Production and Evaluation of Processed Cheese Analogue Using Ricotta Cheese Prepared from Sweet Whey

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ABSTRACT

Spreadable processed cheese analogue was prepared by replacing 2.5, 5 and 7.5% of skim milk powder with 9.22, 18.44 and 27.7 of Ricotta cheese, respectively. The obtained results showed that it is possible to successively use Ricotta cheese as an ingredient for processed cheese manufacturing with good flavour and acceptability. Production of processed cheese analogue with addition of Ricotta cheese significantly increased the total nitrogen, soluble nitrogen, fat and ash as compared with the control. At the same time, lactose content was significantly decreased comparing with the control. However, total solids, salt contents and pH values in all treatments were changed within a narrow range where the variations were not significant. Storage of cheese for 60 days showed a general trend of increment in all components ratios except lactose where the ratios were decreased. The texture of processed cheese analogue improved with adding Ricotta cheese. Replacement of skim milk powder at ratios of 2.5 and 5% with Ricotta cheese did not alter the colour, taste and overall acceptability while the 7.5% revealed the lowest acceptability by the panel-lists. Therefore, producing processed cheese analogue can be made with addition of Ricotta cheese up to 18.44% with satisfied sensory attributes.

Key words: Ricotta cheese, processed cheese, whey protein.

INTRODUCTION

Processed cheese enjoys great popularity all over the world, because of its favorable texture and taste and easy to handle, easy to eat, attractive to all ages, kids, teenagers and senescent (Uhluman, 1985).

According to the last published FAO Statistical yearbook in 2014, the Egyptian milk production was 5.8 million tons and cheese production was 644 thousand tons (statistics of 2011). Processed cheese is an important segment of this production.

Processed cheese is a dairy product which differs from natural cheese in the fact that it is not made directly from milk. However, the main ingredient of processed cheese is natural cheese. Processed cheese is produced by blending natural cheese of different ages and degrees of maturity in the presence of emulsifying salts and other dairy and non-dairy ingredients followed by heating and continuous mixing (processing) to form a homogeneous product with an extended shelf life (Meyer, 1973, Thomas, 1973, Caric *et al*.,1985, Guinee *et al*., 2004).

Processed cheese could be as blocks, portions, slices, spreadable, plain or flavoured, sterilized or conventional or even in the dry form. Processed cheese can easily made using simple ingredients such as cheese and with addition of water and melting salts, or from a complex mix of ingredients including different types of proteins, fat, gums, stabilizers, flavourings and added minerals (Lee *et al.*, 2003).

Nowadays manufacturers also use other dairy ingredients, such as whey, buttermilk, butterfat, casein, caseinates, whey proteins, and non-dairy hydrocolloids. Processed cheese analogues can be produced using other non-dairy ingredients such as vegetable oil and non-dairy proteins (Caric & Kaláb, 1997).

In Egypt, the production of processed cheese is a vital sector in the Egyptian dairy industry in order to meet the growing demand of this product. Several brands of processed cheeses are available in the Egyptian market. Processed cheese products are generally manufactured by blending of shredded natural cheeses (mainly mature Cheddar

cheese and young Ras cheese) in addition to skim milk, caseinates, whey protein concentrate as other sources of milk protein and addition of vegetable oils (Abd El Salam *et al.,* 2005, Abou-Donia, 2006).

The Egyptian standards committee covers two main types of processed cheese, the first is the products based on milk-derived ingredients and the second regulates the use of products containing vegetable oils (Egyptian Standards, 2002).

Different categories of whey are available to be included in the processed cheese manufacturing, "sweet" whey (pH ≥ 5.8) obtained from Cheddar, Mozzarella, and other similar cheeses or rennet casein production, "medium" acid whey (pH 5.0 to 5.8) obtained from the production of fresh acid cheeses such as Danbo, Queso Blanco, and other similar cheeses, and "acid" whey (pH < 5.0) obtained from the manufacture of fresh acid cheeses like Quarg, Cottage cheese, Cream cheese (Gallardo-Escamilla *et al.,* 2005, Wright *et al.,* 2009).

