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Research Article

The Effect of Storage Conditions on Physicochemical, Microbial and Textural Properties of UHT-Processed Cheese

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Abstract

This study investigated the effect of storage condition (time and temperature) on physicochemical, textural and microbial properties of UHT-Processed cheese. The UHT-processed cheese was stored in controlled incubators at 4, 18, 32 and 37°C (the study plan used the recommended temperature (4°C), the average of temperature in winter and springer (18°C), in summer (32°C) and in Upper Egypt in some year months (37°C)) and at room temperature (20 - 25°C in months of September – December) for 120 days. The results showed that there was no significant ($P \geq 0.05$) changes were observed in the protein %, fat %, dry matter (DM %), and pH values of UHT-processed cheese during storage for 120 days at 4 and 18°C. On the other side, protein % and fat % were significant ($P \leq 0.05$) increased during storage at 32°C, 37°C, while, the weight and pH values were decreased. On room temperatures, the fat% and DM% were increased by the end of storage (at day 120), while the protein% and pH values were not changed. The hardness, gumminess and chewiness were increased during storage at all temperatures, while the adhesiveness values were decreased. Springiness was not changed at 4 and 18°C, but it was increased at other storage temperature. Concerning the cohesiveness values, there was no significant ($P \geq 0.05$) changes were observed except with sample stored at 37°C. No microorganisms were found in all processed cheese samples stored at different temperatures. These results confirmed that the best temperature to storage UHT-processed cheese is at 4°C followed by 18°C.

Keywords: UHT; Processed Cheese; Texture Properties; Microbial Quality; Storage Condition

Abbreviations

UHT: Ultra-High Temperature; DM: Dry Matter

Introduction

Processed cheese is a widespread dairy product consumed in many world countries [1]. Moreover, processed cheeses have a high content of proteins, fats, minerals and vitamins which are considered as the most important elements of the diet [2]. Processed cheeses are traditionally manufactured from a mixture of one or more natural cheeses (different ages and degrees of maturity) with many other dairy ingredients such as anhydrous butterfat, butter, cream, milk powder, whey and buttermilk, and nondairy ingredients (e.g. stabilizers, preservatives, flavor enhancers) followed by heating and continuous mixing to form a homogeneous product with an extended shelf life [3-5]. Processed cheese is a dairy product which differs from natural cheese in the fact that process cheese is not made directly from milk. However, natural cheese is the main ingredient of process cheese. The characteristics of processed cheese are affected by diverse factors such as the types and properties of natural cheeses, additional ingredients, emulsifying conditions, moisture and fat content, pH value, and ripening [6-8]. The emulsifying step reinforces the qualities of the processed cheese, especially its mechanical properties and viscosity. The continuous raise in viscosity through cooking is named the creaming impact, and the continuous cooking itself is named creaming. The creaming impact can also be stimulated by cooling and storage, which basi-

cally modulation the network of casein [9]. The consistency is one of the most important and very critically parameters of processed cheeses [4]. The particular consistency of the product is affected by many factors, which can be split into 4 major groups: (a) physicochemical properties of the processed cheese (DM, protein, fat and fat/DM content and pH value); (b) the composition of the raw material mixture (e.g. the type and degree of maturity of the natural cheeses, the composition and concentration of the emulsifying salts, and the composition and concentration of the stabilizers); (c) processing conditions (e.g. agitation speed, melting temperature, stirring time and rate of cooling the melt); and (d) storage temperature, and length of the storage period [10,11,12]. The main and significant part of the process is heating treatment for a suitable time with continuous stirring (emulsifying process) until a homogeneous mass is formed. UHT process involve of heating milk and other dairy products at high temperature (~135 - 145°C) and holding it at these temperatures for a very short time (1 - 10 seconds), then fast cooling in a continuous flow system. The main reason for increased using UHT process in production of milk and dairy products to prolong its shelf-life during storage at ambient temperature. Presently, the shelf life of milk and dairy products treated by UHT process and stored at ambient temperature is 3 - 9 months [13].

Objective of the Study

The objective of this study was to determine the effect of storage times and temperatures on the physicochemical, microbial and textural properties of UHT-processed cheese.

