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PREFERENCE EVALUTION AND PROPERTIES OF REDUCED SODIUM PROCESSED CHEESE SPREADS

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ABSTRACT

Low-sodium processed spreads (LSPS) were made using blends of ordinary and low-sodium Ras cheeses (1:1) with different emulsifying systems (ES). Resultant spreads were chemically analyzed when fresh for salt, ash and mineral contents. Values of pH, soluble nitrogen (SN), total volatile fatty acids (TVFA), physical properties and cheese preference were evaluated in fresh and stored samples. LSPS had lower salt, ash and Na content with higher K and TVFA values. Incorporation of low-sodium Ras cheese by 50% in the base blend with commercial ES decreased Na by up to 37.87%. Substitution of ES to be in K-form increased the reduction in Na ratio up to 67.54%. Values of pH and SN in LSPS were affected by cheese treatments and ES in the blend. LSPS was more meltable, less firm, less viscous and exude more oil than the control. Preference evaluation of cheese spreads indicated that substitution of sodium with potassium significantly lowered the acceptability of the product. High palatable cheese spreads with non significant difference can be produced using blend of ordinary and low-sodium Ras cheese (LSRCh), 1:1 with ES consists of K and Na salts when K/Na ratio in processed product is still < 0.1. Storage of spread samples decreased pH and meltability values while SN, TVFA, oil separation and firmness increased.

Key words: Low sodium, Processed cheese, Rheology, Acceptability

INTRODUCTION

In addition to its preservative effect, NaCl plays important roles in foods which are dietary and flavour effect. The most frequent estimate of the minimum adult daily requirement for sodium is 200 mg (0.5 g of NaCl), while the average total daily sodium intake by most persons in developed countries is 4 to 5 g per day which equal 10 to 12 g of NaCl (**Dillon, 1987**; **IFT, 1980**). These quantities are regarded as excessive, even dangerous, by many of those responsible for public health (**Shank *et al* 1982 and Dillon, 1987**). The excessive intakes of Na have

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toxic or at least undesirable, physiological effects, the most significant of which are hypertension & cardiovascular diseases and increased calcium excretion which may lead to osteoporosis as well as the incidence of kidney stones (**Guinee and Fox, 1993**). Dairy products contribute about 11% of the total sodium and cheeses have been listed as an important source of it in the human diet (**Forsythe and Miller, 1980; Albernethy, 1979**). The dairy industry is seeking for ways to reduce the sodium content of natural and processed cheeses which contain more sodium than do other dairy products. The use of unsalted cheese is unsuitable in process cheese, and produces too meltable and significantly less desirable than NaCl salted cheese (**Olson, 1982**). The author suggested that some reduction in sodium may be feasible in Cheddar cheese either by lowering the amount of salt added or by substituting some of NaCl with KCl. Despite its inherent bitter taste, potassium chloride (KCl) has been widely and successfully used as a partial replacement for NaCl.

Processed cheese are a stable form of ripening cheeses and the precondition for a correct melting of the disintegrated mass is addition of certain salts, called emulsifiers or fluxing agent. The additive of flux, being a mixture of sodium salts of weak polybasic acids is applied and thus it increases the level of sodium in the product. Option available to reduce the sodium content of processed cheeses include lowering NaCl or substitution of NaCl / KCl mixtures in natural cheese manufacture and selection of alternate lowered sodium emulsifier salt systems. Investigations of proposed alternate emulsifier salts are needed to formulate systems capable of meeting technological and consumer objectives. Therefore, this study was conducted to define more clearly factors influencing processed cheese flavors and acceptances as well as to develop formulation providing consumer- acceptable processed cheese with reduction of sodium concentrations.

MATERIAL AND METHODS

Brine salts for natural cheeses

A food grade granulated salt (sodium chloride) was obtained from EL-Nasr salines Co., Alexandria, Egypt. Whereas pure fine grade of potassium chloride produced by EL-Nasr Pharmaceutical Chemicals Co., Cairo, Egypt was used.

Emulsifying salts

Commercial JOHA emulsifying salts S9s and NO recommended for spreadable processed cheese were obtained from BK Ladenburg Corp., GmbH, Germany. Individual emulsifying salts of tripotassium citrate (monohydrate) and dipotassium hydrogen orthophosphate (anhydrous) were obtained from J.T. Baker Inc., NJ, USA.

Butter fat

Fresh unsalted butter used to adjust the fat / dry matter ratio was obtained from Modern Agriculture Development Co., (DINA), Alexandria Desert Road, Egypt.

Preservatives

Nisaplin (commercial name for the preparation of the food preservative nisin) manufactured by Danisco Cultor, Aplin and Barrett Ltd, UK was used.

Ras cheese manufacture

Ordinary Ras cheese (control) was made according to **Hofi *et at* (1970)** using cow's milk (3% fat) and ripened for 2 months at 14°C, before use.

Low sodium Ras cheese (LSRCh) manufacture

Low sodium Ras cheese was made by the same procedure of ordinary Ras cheese with some modification as follows:

After clotting the milk, cutting and partially whey removal from curd as mentioned in ordinary Ras cheese, a mixture of NaCl and KCl (1:1) was added to the curd particles in ratio 1% of the original milk weight. The curd particles were stirred in the brine solution (NaCl : KCl, 1:1) for 15 min. and then the whey was completely drained. The curd was filled in the molds and pressed for 4 hr. After taking out the cheese blocks, it was soaked overnight in a brine solution (20% concentration) made of NaCl + KCl in ratio 1:1 and adjusted the pH to 4.6 by lactic acid. The cheese was then drained off brine, dried on cheese cloth, waxed with paraffin elastic wax and ripened at 14° C & 85-90% RH for 2 months before use. Analyses of ordinary and low-sodium Ras cheeses are presented in Table (1).