From the nutritional point of view, cheese whey has a high nutritional added value (Vasala *et al.,* 2005, Prazeres *et al.,* 2012).

Using salted whey in processed cheese enhances the palatability, reduce the production cost and reduce the problems related to salt whey in the environments (Awad *et al.*, 2013).

Due to the high cost of fresh milk and skim milk powder in Egypt, which ultimately increases the cost of milk products, other alternatives are currently being sought in order to process nutritionally acceptable processed cheese.

The objectives of this study are: Production of spreadable processed cheese analogue using Ricotta cheese prepared from sweet whey of Mozzarella cheese. Also, evaluate the physicochemical, rheological and sensorial characteristics of the prepared cheese as fresh and after 60 days of storage at 5ºC.

MATERIALS AND METHODS

Materials

Ras cheese (aged 4 months) was obtained from the pilot plant of Agricultural Secondary School, Damanhour, Behera Governorate with the following chemical analysis:

Table 1: Chemical composition and pH of Ras cheese

Component	(%)
Moisture	35
Total nitrogen	3.89
Fat	36.0
Salts	2.3
pH	4.7

Skim milk powder (SMP), a product of Denmark (Dano), with the following chemical composition:

Table 2: Chemical composition of skim milk powder

Component	(%)
Dry matter	96.0
Total nitrogen	5.88
Fat	1.25
Lactose	51.00
Minerals	6.25

Mozzarella cheese whey was obtained from the pilot plant of Agricultural Secondary School, Damanhour, Behera Governorate with the following chemical composition:

Table 3: Chemical composition and pH of Mozzarella cheese whey.

Component	(%)
Dry matter	6.90
Total nitrogen	0.17
Fat	0.60
Lactose	4.63
Ash	0.54
pH	6.00
Acidity	0.22

Butter fat, a product of Newzealand, Margarine (with trade name "Fern") a product of Newzealand and packed by IFFCO Egypt, Attaqa, Suez, Egypt. JOHA emulsifying salt (JOHA S9 special) was obtained from BK Ladenburg corp., GmbH, Germany.

Anato solution and potassium sorbate (food grade) were obtained from pilot plant of Agricultural Secondary School, Damanhour, Behera Governorate.

Starch El-Watanya for corn products-Ramadan 10th, Egypt. Citric acid anhydrous, food grade and sodium chloride edible grade were obtained from El Nasr Company, Egypt.

Methods

Preparation of Ricotta cheese:

Ricotta cheese was prepared as described by Mahran *et al.* (1999). Mozzarella cheese whey was heated to 90°C for 1 hr in an open kettle, and then acidified with acetic acid to obtain pH of 5.4 to coagulate (coprecipitate) whey proteins and casein. The coagulated curd mass was left in the whey for 10 mins and then scooped in cheesecloth and hanged for 15 mins to drain whey. The obtained Ricotta cheese in cheesecloth was placed over a drainage table and allow to achieve complete drainage at room temperature for 90 mins. the Ricotta cheese was then transferred to a stainless tray and kept in refrigerator overnight. The cheese was weighed to calculate the yield.

Chemical composition of Ricotta cheese is as shown in Table (4).

Table 4: Chemical composition and pH of Ricotta cheese

Component	(%)
Dry matter	27.1
Total nitrogen	2.59
Fat	5.30
Lactose	3.94
Ash	0.97
pH	4.70
Acidity	1.32
Yield	5.48

Processed cheese manufacture

Three treatments plus control of spreadable processed cheese analogue were prepared according to Muir *et al.* (1999**)** using the ingredients mentioned before. All ingredients without citric acid were placed in the cooker and mixed well at 50°C for 5 mins and then pH value was adjusted to 5.8 by addition of the required amount of citric acid. The melted mixture was cooked at 90°C for 10 mins and packed in plastic containers (120g). The containers were kept at refrigeration temperature (6°C) until used. Representative samples were taken for analysis at zero time and after 60 days of storage at refrigeration temperature.