Materials and Methods

Cow skim milk powder (34% protein) and milk protein concentrate (70% protein) were obtained from Fonterra Ltd, Auckland, New Zealand. Emulsifying salt was obtained from JOHA BK Ladenburg, Germany, and added to processed cheese by 2%. Cheddar cheese (6 months old, 62.4% DM, 25% protein and 34% fat) was obtained from Al Sakr for food products (Rotana), Alexandria, Egypt. Butter 82% fat was obtained from Al Sakr for food products (Rotana), Alexandria, Egypt. Sodium sorbate and Citric acid were obtained from El-Nasr Chemicals Co., Egypt. Acrylamide (2X) was obtained from SERVA Feibiochemia, New York. Bis-Acrylamide and Tetramethylethylenediamine (TMED) were obtained from Sigma-Aldrich (St. Louis, MO). Ammonium persulphate and Glycine were obtained from Oxford, India.

Methods UHT-processed cheese manufacturing

UHT-processed cheese was prepared according the method of Muir., *et al.* [14] with some modifications, by blending the dry ingredients with previously warmed milk fat (60°C) (Table 1) into a processing kettle. Warmed distilled water (60°C) was added to assure that the moisture content of the UHT-processed cheese is controlled at approximately 60 ± 1.0% (w/w). Cooking was carried out using direct an injection of steam at a pressure of 1.5 bars to 86°C with continuous agitation for 4 minutes. After that, the blend was treated in UHT unit (at 142°C/3 sec). The processed cheese was packed at70°C. According to Egyptian standard, it is recommended to store the processed cheese at 2 - 5°C. So, the study plan used the recommended temperature (4°C), the average of temperature in winter and springer (18°C), in summer (32°C) and in Upper Egypt in some months (37°C). The room temperature was about 20 - 25°C, in months of September - December, as the temperature is lower during the night hours. So, the UHT-processed cheese samples were stored in controlled incubators (at 4, 18, 32 and 37°C), and at room temperature (20 - 25°C) for 30, 60 and 120 days.

Ingredients	%	DM	Protein %	Fat%	Lactose %
SMP*	8	7.72	2.72	0.077	4
MPC**	4.8	4.41	3.36	0.067	0.72
Salt	0.4	0.35	-	-	-
Butter 82%	21	17.67	ND	16.81	ND
Stabilizer	0.25	0.23	-	-	-
Emulsifying salts	2	2	-	-	-
Cheddar cheese	15	9.36	3.75	5.1	-
Sodium sorbate	0.1	0.09	-	-	-
Citric acid	0.5	0.47	-	-	-

Table 1: The formula of UHT-processed cheese.

*SMP: Skimmed Milk Powder; **MPC: Milk Protein Concentrate.

Physicochemical analysis of UHT-processed cheese

Chemical analysis of UHT- processed cheese (protein %, fat % and dray matter % (DM %)) was carried out according the AOAC procedures [15]. The pH of homogenized UHT- processed cheese was measured using pH meter (Martini, Italy) [16].

Microbiological evaluation

Coliform count

UHT- processed cheese samples were serially diluted by sodium citrate (2%). The enumerations of coliform bacteria were carried out on violet red lactose agar medium (Oxoid, England) and the plates were incubated at 37°C for 24h [17].

Yeast and mold count

The enumerations of yeasts and molds were carried out on Dichloran Rose-Bengal Chloramphenicol (DRBC) agar medium (Oxoid, England). Plates were incubated for 5 days at 25°C [18].

Thermo-spore forming bacteria

The enumeration of colony-forming units (CFU) of resistant spores of thermophilic bacteria in UHT-processed cheese samples by using a colony-count technique [19].

Texture profile analysis

The textural analysis of UHT- processed cheese samples were performed using texture analyzer (Stable Micro Systems ltd. Vienna court, Lammas TA.XT. Plus) based on the procedure stated by Bourne [20], Cone Probe with 25 mm diameter was used in test. The optimized test condition were 60 mm back-off distance to sample, deformation ratio 35%, speed of test 60 mm per min and force of trigger 0.15N. The Hardness (g), adhesiveness (g/s), springiness (m), cohesiveness, gumminess, and chewiness of processed cheese were measured at 20°C.