Manufacture of Low-sodium processed cheese (LSPC) spread

The base blend of processed cheese spreads with low-sodium content was formulated of ordinary and LSRCh (2 months old) in ratio of 1:1. The final products were adjusted to contain 58% moisture, 45% F/DM, 2.5% emulsifying salt and 0.01% nisin preparation. Four different formulas were made from Ras cheese and low-sodium Ras cheese (1:1) using mixtures of substituting commercial sodium salt (NaES) with formulated potassium salts of tri K-citrate + di K-phosphate, 1:2 (KES). First treatment (L.S 1) was made with 100% of KES, second with KES and NaES, 1:1, third with KES : NaES, 1:2 and lastly one with 100% NaES. Control processed cheese was manufactured using ordinary Ras cheese with commercial emulsifying salt of JOHA S_9 special + NO, 1:1 (NaES). The blend of low sodium and control Ras cheeses, butter, water, emulsifying salt and nisin were added consecutively in the processing kettle and cooked for 8 min at 85-90°C using indirect steam at pressure 2-2.5 Kg/cm^2. After processing, the melted processed cheese was poured into wide mouth glass jars (150 g) and capped directly after filling. The resultant cheese was left at room temperature for cooling and then analyzed when fresh and monthly up to 3 months during storage in refrigerator (5±1° C). Ingredients of each formula are shown in Table (2).

Chemical analysis

Cheese samples were tested for moisture and ash contents as mentioned in **AOAC (1995)**. Total & soluble nitrogen, fat and titratable acidity were determined according to **Ling (1963)**. Salt content was estimated according to **Bradley *et al* (1992)**. Sodium and potassium were estimated using atomic absorption spectrophotometer as described by **FAO (1980)**. Total volatile fatty acids (TVFA) values were determined according to **Kosikowski (1982)**.

Table 1. Chemical composition of ordinary and low – sodium Ras cheeses used in processed cheese spread manufacture

Ras Cheese	Moisture %	Fat %	TN %	Salt %	Acidity %	SN %	TVFA*	Ash %	Na %	K %
Ordinary	35.36	29.88	3.597	3.68	1.27	0.5746	27.6	4.29	2.1487	0.1120
Low-sodium	34.53	30.12	3.652	3.06	1.36	0.5851	30.1	4.17	1.6233	0.8766

TN: Total Nitrogen. SN: Soluble Nitrogen.
*TVFA: Total Volatile Fatty Acids (ml 0.1 N-NaOH / 100g cheese).

Table 2. Composition of different blends of processed cheese spread made using low-sodium Ras cheeses with different food additives (Kg / 100 Kg)

Ingredients	Treatments				
	Control	L.S 1	L.S 2	L.S 3	L.S 4
Ordinary Ras cheese	59.98	29.94	29.94	29.94	29.94
Low Na- Ras cheese	--	29.94	29.94	29.94	29.94
Butter fat	0.39	0.45	0.45	0.45	0.45
Emulsifying salt:					
S_9S (commercial)	1.25	--	0.63	0.83	1.25
NO (commercial)	1.25	--	0.63	0.83	1.25
K-Citrate	--	0.83	0.42	0.29	--
K-Phosphate	--	1.67	0.83	0.55	--
Water	37.03	37.07	37.07	37.07	37.07
Total	100	100	100	100	100
Nisaplin	0.01	0.01	0.01	0.01	0.01

L.S1: 100% KES (k-citrate : k-phosphate, 1:2).
L.S2: KES : commercial Na- salt (NaES), 1 : 1.
L.S3: KES : NaES, 1 : 2.
L.S4: 100% NaES.

Physical properties

Values of pH were measured using a digital pH meter (Cole-Palmer, IL). Oil separation index was determined according to **Thomas, (1973).** Cheese meltability was determined as described by **Rayan *et al* (1980).** Cheese firmness was measured using a penetrometer (Kochler Co. Inc., USA), as described by **El-Shabrawy *et al* (2002).** The apparent viscosity was measured as described by **Schenz and Morr (1996)** using a coaxial rotational viscometer (Rheotest, Germany) at shear rates ranging from 0.3333 to 145.8 S^{-1} at 50°C.

Sensory evaluation

Sensory attributes of samples were evaluated by the faculty and graduate students (8-10 panelists each course) at Food Sci. Dept., Ain Shams University according to **Meyer (1973)** for outer appearance (20 points), body & texture (40 points) as well as aroma & flavour (40 points).

Statistical analyses

Statistical analyses were performed according to **SAS Institute (1990)** using General Linear Model (GLM) with main effect of treatments. Duncan's multiple range was used to separate among means of three replicates at $p \leq 0.05$.

RESULTS AND DISCUSSION

Salt, ash, potassium and sodium contents

The data in Table (3) indicate that control of ordinary Ras cheese with commercial emulsifying salts had significantly higher salt and ash contents than that of all LSPS treatments. Among treatments, there was slight difference in salt and ash being higher in L.S 4 and the lowest in L.S 1. The differences are mainly due to the emulsifying mixture. Commercial emulsifying salt added to control was mostly sodium salt and in hygroscopic form. This would increase the ash as well as the salt content in resultant product. In treatments of low sodium, the commercial emulsifying salt was substituted partially with K-citrate and -phosphate and the base included a part of LSRCh. This would lead to lower ash and salt content in the final product. Treatment L.S 4 had close salt and ash values to control one since it was made with same emulsifying salt but 50% of the cheese base was of LSRCh. Control processed cheese had lowest K content with highest Na content. Among LSPC, L.S 1 possessed the highest K content with lowest of Na, while L.S 4 had the lowest K content with highest of Na. The differences in K and Na contents are mainly due to the base formula and emulsifying mixtures. The difference in Na ratio among low-sodium treatments is due to the emulsifying mixture, while the difference between control and L.S 4 is regarded to the base formula.

