsifying salts and state of protein network as well as the changes in chemical composition during storage (Thomas, 1970 and Younis *et al.*, 1991b). Gupta & Reuter (1993) reported variations in penetration values of commercial processed cheeses from India which they attributed to the different raw cheeses used in their manufacture. Although native and denatured whey proteins (WPs) have low texture-forming capacity (Korolczuk & Mahaut, 1991), WPs improves the consistency of cheeses. Also, they found that 1 % denatured WPs have similar effects on consistency to 0.6 to 1.2 % casein. It is probable that the lower penetration values of processed cheese foods with the increase in WPs that mostly become denatured on subsequent heat processing at 82 °C for 3 – 5 min. However, during processing WP are subjected to denaturation, which can bind more water (Abd El-Salam *et al.*, 1997), increase cheese viscosity and increase the emulsification of the fat globules in PCSs. The presence of emulsifying salts in the blend may affect the heat denaturation and insolubilization

through the masking of calcium (de Rhan & Chanton, 1984).

Melting index

The meltability (mm) of PCSs from different treatments when fresh & after 1 and 3 months of storage at 7 °C are presented in Fig. (1). The PCSs of TMP had significantly higher meltability values than control and other treatments ($p < 0.05$) (Table, 6). Also, among the treatments with TMP, at the highest levels of TMP the spreads showed higher meltability values. On the other hand, PCSs made with different ratios of CCP had the lowest melting quality, which was increased with increasing CCP ratios added to the formula. However, the meltability values of all treatments were slightly decreased after storage at 7°C for 3 months. The effect of storage at 5°C was reported non-significant up to 2 months of storage (Mohamed, 2004). Also, Abd El-Salam *et al.* (1996) reported that the meltability of the PCSs increased with the increasing in the percentage added of WPC, while it's decreased with advanced storage. Sood & Kosikowski (1979) mentioned that the melting index of processed cheese is controlled largely by the ratio of insoluble to total casein nitrogen in ingredient. However, Gouda *et al.* (1985) reported that fully replacement of the cheese solids not fat by calcium caseinate gave poor spreadability in the resultant PCSs. Generally, Guinee (2003) mentioned that the effect of added WP on the flowability of PCSs might be due to differences in: pre-treatment of the WP and its levels of denaturation; methods of WP inclusion; the overall product formulation and processing conditions.

Oil separation index

Oil separation values (%) of PCSs made by replacing the hard cheeses in the base blend with those of TMP and CCP, individually, at ratios of 0 (control), 25, 50, 75 and 100% when fresh & after 1 and 3 months of storage at 7 °C are presented in Fig. (1). A marked difference was found in the oil separation indexes of PCSs among treatment with TMP and CCP. In the other words, the results of fresh spreads showed significant differences ($p < 0.05$) (Table, 6) in oil separation index between control, TMP and CCP treatments. Also, the PCSs made with different levels of TMP showed medium percentages of oil separation between the control and treated with CCP. Moreover, there was no oil separation observed in fresh control samples (zero point). The absence of oil separation in control spread suggests that the emulsifying salts were suitable for maintaining a uniform structure and distribution of protein and fat contents after the melting stage, also adjusting the pH to the desired levels to avoid any oil separation from the products (Younis *et al.*, 1991b). Also, the high oil separation percentages were observed in PCSs made with different ratios of CCP, the values increased with increasing CCP ratios added to the formula. During the storage in the refrigerator for 3 months, the oil separation values were slightly pronounced in all treatments as the storage period increased. The results in agree with those of Abd El-Salam *et al.* (1996); Hamed *et al.* (1997) and Mohamed

(2004). Presumably, unfolding of the WP molecule during heat processing exposes hydrophobic groups that can orient at the oil and water interface and improve emulsion stability (Modler, 1985). TMP exhibited excellent emulsification and foaming potential when compared with CCP. However, in food product applications such as cream liqueurs TMP was inferior to CCP. Replacement of caseinate by TMP in a processed cheese formulation gave excellent water binding characteristics, and there may be some long-term potential in this area (Kelly, 1986 and Metwally, 1992).