Physicochemical analysis

Total solids and ash content were determined as described in the AOAC (1990).Total and soluble nitrogen were determined by Kjeldahl method (AOAC, 2000). Fat content was determined by Gerber method (AOAC, 2000). pH value was measured using a digital glass electrode pH meter (HANNA HI9321 microprocessor). Salt content was determined using the modified Volhard's method as described by Kosikowski (1966). Lactose content was determined according to Acton (1977).

Table 5: Ingredients incorporated in the processed cheese blends calculated as percentage

Ingredients	Control	T_1	T_2	T_3
H_2O	53.6	46.9	40.2	33.5
Margarine	12.5	12.5	12.5	12.5
Butter	3.00	3.00	3.00	3.00
Dried skim milk	10.0	7.50	5.00	2.50
Emulsifier	2.50	2.50	2.50	2.50
NaCl	0.75	0.75	0.75	0.75
Citric acid	0.15	0.15	0.15	0.15
Starch	2.50	2.50	2.50	2.50
Ras Cheese	15.0	15.00	15.00	15.00
K. Sorbate	0.50	0.50	0.50	0.50
Anato	0.002	0.002	0.002	0.002
Ricotta cheese	----------	9.22 = (2.5 DM+6.72 water)	18.44 = (5 DM+13.44 water)	27.7 = (7.5DM+20.2 water)
Total	100	100	100	100

Rheological properties

Meltability

Meltability of cheese was measured in duplicate by using the melting test as described by Olson and Price (1958) with the modification of Rayan *et al.* (1980). A cylinder of cheese sample (15±0.2g) was put in a Pyrex glass tube, 30 mm in diameter and 250 mm long and a reference line was marked on the tube aligned with the front edge of the cheese sample. The tube was immediately placed in horizontal position in an oven at 110ºC for 30 mins. The distance of flow from the reference line to the leading edge of the melted cheese was quickly measured and recorded in mm as cheese meltability .

Oiling-off

The fat leakage method as described by Ghosh & Singh (1992b) was used to determine the oiling-off percentage. Four cheese disks (25 mm in diameter and 4 mm thick) for each treatment were placed on a Whatman No.42 filter-paper and placed in an atmospheric oven at 100ºC for 10 mins. The area of each oily ring was measured with a planimeter (Ushikata , electronic digital planimeter 220L, with read unit No. 96737, Tokyo, Japan). Oiling-off was recorded by comparing the area of fat leakage with the area around the original disk.

Textural properties

Textural properties of processed cheese were determined using the Texture Profile Analyzer (TPA) TA1000, CNS-Farnell, England. Samples for texture profile analysis (TPA) were obtained from the middle of the whole cheese block to avoid surface effects. The test was performed using the TA 17 probe (30° and 25 mm diameter) and operated at a crosshead speed of 1 mm.s−1 and penetration distance of 10 mm. Hardness, cohesiveness, springiness and chewiness were evaluated in triplicate according to the definitions given by IDF (1991).

Organoleptic properties

Spreadable processed cheeses were organoleptically evaluated by 10 staff members at the Department of Dairy Science and Technology, Faculty of Agriculture, Alexandria University and the Department of Food & Dairy Science and Technology, Faculty of Agriculture, Damanhour University. The score card was designed in the light of the score card suggested by the Scheme of Meyer (1973) as follows: Appearance (20 points), body and texture (40 points) and flavour (40 points), which give total score of 100 points.