The data in Table (3) also indicated that the ratio of K / Na was 0.0336, 2.0645, 0.7196, 0.5170 and 0.1848 in control, L.S 1, L.S 2, L.S 3 and L.S 4 respectively. This means that potassium content was less than sodium content in all samples expect in L.S 1 which had higher K than Na. Low-sodium treatments presented a reduction of Na content equal to 67.54, 52.70, 48.96 and 37.87 % for L.S 1, L.S 2, L.S 3 and L.S 4

Table 3. Salt, ash, potassium and sodium contents of low – sodium processed cheese spreads made using blend of ordinary and low sodium Ras cheeses (1:1) with different emulsifying salt mixtures

Treatments	Salt %	Ash %	K %	Na %	K / Na ratio	Na reduction %
Control	2.91 [A]	4.75 [A]	0.0779	2.3130	0.0336	0.00
L.S 1	2.39 [C]	4.32 [C]	1.5500	0.7508	2.0645	67.54
L.S 2	2.48 [BC]	4.41 [BC]	0.7872	1.0940	0.7196	52.70
L.S 3	2.51 [BC]	4.46 [BC]	0.6101	1.1800	0.5170	48.98
L.S 4	2.59 [B]	4.55 [B]	0.2657	1.4370	0.1848	37.87

See legend to Table (2) for details.
A, B, C: Means with same letter among treatments are not significantly different.

respectively compared to the control one. Therefore, using only 50 % of the cheese base in the formula from LSRCh lowered the Na content by up to 37.87 % in resultant processed cheese. Furthermore, blend of 1:1 of ordinary and LSRCh with emulsifying salt mixture consists of 100 % K salt (L.S 1) resulted in processed cheese with up to 67.54 % reduction in Na content.

Values of pH

The pH values of LSPS (Table, 4) indicated a slight difference among different treatments. Highest pH value was noticed in L.S 1 with formulated emulsifying salt of K-citrate + K-phosphate (1:2), while the lowest was observed in L.S 4 with 100% commercial salt. These differences are mainly due to the different emulsifying salts and/or the acidity degree in cheese base. Value of pH decreased with incorporation of LSRCh in the blend due to its higher acidity than ordinary Ras cheese (Table, 1). On the other hand, emulsifying system contains K-phosphate may increase the pH of resultant processed cheese.

Values of pH slightly decreased during storage in all samples and this could be attributed to the changes of cheese compounds such as lactose and proteins through a limited growth and activity of resistant microflora and enzymes in the spreads. The results are in accordance with **Aly *et al* (1995), Abd El-Hamid *et al* (2000, a), Awad (2003) and Awad *et al* (2003).**

Soluble nitrogen contents

Soluble nitrogen (SN) contents of LSPS, (Table, 4) indicated that the value of SN being lower in L.S 1 and higher in L.S 4 as well as control one. The higher value of SN in L.S 4 and control treatments is mainly due to the effect of emulsifying salt used in peptidizing the protein of cheese base. Control and L.S 4

Table 4. Values of pH, soluble nitrogen and total volatile fatty acids of low – sodium processed cheese spreads made using blend of ordinary and low sodium Ras cheeses (1:1) with different emulsifying salt mixtures

Treatments	Storage period (at 5°C)			
	Fresh	1 month	2 months	3 months
	pH values			
Control	5.84 ABa	5.81 Aa	5.80 Aab	5.76 Ab
L.S 1	5.91 Aa	5.84 Aab	5.82 Aab	5.80 Ab
L.S 2	5.88 Aa	5.80 Aab	5.77 ABab	5.76 Ab
L.S 3	5.85 ABa	5.77 Aab	5.76 ABab	5.73 ABb
L.S 4	5.81 Ba	5.77 Aa	5.75 Bab	5.70 Bb
	Soluble nitrogen			
Control	1.406 Ab	1.511 Aab	1.683 Aa	1.832 Aa
L.S 1	1.107 Bb	1.191 Bab	1.201 Ba	1.317 Ba
L.S 2	1.295 ABb	1.336 ABab	1.447 ABa	1.528 ABa
L.S 3	1.338 Ab	1.411 Aab	1.522 Aa	1.641 Aa
L.S 4	1.532 Ad	1.606 Acd	1.785 Abc	1.902 Aa
	TVFA*			
Control	49 Bc	52 Bb	54 Cb	60 Ca
L.S 1	59 Ac	62 Ac	68 Ab	75 Aa
L.S 2	57 Ab	62 Aab	65 Aa	70 Aa
L.S 3	58 Ac	59 Abc	64 ABab	69 ABa
L.S 4	57 Ac	59 Ab	61 Bb	66 Ba

See legend to Table (2) for details.
*TVFA: Total Volatile Fatty Acid (ml NaOH 0.1 N / 100g cheese)
A, B, C: Means with same letter among treatments in the same storage period are not significantly different.
a, b, c : Means with same letter of each treatment during storage periods are not significantly different.

treatments made with 100% commercial emulsifying salt which is effective in protein peptidization. On the other hand, L.S 1 made using formulated salt mixture of K-citrate and -phosphate which known to be less effective in protein peptidization and thus gives a less value of SN. Adding commercial emulsifying salt as a substitution of citrate and phosphate mixture increased SN of treatments L.S 2 and L.S 3. The data in Table (4) also showed that L.S 4 had slightly higher SN than that of control even the emulsifying salt used is similar. This could be due to the slightly higher SN of LSRCh (Table, 1) in the base formula of L.S 4.