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE)

SDS-PAGE (12.5%) technique was conducted using the discontinuous buffer system described by Laemmli [21] and mentioned by Hames and Rickwood [22]. The obtained PAGs were analyzed by total lab software (V1.11).

Sensory evaluation

UHT-processed cheese samples were evaluated for organoleptic characteristics (color, smell, taste, texture and appearance), by 20 trained panelists (6 males and 14 females) from Dairy Science and Technology Department, Faculty of Agriculture, University of Alexandria, with ages ranging from 20 to 56 years, they have a good experience in the sensory evaluation of dairy products. Processed cheese samples (15 g) were presented in white small dishes coded randomly with 3-digit numbers, at a temperature of 20°C. Water was provided between evaluations of samples for mouth rinsing. Five points system was used for evaluation based on the method of Bodyfelt and Potter [23] with minor modification. The evaluation was identified using a 5-point hedonic scale (1 = dislike extremely, 2 = dislike moderately, slightly, 3 = neither like nor dislike, 4 = like moderately, and 5 = like extremely).

Statistical analysis

Statistical analyses were carried out using SAS, 2004 (SAS Institute, Inc., Cary, NC). Means were compared by Duncan's test at the significance level of $P < 0.05$ [24].

Results and Discussion

Microbiological quality of UHT-processed cheese

The microbiological assays of UHT-processed cheese during storage for 120 day at 4, 18, 32, 37°C and room temperature showed that no microorganisms were found in all processed cheese samples stored at different temperatures. These results were agreed with that reported by Lazárková., *et al*. [25] whose evaluated the impacts of four different sterilizing modes (110°C/100 min, 115°C/32 min, 120°C/10 min, and 125°C/3.2 min with a constant lethal effect on microorganisms) on some chemical, microbiological, and sensory properties of processed cheese depending on the lactose (%) additions. They found that all sterilizing modes used were sufficient to inactivate the microorganism groups (total count of microorganisms, yeasts and molds, and spore-forming bacteria). El-Sayed., *et al.* [26] found that after UHT process of row milks containing of mesophilic and thermophilic spore forming bacteria (max log 2.63 of mesophilic and log 1.9 of thermophilic), all samples were sterilized and there were no any microbiological defects after streak plates from incubated samples for 5 days at 32 or 55°C. The absence of all microorganisms indicated that the product was safe even after storage at 4, 18, 32, 37°C and room temperature [27].

The effect of storage times and conditions on physicochemical analysis of UHT-processed cheese

Chemical composition is one of the most substantial factors impressing cheese quality [28]. The physicochemical proper-

ties of UHT-processed cheese stored at 4, 18, 32, 37 °C and room temperature for 120 days were presented in table 2. The results showed that the protein % not affected during storage at 4, 18°C and room temperature for 120 days. Meanwhile, the protein % was significant (P ≤ 0.05) increased after 60 days at 32°C, and after 30 days at 37°C. Fat % of UHT-processed cheese was significantly (P ≤ 0.05) increased on the day 30 of storage at 32 and 37°C, and on day 120 of storage at room temperature. On the other side, no significant (P ≥ 0.05) differences were found in fat % during storage at 4 and 18°C for 120 days. Also, the DM% of UHT-processed cheese not changed during storage at 4 and 18°C/120 days. While, DM % was increased during storage at 32°C and 37°C. At room temperature, the increased in DM% was found by the end of storage time (day 120). These results in agreeing with El-Assar., *et al.* [29] who found that the DM% and Ash% of low fat processed cheese (control sample) stored for 2 months at 6°C was significantly (P ≤ 0.05) increased, while, the protein and fat values not changed. This increased in DM% and Ash% due to the decrease in moisture % of stored cheese. The weight of UHT-processed cheese not changed during storage at 4°C/120 days. Meanwhile, the weight of cheese samples was decreased during storage at 18, 32, 37°C and room temperature. The highest decreased in cheese weight was found with 32 and 37°C. The decrease in cheese weight at room temperature was found only at the end of storage time (day 120). The pH values were significant (P ≤ 0.05) decreased in cheese samples stored at 32 and 37°C/120 days and not changed at 4°C, 18°C and room temperature. These results differ with that reported by Hassan., *et al.* [30] who found that the pH values of processed cheese stored at 5°C were significant decreased during storage period (3 months). Mohammadi and Fadaei [31] found that the pH value of processed cheese not changed during storage for 3 months at 6°C.