Statistical analysis

Statistical analysis was performed using the statistical analysis systems (SAS, 2013) software (version 9.3, Cary, NC, USA, 2013).Analysis of variance (ANOVA) was used at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Physicochemical properties of prepared processed cheese analogue

Chemical composition of prepared processed cheese was shown in Table (6). The data showed that addition of Ricotta cheese proportionally and significantly increased the total nitrogen by 6.8, 15.4 and 22.4%, soluble nitrogen by 70.4, 139.6 and 210%, fat by 2.8, 5 and 7.8% and ash by 2.26, 7.77 and 11.65% in T1, T2 and T3,, respectively as compared with the control. At the same time, lactose content was significantly decreased by 18, 36 and 35.6% in T1, T2 and T3, respectively comparing with the control. However, total solids, salt contents and pH values in all treatments were changed within a narrow range where the variations were not significant. The observed data were expected since the quantities of Ricotta cheese (9.22, 18.44 and 27.7g) which displaced 2.5, 5 and 7.5g skim milk powder in T1, T2 and T3, respectively were always higher in protein and fat content and lower in lactose content than the displaced quantities of skim milk powder.

During storage period (up to 60 days), there was a general trend of increment in all components except lactose. By the end of storage period, total solids were increased by 1.17, 0.58, 0.57 and 0.85% for the control, T1, T2 and T3,, respectively. It could be attributed to the slight loss of moisture during storage. In accordance, the increment in total nitrogen was 1.26, 2.72, 1.75 and 1.02%, soluble nitrogen 5.66, 4.06, 2.89 and 2.43%, fat 1.11, 0.54, 2.12 and 1.03%, salt 2.04, 3.06, 2.0 and 2.02% and ash 3.2, 2.8, 4.8 and 0.9% in control and T1, T2 and T3, respectively. The decrease of lactose content (3.5, 4.3, 4.9 and 4.9% in control and T1, T2 and T3, respectively) at the end of storage period. These results are consistent with those of Emara (1984), Abd EL-Baky *et al.* (1987), EL- Neshawy

Table 6: Chemical composition and pH of prepared processed cheese analogue using Ricotta cheese

Treatments / Storage period (days)	Control		T1		T2		T3		SED
	0	60	0	60	0	60	0	60	
T S %	34.2^{a}	34.6^{a}	34.5^{a}	34.7^{a}	34.7^{a}	34.9^{a}	35.0^{a}	35.3^{a}	0.2
T N %	1.24^{g}	1.26^{fg}	1.33^{ef}	1.36^{de}	1.43^{cd}	1.46^{bc}	1.52^{ab}	1.45^{a}	0.015
S N%	0.25^{d}	0.26^{d}	0.42^{c}	0.44^{c}	0.60^{b}	0.61^{b}	0.77^{a}	0.79^{a}	0.004
Fat %	17.90^{e}	18.10^{de}	18.4^{cde}	18.5^{cd}	18.80^{bc}	19.20^{ab}	19.30^{ab}	19.50^{a}	0.1
Salt %	0.98^{a}	1.00^{a}	0.98^{a}	1.01^{a}	1.00^{a}	1.02^{a}	0.99^{a}	1.01^{a}	0.008
Ash %	3.09^{c}	3.19^{bc}	3.16^{bc}	3.25^{abc}	3.33^{ab}	3.46^{a}	3.45^{a}	3.48^{a}	0.05
Lactose%	5.39^{a}	5.20^{a}	4.42^{b}	4.23^{b}	3.45^{c}	3.28^{c}	3.47^{d}	3.30^{d}	0.09
pH	5.43^{a}	5.33^{ab}	5.35^{ab}	5.29^{ab}	5.39^{ab}	5.26^{ab}	5.36^{ab}	5.23^{b}	0.039

Control: processed cheese analogue made using 0% of Ricotta cheese, T1: processed cheese analogue made using 9.22% of Ricotta cheese, T2: processed cheese analogue made using 18.44% of Ricotta cheese, T3: processed cheese analogue made using 27.7% of Ricotta cheese. T S%: total solids %, T N %: total nitrogen, S N %: soluble nitrogen, SED: Standard Error of Difference.

Within the same column, numbers with the same superscript letter were not significantly different (Tukey multiple comparison post-hoc test P< 0.05), n=3.

et al. (1987), Aly *et al.* (1995) who stated that during storage at refrigerator or room temperature, there were no marked changes in moisture, fat and salt contents of processed cheese.