SN gradually increased in all stored processed spread samples. These changes could be the result of enzymatic activity of resistant proteinases. It could be also due to the hydrolysis of emulsifying salts which may cause more solubilization of proteins. These findings are in corrospendance with that reported by **Aly *et al* (1995), Abd El-Hamid *et al* (2000, a), Awad (2003), Awad *et al* (2003).**

Total volatile fatty acids

The total volatile fatty acids (TVFA) of all treatments (Table, 4) indicated that control processed cheese had significantly lower TVFA values compared to LSPS either when fresh or during storage. The higher TVFA in LSPS is due to the incorporation of LSRCh in the blend which has higher TVFA. The results agree with **Lindsay *et al* (1982)** and **Aly (1995).**

Values of TVFA significantly increased during storage of all samples. This could be due to the residual activity of heat-resistant lipases in the base formula which cause the fat hydrolysis. Our findings are coincide with **El-Neshawy *et al* (1987), Aly (1995), Aly *et al* (1995).**

Oil separation

The oil separation index varied significantly among treatments of LSPS with different emulsifying mixtures. These differences are mainly due to the different emulsifying mixtures used. In treatment L.S 1, the salt mixture consistes of K-citrate and -phosphate which are less effective in creaming action and therefore gives a lower emulsification degree. On the other hand, most of commercial applied emulsifying salts, contain short chain polyphosphate which characterized by strong creaming action. Meanwhile, the resultant cheese is in a good state of emulsion and less able to lose fat. Thus, using commercial emulsifying salt or substitution of it in the emulsifying mixture will result in less oil separation compared to citrate or orthophosphate.

Oil separation index of stored samples increased with prolonging the storage period. This could be correlated to the decrease in pH values and the increase in SN which result in lower degree of emulsification and higher fat leakage. The results are in accordance with **Abd El-Hamid *et al* (2000, c), El-Shabrawy *et al* (2002), Awad (2003) and Awad *et al* (2003).**

Cheese meltability

Meltability values of LSPS (Table, 5) indicated that the meltability was significantly higher in low-sodium treatments than control. Among treatments, it was highest in L.S 1 followed by L.S 2 then L.S 3 and L.S 4 was close to control one. These differences could be due to the

Table 5. Oil separation and meltability of low – sodium processed cheese spreads made using blend of ordinary and low sodium Ras cheeses (1:1) with different emulsifying salt mixtures

Treatments	Storage period (at 5°C)			
	Fresh	1 month	2 months	3 months
		Oil separation index		
Control	18.4 Cb	18.8 Cab	19.1 Ca	21.2 Da
L.S 1	31.5 Ac	33.0 Abc	36.5 Ab	41.1 Aa
L.S 2	22.6 Bb	22.7 Bb	24.1 Bab	27.7 Ba
L.S 3	19.8 Cb	20.2 Cb	23.2 Bab	25.2 Ca
L.S 4	18.7 Cb	19.1 Cab	19.9 Ca	22.1 Da
		Meltability (mm)		
Control	114.5 Ca	113.4 Ca	105.1 Bb	91.8 Bc
L.S 1	133.1 Aa	131.0 Aa	119.5 Ab	104.4 Ac
L.S 2	129.7 ABa	128.2 ABa	114.4 Ab	100.3 Ac
L.S 3	122.4 Ba	121.2 Ba	112.6 ABb	96.9 ABc
L.S 4	119.6 BCa	117.0 BCa	106.8 Bb	92.7 Bc

See legend to Table (2) and (4) for details.

differences of cheese base and emulsifying salts. The higher meltability of L.S 1 is mainly due to the emulsifying salt used of 100% of K-citrate and orthophosphate. Both of these salts had very low creaming action and the body of final product well be thin (low viscosity) as in raw cheese (**Meyer, 1973 and Berger *et al* 1993**). Therefore, the cheese spread of these salts is highly meltable than polyphosphate. Consequently, substituting citrate and orthophosphate with commercial emulsifying salt will lead to lower meltability as indicated in treatments L.S 2, L.S 3 and L.S 4 being proportional to substituting ratio. The slightly higher meltability values of L.S 4 than control is due to the LSRCh included in base blend which characterized by slightly higher SN (Table, 1).

The cheese meltability showed a tendency towards decrease along the storage in all samples. This could be due to the changes occured in chemical properties of processed spreads such as pH, protein, emulsifying salt form and product setting. The data agree with **Olson and Price (1961), Abd El-Hamied *et al* (2000, b) and Awad (2003)**.

Firmness

It is well known that penetrometer readings are inversely related to the cheese firmness. Figure (1) indicates that the least penetration value was noticed

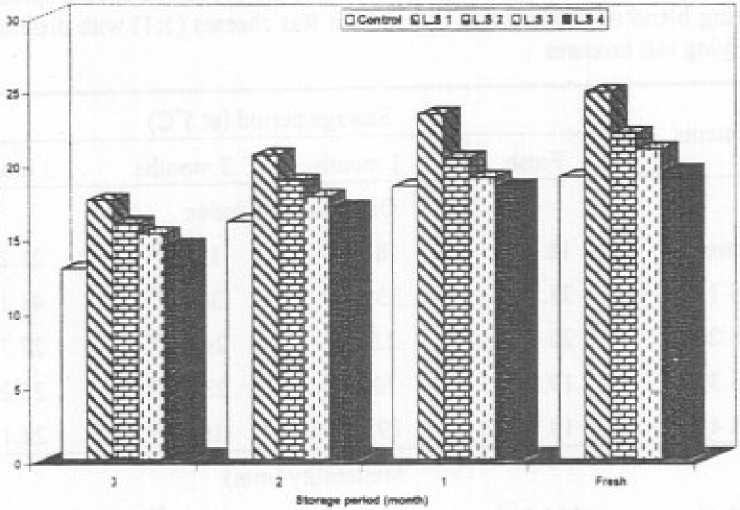

Fig. 1. Penetration values (mm) of low-sodium processed cheese spreads made using blend of ordinary and low sodium Ras cheeses (1:1) with different emulsifying salt mixtures