Whiteness values

Fig. (1) shows the whiteness values of PCSs from all treatments where significant differences were observed between control and the other treatments ($p < 0.05$) (Table, 6). PCSs made with different levels of TMP showed the highest and control the lowest whiteness values, as compared with the other treatments. Increasing the ratios of added TMP, the whiteness values of PCSs increased. The PCSs with incorporation of CCP at the different levels also showed whiteness, but lower than treated with TMP. Moreover, there were slightly inconsistency in the whiteness values of PCSs containing CCP during storage; which may be due to it's granular texture. During cold storage the whiteness of PCSs slightly decreased ($p > 0.05$), especially at the end of the storage. The results in agree with those of Khader *et al.* (1997) and Abd El-Salam *et al.* (1998). This can largely be attributed to the denaturation of the WP during processing increasing the opaque particles in the mass and in turn reflecting more light (Walestra and Jenness, 1984). During the storage the PCSs gradually become darker, due to occurred the Maillard browning reactions (Guinee, 2003). Therefore, the colour of processed cheeses containing WPCs can be a function of two opposite effects; namely the browning reaction and the whiteness from the denaturation of WPCs.

Sensory evaluation.

Table (4) shows the scores for sensory evaluation of PCSs from different treatments which were were found to be significantly different ($p < 0.05$) (Table, 6). Also, t PCSs with TMP at replacement ratios of 25 and 50% were ranked the highest scores for different attributes; followed by control. Addition of TMP at the ratio of 25% replacement improved the flavour & aroma, body & texture as well as appearance & colour of the resultant spreads. However, increasing the ratios of added TMP, the sharp flavour was decreased and whiteness as well as spreadability of PCSs increased. On another hand, the PCSs with incorporation of CCP at the different levels improved the flavour and colour compared to the control, but the body and texture characterized by granular texture particularly at high CCP ratio. The sensory scores of PCSs samples were slightly increased after 1 month of storage (Table, 4), and theafter slightly decreased. These changes could be related to changes in the chemical composition of the PCSs (Hamed *et al.*, 1997 and Abd El-Salam *et al.*, 1996 & 1998). Replacement of caseinate by TMP in a processed cheese formulation gave excellent flavour and water

binding characteristics (Kelly, 1986). However, Abou Dawood *et al.* (1983) mentioned that higher levels of WPs gave flat flavour and pasty texture in PCS. Also, increasing the content of the mature cheesein blend decreased the complex modulus; yield stress and hardness, but not the taste of the processed cheese. The rapid cooling of the molten mix decreased the complex modulus and improved the spreadability, and increased the stickiness of processed cheese(Piska and Stetina, 2004). Also, Gouda *et al.* (1985) reported that fully replacement of the cheese solids not fat by calcium caseinate gave a poor spreadability in the resultant PCSs.

Table (4): Effect of replacing the hard cheeses with different ratios of total milk proteinate (TMP) and casein co-precipitate (CCP) on the sensory properties of processed cheese spreads, during storage at 7°C for 3 months.

Character assessed	Storage period (month)	Control	Ratios of replacement (%)							
			TMP				CCP			
			25	50	75	100	25	50	75	100
F. & A.[1] (40)	Fresh	36.0	39.0	37.0	30.3	28.3	31.5	30.3	28.0	27.0
B. &T.[2] (40)		35.5	38.5	36.0	30.5	28.5	25.0	21.0	20.0	20.0
A. &C.[3] (20)		17.3	19.3	18.0	15.2	14.5	12.3	12.0	11.3	11.0
T.S.[4] (100)		88.8	96.8	91.0	76.0	71.3	68.8	63.3	59.3	58.0
F. & A.[1] (40)	1	36.5	39.5	37.5	30.0	28.0	31.0	29.5	28.0	27.5
B. &T.[2] (40)		35.5	38.5	36.5	30.3	28.0	25.0	20.3	20.0	20.3
A. &C.[3] (20)		17.5	19.5	18.5	15.0	14.0	12.0	12.0	11.0	10.0
T.S.[4] (100)		89.5	97.5	92.5	75.3	70.0	68.0	61.8	59.0	57.8
F. & A.[1] (40)	3	36.0	39.0	37.0	29.2	27.3	30.0	28.0	27.3	25.0
B. &T.[2] (40)		35.0	38.0	36.0	29.0	27.0	24.3	19.5	19.0	20.0
A. &C.[3] (20)		17.0	19.0	18.0	14.3	13.0	11.3	10.3	10.0	10.0
T.S.[4] (100)		88.0	96.0	91.0	72.5	67.3	65.6	57.8	56.3	55.0

[1]Flavour & aroma. [2]Body & texture.
[3]Appearance & colour. [4]Total score.