Addition of Ricotta cheese was markedly elevated soluble nitrogen in all treatments in comparison with the control. Over the storage period, soluble nitrogen content was increased due probably to the activity of some residual enzymatic activity of resistant proteinases present in the product. It could be also due to the hydrolysis of polyphosphate in emulsifying salts which caused more solubilization of proteins. These results are in agreement with those reported by Awad (2003), Awad & Salama (2010a, b). The increment of soluble protein due to storage was not significant.

Storage of cheese led to insignificant slight decrease in all pH values. This can be attributed to the pH adjustment of the formulas before cooking process. The decrease in pH during storage could be related to the hydrolysis occurred in emulsifying salts and their interaction with proteins Awad (2003), Awad *et al*. (2003), Awad & Salama (2010a, b).

Rheological properties

Meltability and oil separation of prepared cheese have been shown in Table (7).

Meltability

Meltability is the capacity of cheese particles to flow together and form a uniform continuous melt. Melting is an important character which use to determine the resistance of processed cheese

Table 7: Meltability and oil separation of prepared processed cheese analogue using Ricotta cheese

Treatment	Meltability (mm)		Oil Separation	
Storage (days)	0	60	0	60
Control	22.53^{a}	21.97^{ab}	6.80^{bcd}	8.63^{a}
T1	21.80^{ab}	21.23^{abc}	6.07^{de}	7.50^{b}
T2	21.27^{abc}	20.90^{bcd}	5.47^{ef}	7.03^{bc}
T3	20.10^{cd}	19.63^{d}	5.10^{f}	6.63^{cd}
SED	0.28		0.158	

Control: processed cheese analogue made using 0% of Ricotta cheese, T1: processed cheese analogue made using 9.22% of Ricotta cheese, T2: processed cheese analogue made using 18.44% of Ricotta cheese, T3: processed cheese analogue made using 27.7% of Ricotta cheese. SED: Standard Error of Difference.

Within the same column, numbers with the same superscript letter were not significantly different (Tukey multiple comparison post-hoc test P< 0.05), n=3.

against changes of temperature during transportation and storing. Therefore, as meltability decreased the quality of processed cheese improved (Abbas, 2003). The results in Table (7) showed that meltability values of cheese contained Ricotta cheese were significantly decreased proportionally with the increasing of Ricotta cheese ratio and as it compared with the control. After 60 days of cold storage the meltability values were significantly decreased comparing with the fresh cheese and as it compared with its control.

Cold storage led to decrease in meltability of cheese because of the changes occurred in chemical properties of spreadable processed cheese such as pH, protein state, and product setting (Olson & Price, 1958, Abd El-Salam *et al.*,1996, Abd El-Hamid *et al.*, 2000c, Awad *et al.*,2003, 2004, Mohamed, 2004 & Awad and Salama, 2010a, b).

The obtained results revealed that addition of Ricotta cheese to the blend of processed cheese improved the melting property, as well as storage at refrigeration temperature for 60 days has no negative effect on meltability of cheese.

Oiling-off

Oiling-off is the separation of fat in an oil form from the cheese mass. It is a serious defect where the cheese loses its homogeneity and the separated oil going to rapid deterioration. Oiling-off values (Table 7) of fresh processed cheese made with Ricotta cheese were significantly reduced with the successive addition of Ricotta cheese. It was reduced by 10.7, 19.6 and 25.0% for T1, T2 and T3, respectively comparing with the control. The same trend was obtained for the stored cheese. It was reduced by 13.1, 18.5 and 23.2% for T1, T2 and T3, respectively comparing with the control. On the other hand, cold storage led to significant increase in the amount of the separated oil in comparison with the values of fresh cheese. It was increased by 26.9, 23.5, 28.5 and 30% for the control, T1, T2 and T3, respectively. Therefore, the addition of Ricotta cheese improved the resistance of cheese against the defect of oil separation. Improving effect of added Ricotta cheese may be attributed to the nature of whey proteins that affect the emulsification degree of the product, while the negative effect of cold storage that led to increasing of the free oil may due to the corresponding changes in pH value and SN content during storage. Many investigators found that the oil separation index of stored samples increased with prolonging of storage period (Abd El hamid *et al.,* 2000c, El-Shabrawy *et al.,* 2002, Awad, 2003, Awad *et al*., 2003, 2004 & Awad and Salama, 2010 a, b).