for control treatment while the highest was noticed with L.S 1 followed by L.S 2, then L.S 3 and lastly L.S 4. This difference is related to the different emulsifying system and its effect on the protein state and emulsification degree in resultant spreads. Commercial emulsifying salt that have been used in control as well as L.S 4 contains polyphosphates which lead to higher creaming action and therefore increase the cheese firmness. On the other hand in low-sodium treatments, commercial emulsifying salt was substituted proportionally with K-citrate and -orthophosphate which has less creaming action and so produce less firm processed cheese. **Aizawa and Yoneda (1990)** reported that firmness increased in processed cheese by adding polyphosphate as emulsifying salt rather than monophosphate and/or citrate. The slight difference between control and L.S 4 is mainly due to the cheese base used since LSRCh contained slightly higher SN that may lead to higher peneteration (lower firmness) in the cheese.

The penetration values in stored processed cheese samples decreased with prolonging the storage period, i.e. the firmness increased. This could be attributed to the changes occurred in chemical properties of final product during storage especially pH value. The data agree with **Younis *et al* (1991), Abd El-Hamid *et al* (2000, c) Awad *et al* (2002) and Awad (2003).**

Viscosity

Apparent viscosity of cheese spreads illustrated in Fig. (2) showed that control possessed the highest viscosity while low-sodium treatments were in the order of L.S 4 > L.S 3 > L.S 2 > L.S 1. Control treatment was made using 100 % commercial emulsifying salts (S_9s + NO, 1:1) which known to have strong creaming action and thus strong moisture absorbing effect. With those properties the resultant processed cheese became more viscous, produce hard body and less melting cheese. Consequently, L.S 4 with same emulsifying system has comparatively high viscosity to other low-sodium treatments. The difference between L.S 4 and control in viscosity is due to the cheese base. Since L.S 4 contained LSRCh that has higher SN content which may lead to lower viscosity. Substitution of commercial salt with K-citrate and K-phosphate as in L.S 1, L.S 2 and L.S 3 which have weak creaming action, i.e. less moisture absorption and therefore produce thin and less viscous processed cheese. Variance in viscosity of LSPS was dependant on the substituting ratio of commercial salt with K-citrate and -phosphate in emulsifying mixture. The results are in agreement with **Meyer (1973), Kirchmeier *et al* (1978), Aizawa and Yoneda (1990), Eckner *et al* (1994), Abd El-Hamid *et al* (2000, c) and Awad *et al* (2004)**. The viscosity value of cheese sample decreased with increasing the viscometer shear rate. This flow behaviour follows the pseudoplastic type and sometimes called "shear thinning" which means that the product gets thin and the viscosity decreased with increasing the shear rates, while the shear stress increased.

Storage of processed cheese spreads up to 3 months resulted in slightly lower viscosity values. This decrease could be attributed to the changes occurred in cheese composition and partial protein degradation. There are several factor can affect the viscosity values in processed cheese such as pH, SN, action of emulsifying salts, state of protein and composition of ingredients used in the formula (**Kirchmeier *et al* 1978; Younis *et al* 1991 and Awad *et al* 2004**).

Sensory evaluation

The sensory evaluation scores of LSPS are presented in Table (6). The score of cheese appearance as well as body and texture showed that treatments of LSPS scored higher and non significant values to control in L.S 3 and L.S 4 while L.S 2 scored slightly lower and L.S 1 scored the least. The body & texture was almost similar in all LSPS to control one except L.S 1 with emulsifying mixture of K-citrate and –phosphate which was significantly lower. Flavour scores indicate that the cheese spreads were highly affected by the ratio of sodium and potassium in resultant product. The aroma and flavour were acceptable in all low-sodium spread formulas being significantly less in L.S 1 which has the highest Na-reduction percent and highest potassium content. **Berger *et al* (1993)** mentioned that potassium phosphates when used as emulsifying salts at high levels give the cheese a bitter taste and this limits its use to such applications as special dietary processed cheese. Therefore, L.S 1, which has the highest amount of potassium, was characterized by slightly bitter taste. The total platability of produced cheese spreads showed that