Costs of recipes

Table (5) shows the total costs (100 kg) of the ingredients used for manufacturing PCSs by replacing the hard cheeses in the base blend with TMP at ratios of 0 (control), 25 and 50%. The results revealed that replacing the hard cheeses by TMP were more lowered the total costs by 13.48 and 25.61 %, respectively, compared with the control spread made without TMP. Also, the costs were decreased when the TMP added to the formula increased. Generally, they can be manufacturing PCSs by replacing the hard cheeses in the base blend with TMP at ratios of 25 and 50 % without any increase in the cost and highly acceptable than the traditional spread.

Finally, PCSs made with substituting hard cheeses could be made by

incorporation of 25 and 50% TMP in the base blend, which gave the best organoleptic, improved the chemical and physical properties; during storage at 7°C for 3 months; as well as reduced the total costs for manufacturing by 13.48 and 25.61 %, respectively than the control spread.

Table (5): Effect of replacing the hard cheeses with total milk proteinate (TMP) at ratios of 25 and 50 % on the total cost of the ingredients (100 kg) used for manufacturing processed cheese spreads.

Ingredients	Price of kg/ L.E	Control	Ratios of replacement (%) TMP	
			25	50
Cheddar cheese	25.0	320.00	227.00	143.50
Ras cheese	12.0	461.28	327.12	206.40
Skim milk powder	15.0	76.80	72.60	68.70
Butter	9.0	92.34	136.98	177.48
TMP	4.5	-	54.54	103.23
Emulsifying salt	12.0	30.00	30.00	30.00
Total cost	-	980.42	848.24	729.31
Cost reduction	-	100.00	13.48	25.61

Table (6): Analysis of variance* for the effect of type and concentration of replacer used, storage period and their interaction on the chemical, physical and sensory properties of processed cheese spreads.

Parameters	Type	Concen-tration	Storage period	Interaction
Total solids	0.7765	0.9554	0.9548	0.7256
Fat in dry matter	0.8769	0.7687	0.9878	0.8224
Total nitrogen	0.0001	0.0001	0.0912	0.2154
Ash	0.0023	0.0003	0.6822	0.5478
Salt in water phase	0.0001	0.0045	0.5587	0.8776
Total volatile fatty acids	0.0001	0.0001	0.0001	0.2546
PH	0.0001	0.0002	0.0001	0.5547
Soluble nitrogen	0.0001	0.0001	0.0001	0.3669
Penetration values	0.0001	0.0001	0.0001	0.5951
Melting index	0.0001	0.0031	0.0003	0.3351
Oil separation values	0.0001	0.0011	0.0002	0.8895
Whiteness values	0.0010	0.0032	0.5447	0.5414
Flavour & aroma	0.0001	0.0001	0.0001	0.6658
Body& texture	0.0001	0.0001	0.0001	0.6952
Appearance& colour	0.0001	0.0001	0.0001	0.2542
Total score	0.0001	0.0001	0.0001	0.9974

* Significant at $p < 0.05$.