Texture Profile Analysis

Texture profile analysis is shown in Table (8).

Hardness

Hardness (g) of cheese is the force required to bite completely through the cheese sample when placed between molars (Gunasekaran & Mehmet, 2003). In the texture analyzer, it is the peak force during the first compression (force required for a pre-determined deformation). Hardness of processed cheese, in particular, is an attribute directly correlates with the moisture content, fat content, pH, emulsifying salt and the type and properties of natural cheese incorporated in the blend.

Table 8: Texture profile analysis (TPA) of prepared processed cheese analogue using Ricotta cheese

Treatments	Control		T1		T2		T3		SED
Storage period (days)	0	60	0	60	0	60	0	60	
Hardness (g)	1136.8^{e}	1316.6^{dc}	1219.2^{de}	1405.8^{c}	1384.0^{c}	1554.6^{ab}	1436.5^{bc}	1606.5^{a}	24.55
Springiness(mm)	0.962^{a}	0.945^{bc}	0.954^{ab}	0.945^{bc}	0.936^{dc}	0.926^{de}	0.925^{de}	0.919^{e}	0.0027
Adhesiveness (g.sec^{-1})	-1255.0^{bcd}	-1151.0^{a}	-1275.6^{cd}	-1169.8^{ab}	-1324.3^{d}	-1239.1^{bc}	-1512.3^{e}	-1439.5^{e}	17.4
Cohesiveness(ratio)	0.655^{a}	0.647^{a}	0.625^{b}	0.609^{b}	0.588^{c}	0.573^{cd}	0.576^{cd}	0.569^{d}	0.0038
Resilience	0.143^{a}	0.136^{ab}	0.136^{ab}	0.131^{ab}	0.131^{ab}	0.126^{b}	0.109^{c}	0.102^{c}	0.0026
Gumminess (g.sec^{-1})	1190.5^{a}	1217.7^{a}	1023.9^{b}	1061.9^{b}	826.4^{c}	849.1^{c}	710.9^{d}	743.0^{d}	13.6
Chewiness (g.mm)	1177.3^{a}	1116.4^{ab}	1047.8^{bc}	999.8^{c}	863.8^{d}	819.7^{de}	754.9^{e}	732.6^{e}	18

Control: processed cheese analogue made using 0% of Ricotta cheese, T1: processed cheese analogue made using 9.22% of Ricotta cheese, T2: processed cheese analogue made using 18.44% of Ricotta cheese, T3: processed cheese analogue made using 27.7% of Ricotta cheese. SED: Standard Error of Difference.

Within the same column, numbers with the same superscript letter were not significantly different (Tukey multiple comparison post-hoc test $P< 0.05$), n=3

In the present study, hardness of both fresh and stored cheese was significantly increased with the addition of Ricotta cheese. As the Ricotta cheese ratio increased, the hardness of cheese increased. At the same time, cold storage of cheese led to significant increment of hardness comparing to the fresh one. Fox *et al*. (2000) reported that the increase of whey protein content increases the hardness of cheese. Moreover, the increase of hardness of stored cheese may be due to decrease in moisture content and less availability of water during storage, consequently loss of texture integrity generating by proteolysis activities (Awad *et al*., 2006).

Springiness

Springiness (mm) or elasticity of cheese is defined as a degree at which the cheese sample goes back to its original shape after partial compression between the tongue and palate (Meullent *et al.,* 1997). In the texture analyzer, it is the height that food recovers.