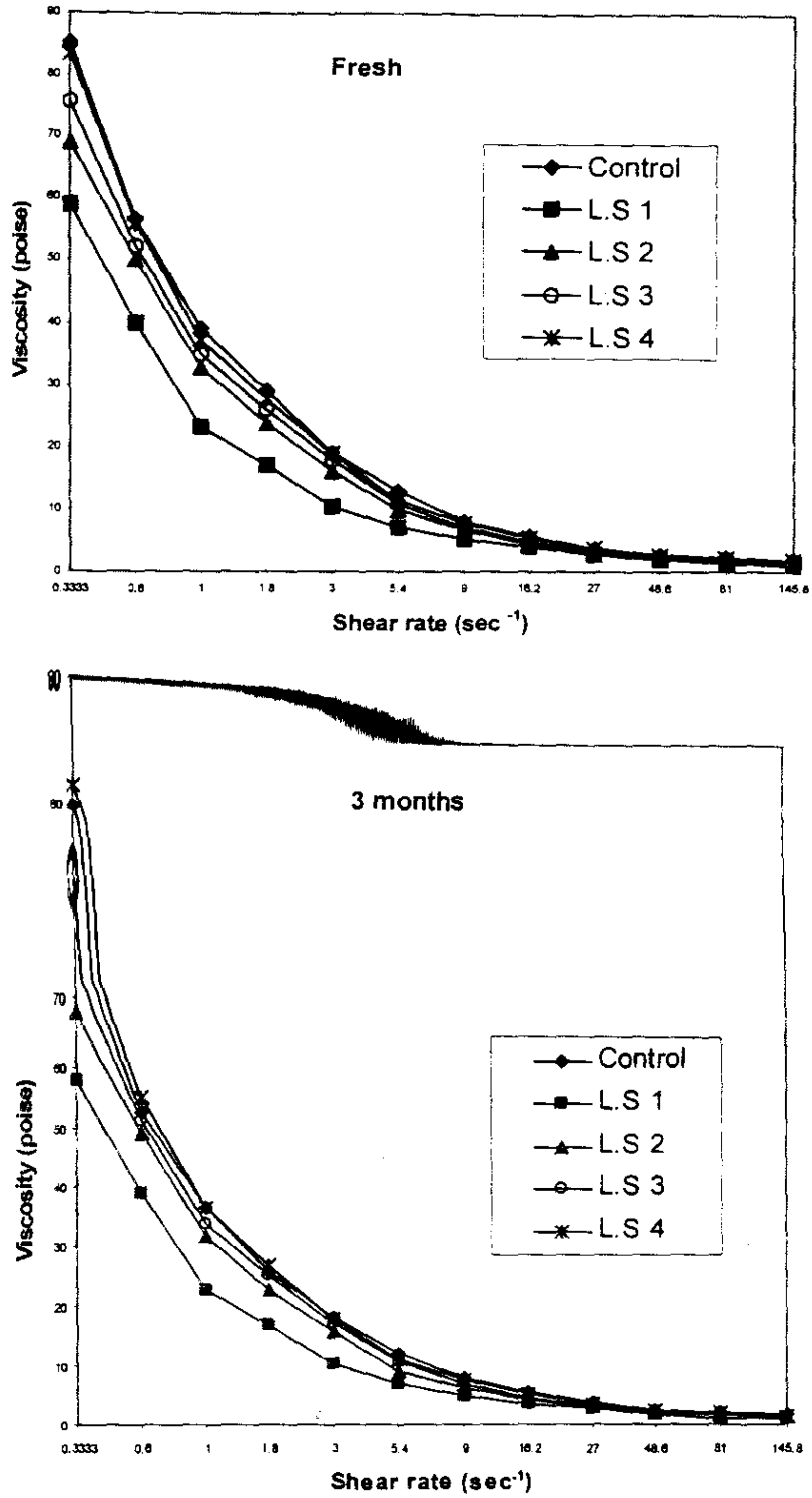

Fig. 2. Viscosity values (poise) at 50°C of low-sodium processed cheese spreads made using blend of ordinary and low sodium Ras cheese (1:1) with different emulsifying salt mixtures, fresh and after 3 months of storage at 5±1°C

Table 6. Sensory evaluation of low-sodium processed cheese spreads made using blend of ordinary and low-sodium Ras cheeses (1:1) with different emulsifying salt mixtures, fresh and during storage at 5±1°C.

Storage period (5°C)	Character assessed	Control	L.S 1	L.S 2	L.S 3	L.S 4
Fresh	O.A. (20)	20^{Aa}	17^{Ba}	19^{Aa}	20^{Aa}	20^{Aa}
	B & T (40)	38^{Aa}	31^{Ba}	37^{Aa}	38^{Aa}	39^{Aa}
	A & F (40)	39^{Aa}	30^{Ba}	37^{Aa}	38^{Aa}	38^{Aa}
	Total (100)	97^{Aa}	78^{Ca}	93^{Ba}	96^{Aa}	97^{Aa}
1 month	O.A. (20)	20^{Aa}	17^{Ba}	19^{Aa}	19^{Aa}	20^{Aa}
	B & T (40)	37^{Aa}	30^{Ba}	37^{Aa}	37^{Aa}	38^{Aa}
	A & F (40)	39^{Aa}	28^{Cb}	35^{Bab}	36^{ABab}	37^{Aab}
	Total (100)	96^{Aa}	75^{Ca}	91^{Ba}	92^{ABb}	95^{Aa}
2 months	O.A. (20)	19^{Aa}	16^{Ba}	19^{Aa}	19^{Aa}	20^{Aa}
	B & T (40)	36^{ABab}	28^{Cb}	35^{Bb}	37^{Aa}	38^{Aa}
	A & F (40)	36^{Ab}	26^{Bc}	35^{Aab}	35^{Ab}	36^{Ab}
	Total (100)	91^{ABb}	70^{Cb}	89^{Bab}	91^{ABb}	94^{Aa}
3 months	O.A (20)	19^{Aa}	16^{Ba}	18^{Aa}	19^{Aa}	18^{Ab}
	B & T (40)	35^{Ab}	27^{Cb}	33^{Bc}	35^{ABb}	36^{Ab}
	A & F (40)	36^{Ab}	26^{Cc}	34^{Bb}	34^{Bb}	36^{Ab}
	Total (100)	90^{Ab}	69^{Cb}	85^{Bb}	88^{Ac}	90^{Ab}

See legend to Table (2) and (4) for details.
O.A.: outer appearance B & T: body & texture A & F: aroma & flavour

LSPS of L.S 2, L.S 3 and L.S 4 were highly acceptable as ordinary full sodium processed cheese. Treatment L.S 1 was significantly differed than other treatments showing lowest acceptability. Furthermore, it could be say that, depending upon how much reduction needed of sodium when substituted by potassium, LSPS with high acceptability can be produced using the formula of L.S 2, L.S 3 and L.S 4.