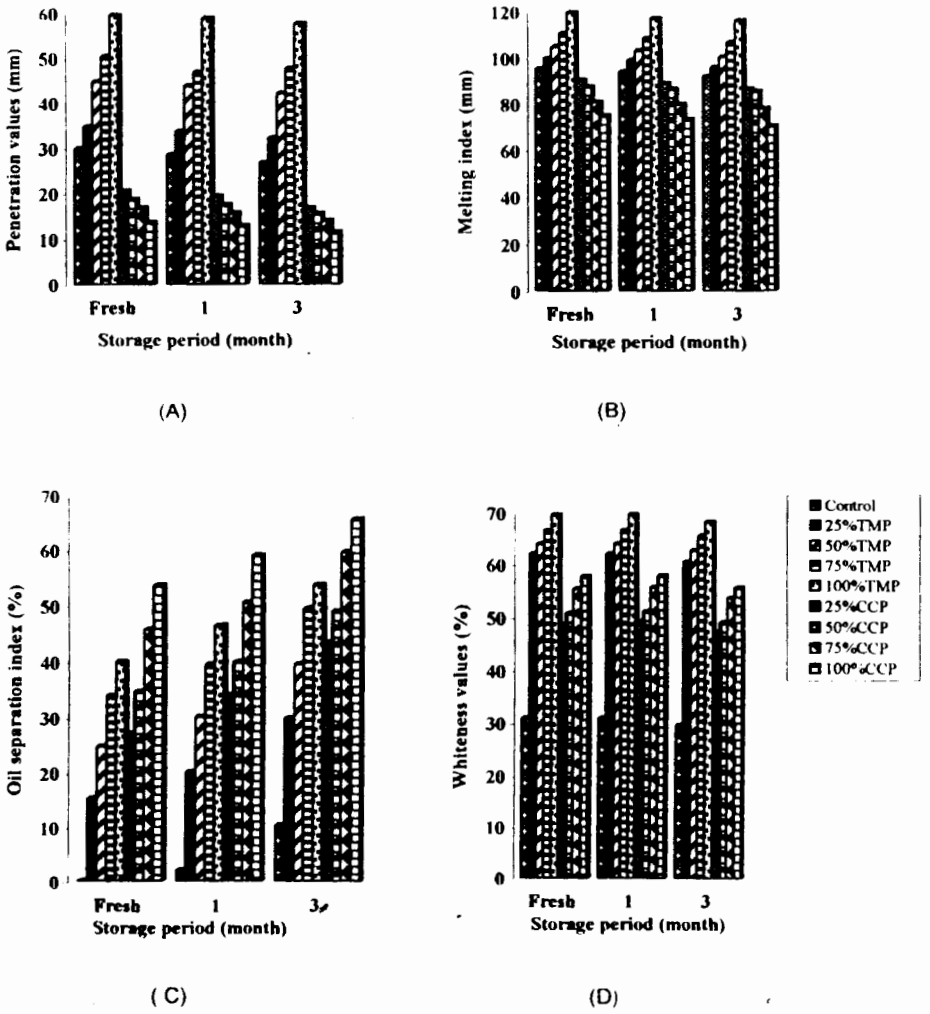

Fig.(1):Effect of replacing the hard cheeses with different ratios of total milk proteinate (TMP) and casein co-precipitate (CCP) on the penetration (A) ,meltability (B), oil separation (C) and whiteness (D) of processed cheese spreads during storage at 7°C for 3 months.

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جودة ودرجة تقبل مفرودات الجبن المطبوخ المصنعة من بروتينات اللبن الكلية والكازين ومرافقاته

تم صناعة مفرودات الجبن المطبوخ باستبدال الجبن الجافة فى الخلطة الأساسية ببروتينات اللبن الكلية والكازين ومرافقاته كلا على حدة وذلك عند مستويات استبدال صفر (جبن المقارنة) ٢٥، ٥٠، ٧٥، ١٠٠ %. وكذلك تم ضبط نسبة الرطوبة إلي ٥٥ % ونسبة الدهن فى المادة الجافة إلى ٥٠ % فى المفرودات الناتجة، ثم قيمت مفرودات الجبن المطبوخ الناتجة للخواص الكيماوية والطبيعية والحسية أثناء التخزين على٧ ° م لمدة ٣ شهور.

أظهرت النتائج أن مفرودات الجبن المطبوخ المضاف لها بروتينات اللبن الكلية والكازين ومرافقاته كبديل للجبن الجافة فى الخلطة الأساسية ذو محتوى مرتفع من النيتروجين الكلى مقارنة بجبن المقارنة. فى حين أظهرت مفرودات جبن المقارنة أعلى قيمة فى رقم الأس الهيدروجيني وفى محتواها من كلا من الرماد، الملح الذائب فى الماء، النيتروجين الذائب، الأحماض الدهنية الطيارة الكلية مقارنة بالمعاملات الأخرى. وعلى الجانب الأخر اتصفت مفرودات الجبن المطبوخ المصنعة ببروتينات اللبن الكلية بقيم أعلى فى كلا من القابلية للاختراق وللانصهار و درجة الابيضاض و بقيم أقل فى انفصال الدهن مقارنة بالمعاملات الأخرى . كذلك أظهر التحكيم الحسي وجود فروق معنوية بين كل المعاملات. وتميزت مفرودات الجبن المطبوخ المصنعة بالكازين ومرافقاته بتركيب حبيبي ، وهذا التركيب يزداد بزيادة النسبة المضافة منها.كذلك اتصفت مفرودات الجبن المطبوخ المصنعة باستبدال الجبن الجافة فى الخلطة الأساسية ببروتينات اللبن الكلية عند مستويات استبدال ٢٥ ،٥٠ % بخواص حسية وكيماوية وطبيعية جيدة مقارنة بالمعاملات الأخرى أثناء التخزين على درجة حرارة الثلاجة لمدة ٣ شهور، ووجد أن هذا الاستبدال يؤدى إلى خفض التكلفة الكلية للصناعة بمقدار١٣,٤٨، ٢٥,٦١ % على التوالي مقارنة بجبن المقارنة.