The results of springiness showed significant differences between the control and treatments, for fresh and stored cheese. Springiness tended to decrease as the ratio of Ricotta cheese increased in fresh and stored cheeses. Springiness values were relatively low comparing with the average values of springiness of processed cheese. The results revealed that addition of Ricotta cheese had little effect on the springiness of examined cheese and agree with the results of adhesiveness.

Adhesiveness

Adhesiveness ($g.sec^{-1}$) of cheese is the work required for pulling a cheese sample away from a surface (Civille & Szczesniak, 1973). In the texture analyzer, it is the work necessary to pull the compressing plunger away from the sample (Work required to overcome the sticky forces between the sample and the probe). Adhesiveness is a negative value, as it increases in the negative side as the adhesiveness is greater and the sample is sticky.

The results obtained in the present study showed values on the negative side for all samples with increasing trend as the ratio of Ricotta cheese increased. Fresh or stored cheese has a high adhesiveness value which means high stickiness with significant differences among treatments in comparison with the corresponding control and the differences between fresh and stored cheese were also significant.

Cohesiveness

Cohesiveness (no unit) is the intermolecular attraction by which the elements of a body are held together (Strength of internal bonds in the sample). The results showed no significant decrease in the cohesiveness values with the increase of Ricotta cheese ratio in both fresh and stored processed cheese. The decrease of cohesiveness may lead to increase of stickiness as this appeared in higher adhesiveness with the increasing of Ricotta cheese ratio.

Resilience

Resilience is the tendency of the cheese to recover to its original dimensions upon removal of the applied force (Kapoor & Metzger, 2008). The results showed very slight decrease in the resilience values with the increase of Ricotta cheese ratio in both fresh and stored processed cheese. Resilience values refer to high elasticity of cheese although high elasticity in processed cheese is not favorable attribute particularly spread processed cheese because the elastic body impairs the spreadability of cheese.

Gumminess

Gumminess ($g.sec^{-1}$) is the energy needed to disintegrate a semisolid food until it is ready to swallow. The data revealed that the addition of Ricotta cheese led to significant decrease in gumminess values in both fresh and stored cheese while the differences between fresh and the corresponding stored cheese were not significant. Difference between control samples and T1 was very small where the differences between the control samples and T2, T3 were considerably high.

Chewiness

Chewiness (g.mm) is the energy needed to chew a solid food until it is ready for swallowing. In the texture analyzer, it is the work necessary for a double compression (Bourne, 1978). Chewiness values tended to be decreased with the addition of successive amount of Ricotta cheese in either fresh or stored processed cheese. All differences among the samples were significant.

As a conclusion, despite some significant differences between treatments and the control, the results of the texture profile analysis indicated that the displacement of dried skim milk by Ricotta cheese with the applied ratios had no considerable influence on the texture characteristics of the prepared processed cheese. These results can be attrib-

uted to the nature of processed cheese composition and its industrial technology that it contains many ingredients from several sources, dairy and non-dairy sources which do not make great difference if one dairy ingredient replaced by another one with accepted ratios. Therefore, processed cheese has a great flexibility towards its rheological and texture properties as the cheese blends are very variables and may contain many ingredients and produced with high quality.

Sensory evaluation

Sensory evaluation was carried out at zero time, as well as at the end of storage period (60 days). The results are shown in Table (9). Panelists found that processed cheese containing Ricotta cheese was softer than control cheese (containing less % of whey protein) at zero time and the end of storage period. The processed cheese containing 18.44% Ricotta cheese (T2) had higher scores of texture and general acceptability than control processed cheese. However, the processed cheese containing 2.5% (DM) or 9.22% Ricotta cheese (T1) received the highest scores in flavour at zero time and at the end of storage period. Storage period had reducing effect on all parameters of sensory evaluation. Acceptability of all processed cheese was reduced with the progress of storage period (Aly *et al.*,1995, Awad *et al.*, 2004 and Awad & Salama 2010a, b).