The organoleptic quality of spreads indicated that processed cheese became slightly less acceptable with extending the storage period. The trend among all treatments including control continued to be same as in fresh samples. Such coincide trend would indicate that addition of potassium instead of sodium in emulsifying system did not affect the platability properties of cheese spreads during storage. These findings are in agreement with **Abd El-Hamid** ***et al*** **(2000, b) and Awad (2003).**

REFERENCES

Abd El-Hamid, L.B.; S.A. El-Shabrawy; R.A. Awad and R.K. Singh (2000, a). Chemical properties of processed Ras cheese spreads as affected by emulsifying salt mixtures. *J. Food Processing and Preservation, 24(3): 191-205.*

Abd El-Hamid, L.B.; S.A. El-Shabrawy; R.A. Awad and R.K. Singh (2000, b). Physical and sensory characteristics of processed Ras cheese spread with formulated emulsifying salt mixtures. *Int. J. Food Properties, 3(1): 15-36.*

Abd El-Hamid, L.B.; S.A. El-Shabrawy; R.A. Awad and R.K. Singh (2000, c). Rheology and microstructure of processed Ras cheese spreads with formulated emulsifying salt mixture. *Int. J. Food Properties, 3(1): 59-75.*

Aizawa, S. and Y. Yoneda (1990). Preparation of melt-resistant process cheese. In Brief communication of the XXIII International Congress, Montreal, October 8-12, vol. II. Brussels, Belgium. c.f. *Dairy Sci. Abst. 54 (2): 827.*

Albernethy, J.D. (1979). Sodium and potassium in high blood pressure. *Food Technol., 33(12): 57-59 & 64.*

Aly, M.E. (1995). An attempt for producing low-sodium Feta-type cheese. *Food Chemistry, 52 (1995): 295-299.*

Aly, M.E.; A.A. Abdel-Baky; S.M. Farahat and U.U.B. Hana (1995). Quality of processed cheese spread made using ultrafilrated retentates with some ripening agents. *Int. Dairy J., 5 (2): 191-209.*

AOAC (1995). *Official Methods of Analysis. 16th Ed., Ch. 33. pp. 58-71.* Dairy products, subchapter 7: Cheese,. Association of Official Analytical Chemists, AOAC international, Arlington, Virginia USA.

Awad, R.A. (2003). Impact of potato puree as a cheese base replacement in the manufacture of processed cheese. *Egyptian J. Dairy Sci., 31(2): 375-387.*

Awad, R.A.; L.B. Abd El-Hamid; S.A. El-Shabrawy and R.K. Singh (2002). Texture and microstructure of block type processed cheese with formulated emulsifying salt mixtures. *Lebensmittel- Wissenschaft und-Technology/ FST, 35(1): 54-61.*

Awad, R.A.; L.B. Abd El-Hamied; A.E. Haggras and O.A. Zammar (2003). Rheological and sensory properties of low fat processed cheese spread with low fat Mozzarella cheese in the base blend. *Egyptian J. Dairy Sci., 31(2): 361-373.*

Awad, R.A.; L.B. Abd El-Hamid; S.A. El-Shabrawy and R.K. Singh (2004). Physical and sensory properties of block processed cheese with formulated emulsifying salt mixtures. ***Int. J. Food Properties, 7(3): 429–448.***

Berger, W.; H. Klostermeyer; K. Merkenich and G. Uhlman (1993). ***Processed Cheese Manufacture, pp. 63-73.*** A JOHA Guide BK Ladenburg. Editor: H. Klostermeyer, Freising, Germany.

Bradley, R.L.; J.E. Arnold and D.M. Barbano (1992). Chemical and physical method. In: ***Standard Method for the Examination of Dairy Products (16th Ed.), pp. 433-531.*** Robert, T. Marchal (ed.) American Public Health Association. Washington, DC, USA.

Dillon, J.C. (1987). Cheese in the diet. In: ***Cheesemaking: Science and Technology, (pp. 499-512).*** A. Eck, ed. Lavoisier Publishing Inc, New York.

Eckner, K.F.; W.A. Dustman, and A.A. Rys-rodriguez (1994). Contribution of composition, physicochemical characteristics and polyphosphates to the microbial safety of pasteurized cheese spreads. ***J. Food Protection, 57 (4): 295-300.***

El-Neshawy, A.A.; A.A. Abdel El-Baky; S.M. Farahat and M.E. Desoky (1987). Cheese curd slurry in the manufacture of processed cheese spread. **Egyptian J. Dairy Sci., 15(2): 287-297.**

El-Shabrawy, S.A.; R.A. Awad and S. A. Saad (2002). Manufacture and properties of flavours processed cheese spread with different fruit flavour. ***Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo. 10(2): 641-657.***

FAO (1980). Soil and Plant Testing and Analysis. ***Soil Bulletin 38 / 2. p. 250.*** Cottenie, A.(ed.), Rome.

Forsythe, R.H. and R.A. Miller (1980). Salt in processed foods. In: ***Biological and Behavioral Aspect of Salt Intake, pp. 221-228.*** (Kare, M. R.; N. J. Fregly and R. A. Bernard, eds.) Academic Press. New York.

Guinee T.B. and P.F. Fox (1993). Salt in Cheese: Physical, Chemical and Biological Aspects. In: ***Cheese Chemistry Physics and Microbiology, 2nd Ed.***, **Vol. (1): 257-301.** Fox, P.F. ed., Chapman and Hall, London, UK.