Table 9: Sensory evaluation of prepared processed cheese analogue using Ricotta cheese

Treatments	Control		T1		T2		T3		SED
Storage period (days)	0	60	0	60	0	60	0	60	
Flavour (40)	25.2^{c}	24.0^{c}	35.0^{a}	32.8^{a}	29.6^{b}	28.0^{b}	25.0^{c}	23.6^{c}	0.50
Body & Texture (30)	26.4^{ab}	24.6^{bcd}	22.4^{ed}	20.8^{e}	27.2^{a}	25.6^{abc}	26.4^{ab}	23.8^{cd}	0.54
Appearance (10)	8.0^{a}	7.0^{abc}	7.2^{abc}	6.4^{c}	7.8^{ab}	6.6^{bc}	7.8^{ab}	6.2^{c}	0.27
General acceptability (20)	14.0^{bc}	12.4^{cde}	12.4^{cde}	11.0^{e}	17.4^{a}	14.4^{b}	13.4^{bcd}	12.0^{de}	0.39

Control: processed cheese analogue made using 0% of Ricotta cheese, T1: processed cheese analogue made using 9.22% of Ricotta cheese, T2: processed cheese analogue made using 18.44% of Ricotta cheese, T3: processed cheese analogue made using 27.7% of Ricotta cheese. SED: Standard Error of Difference.

Within the same column, numbers with the same superscript letter were not significantly different (Tukey multiple comparison post-hoc test $P< 0.05$), n=3.

CONCLUSION

Processed cheese analogue can be successfully produced by replacing 2.5 up to 5% of skim milk powder by Ricotta cheese as an ingredient in the cheese blend. Texture of produced cheese was improved. Moreover, addition of Ricotta cheese up to 18.44% did not alter the colour, taste and overall acceptability. In accordance, the produced cheese had good flavour and a high acceptability according to the sensory evaluation which was carried out on the produced cheese.

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إنتاج وتقييم مشابه جبن مطبوخ باستخدام الجبن الريكوتا المصنع من الشرش الحلو

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تم تصنيع مشابه جبن مطبوخ قابل للفرد باستبدال نسب ٢,٥ ، ٥ ، ٧,٥٪ من اللبن الفرز المجفف الموجود فى خلطة الجبن بنسب ٩,٢٢ ، ١٨,٤٤ ، ٢٧,٧٪ من الجبن الريكوتا مع عمل عينة بدون استبدال (كنترول).

أظهرت النتائج أنه من الممكن استخدام الجبن الريكوتا المصنع من الشرش غير الحامضى كأحد المكونات فى تصنيع مشابه الجبن المطبوخ بنجاح وبنكهة ودرجة قبول جيدة.

كما أظهرت النتائج أن إضافة الجبن الريكوتا لانتاج مشابه للجبن المطبوخ قد أدى إلى زيادة معنوية فى نسبة كل من النيتروجين الكلى والنيتروجين الذائب ونسبة الدهن ونسبة الرماد مقارنة بالعينة الكنترول. وفى نفس الوقت انخفضت نسبة اللاكتوز معنوياً مقارنة بالكنترول.

أظهرت نسبة الجوامد الصلبة والملح ورقم الـ pH تغيرات طفيفة وغير معنوية. وقد أدى تخزين الجبن على حرارة الثلاجة لمدة ستين يوماً إلى اتجاه عام بالزيادة فى نسب جميع مكونات الجبن فيما عدا اللاكتوز الذى انخفضت نسبته.

أدى إضافة الجبن الريكوتا إلى خلطة مشابه الجبن المطبوخ إلى تحسين قوام الجبن الناتج وأظهرت النتائج أن استبدال نسب ٢,٥ ، ٥٪ من اللبن الفرز المجفف بالجبن الريكوتا لم يغير من لون أو مذاق أو القبول العام للجبن الناتج بينما حصل الاستبدال بنسبة ٧,٥٪ على أقل درجة من القبول العام. ومن ثم فإنه يمكن إنتاج جبن مشابه للجبن المطبوخ بنجاح وبصفات حسية مرضية بإضافة الجبن الريكوتا إلى خلطة الجبن المطبوخ بنسبة تصل إلى ١٨,٤٤٪.