Hofi, A.A.; E.H. Youssef; M.A. Ghoneim and G.A. Tawab (1970). Ripening changes in Cephalotyre "Ras" cheese manufactured from raw and pasteurized milk with special references to flavour. ***J. Dairy Sci., 53 (9): 1207-1211.***

IFT (1980). Dietary salt: A scientific status summary by the Institute of Food Technologists' expert panel on food safety and nutrition and the committee on public information. ***Food Technology, 34 (1): 85-91.***

Kirchmeier, O.; G. Weiss and F. Kiermeier (1978). Influence of different phosphates on the flow properties of processed cheese. Zeitschrift fur Lebensmittel – Umtersuchung und Forschung 166 (4) 212 – 220, c.f. ***Dairy Sci. Abst. 40 (11) : 6868.***

Koiskowski, F.V. (1982). ***Cheese and Fermented Milk Foods. 2nd Ed. pp. 560-597.*** Kosikowski F.V. and Associates, Brooktonale, New York..

Lindsay, R.C.; S.M. Hargett and C.S. Bush. (1982). Effect of sodium potassium (1:1) chloride and low sodium chloride concentration on quality of Cheddar cheese. ***J. Dairy Sci., 65 (3): 360-370.***

Ling, E.R. (1963). ***A Text Book of Dairy Chemistry 3rd Ed. Vol. 2.*** practical, **pp.76 -98.** Chapman and Hall. Ltd London, UK.

Meyer, A. (1973). ***Processed Cheese Manufacture. 1st Ed. pp. 30-276.*** Food Trade Press. Ltd., London, UK.

Olson, N.F. (1982). Effects of sodium reduction on natural cheeses. ***Dairy Field, 165 (6): 48, 50, 78.***

Olson, N.F. and W.V. Price (1961). Composition and bacterial growth as factors affecting the body of pasteurized process cheese spread. ***J. Dairy Sci., 44 (7): 1394-1399.***

Rayan, A.; M. Kalab and C.A. Ernstorm (1980). Microstructure and rheology of pasteurized process cheese. ***Scanning Electron Microscopy, 41(3): 635-643.***

SAS institute (1990). ***SAS User's Guide/ STAT Ver. 6.04 4th Ed.*** SAS Inst. Inc. Cary, NC.

Schenz, T.W. and C.V. Morr (1996). Viscosity, In: ***Methods of Testing Protein Functionally,*** **pp. 61-75.** Hall, G. M. ed. Blackie Academic and Professional, London, UK.

Shank, F.R.; K.P. Youngmee; B.F. Harland; J.E. Vanderbeen; A.L. Forbes and L. Prosky (1982). Perspective of Food and Drug Administration on dietary sodium. ***J. American Dietetic Association, 80(1): 29-35.***

Thomas, M.A. (1973). The use of a hard milk fat fraction in processed cheese. ***Aust. J. Dairy Technol., 28(2): 77-80.***

Younis, M.F.; A.Y. Tamime; G. Daves; E. A.Hunter; A.H. Dawood and S.M. Abdou (1991). Production of processed cheese using Cheddar cheese and cheese base. 3. compositional quality. ***Milchwissenshaft, 46 (9): 566-569.***

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تقييم أفضلية وخواص مفرودات الجبن المطبوخ منخفض الصوديوم

[١٦]

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تم عمل مفرودات من الجبن المطبوخ منخفض الصوديوم باستخدام خليط من الجبن الراس العادي والمنخفض الصوديوم بنسبه (١ : ١) مع استعمال نظم مختلفة من أملاح الاستحلاب. وقد تم تحليل الجبن الناتجة كيماويا وهي طازجة من حيث محتواها من الملح والرماد والعناصر المعدنيه. كما تم تقييم الخواص الطبيعية والحسية وتقدير الأحماض الدهنية الطيارة والنتروجين الذائب وقيم الرقم الهيدروجيني في عينات من الجبن الطازجة وكذلك أثناء التخزين شهريا على درجة ٥°م حتى ٣ اشهر. أظهرت النتائج أن الجبن المطبوخ منخفض الصوديوم يحتوى على نسب اقل من الملح والرماد والصوديوم مع ارتفاع محتواها من الكالسيوم والأحماض الدهنية الطيارة. وأدى وجود ٥٠% من الخلطة الأساسية على صورة جبن رلس منخفض الصوديوم في ظل وجود ملح الاستحلاب التجاري إلى نقص في الصوديوم بنسبه ٣٧,٨٧% وعند استبدال ملح الاستحلاب بملح بوتاسيومي زاد الانخفاض في نسبه الصوديوم إلى ٦٧,٥٤% معتمدا على نسبه الاستبدال. تأثرت قيم الرقم الهيدروجيني والنتروجين الذائب بنوع الجبن في الخلطة الأساسية وكذلك نظام الاستحلاب المستخدم. أظهرت الجبن المطبوخة منخفضة الصوديوم قيم اقل في الصلابة وفي اللزوجة وكانت أكثر انصهاراً ولها ميل أكبر لفصل الدهن بالنسبة لجبن المقارنة. وأوضحت اختبارات التفضيل أن استبدال الصوديوم بالبوتاسيوم كان له تأثير معنوى على درجة تقبل الجبن الناتج. ومن نتائج الدراسة فأنة يمكن الحصول على جبن مطبوخ منخفض الصوديوم بدون فروق معنوية باستخدام خليط من الجبن الراس العادي والمنخفض الصوديوم بنسبه (١ : ١) في الخلطة الاساسية وكذلك مع استبدال الصوديوم بالبوتاسيوم في نظام الاستحلاب مع مراعاة أن تكون نسبه البوتاسيوم/ الصوديوم في الناتج النهائي أقل من ١. وقد أدى تخزين الجبن المطبوخ إلى انخفاض في قيم الرقم الهيدروجيني ، الانصهار والتحكيم الحسي بينما زاد قيم النتروجين الذائب والأحماض الدهنيه الحرة وفصل الدهن والصلابة في العينات.

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