The effect of storage time and temperature on texture profile analysis of UHT- processed cheese

The textural properties of cheeses are great importance for the characterization of the product and for the consumers' hedonic reactions [32]. Also, the texture of cheese is deemed to be one a one of the main determinants of consumer preference of different cheese types [33]. Data presented in table 3 illustrates the effect of storage times and temperatures on texture properties (Hardness, adhesiveness, Springiness, Cohesiveness, Gumminess and Chewiness) of UHT-processed cheese. The hardness of UHT-processed cheese was increased during the storage period at all temperatures. The highest increase in hardness was found with storage at 37°C followed by 32°C and then room temperature. While, the lowest increase in hardness was found with storage at 4 and 18°C. The hardness of UHT-processed cheese was increased with the increase in storage time and temperature. These results in agreement with [34] who observed an increase in hardness and a decrease in adhesiveness during the storage period (30 days/6°C) in processed cheese samples manufactured with emulsifying salts as well as with carrageenan.

The adhesiveness of UHT-processed cheese was significant (P ≤ 0.05) decreased during the storage with all temperatures and the highest decrease was found with temperature 37°C followed by 32°C. No significant (P ≥ 0.05) differences were found in adhesiveness between the samples stored at 4°C, 18 °C and room temperature. These results were agree with Everard., *et al.* [35] who noted lower adhesiveness values for processed cheeses containing higher levels of moisture and emulsifying salts. Springiness is the ability of a materials to recover its original shape after distorted during initial pressure. The UHT-processed cheese samples stored at 32°C, 37°C and room temperature showed significant increase in springiness during storage times, while, the cheese samples stored at 4 and 18°C not affected. The highest springiness value was found with the sample stored at 37°C and the lowest value was found with the sample stored at 4°C. Cohesiveness is the power of the internal bonds forming the body of the product [36]. The cohesiveness refers to the strength of internal bonds especially the protein-protein interactions [37]. The cohesiveness value was significant (P ≤ 0.05) increased by the end of storage period (day 120) at 37°C and not changed with other storage temperatures. The processed cheese samples stored at 37°C showed the highest cohesiveness value followed by the sample stored at 32°C and room temperature. On the other side, the lowest cohesiveness values were found at 4 and 18°C. Gumminess is the energy required to disintegrate a semi-solid food for swallowing calculated parameter: Hardness × Cohesiveness. The gumminess in processed cheese was found to be related to moisture content and hardness [38]. The Gumminess and Chewiness of processed cheese sample stored at all temperatures were significant (P ≤ 0.05) increased during storage. The highest Gumminess and Chewiness values were found at 37°C followed by 32°C and the lowest Gumminess and Chewiness values were found at 4°C followed by 18°C then room temperature. The change in texture properties of processed cheese samples with phosphate emulsifying salts during the storage period is attributed mainly to the hydrolysis of polyphosphates and related formation of casein ma-

Temp.	Parameters	Storage Times (days)			
		1	30	60	120
4 °C	Protein%	9.67± 0.33^{aA}	9.60 ±0.69^{aA}	9.61± 0.59^{bA}	9.66±0.55^{bA}
	Fat %	22.46±1.55^{aA}	22.33±1.25^{bA}	22.30± 1.40^{cA}	22.36±0.95^{cA}
	DM %	41.36± 1.35^{aA}	41.53 ±1.25^{cA}	41.63± 1.35^{bA}	41.68±1.35^{dA}
	pH	5.65 ±0.035^{aA}	5.64±0.025^{aA}	5.66±0.045^{aA}	5.66±0.035^{aA}
	Weight	121.46±0.198^{aA}	121.43±2.15^{aA}	121.43± 1.45^{aA}	121.36± 2.15^{aA}
18 °C	Protein%	9.67±0.33^{aA}	9.67± 0.67^{aA}	9.83± 0.61^{bA}	10.11±0.61^{bA}
	Fat %	22.46±1.55^{aA}	23.99± 0.90^{bA}	23.75±1.20^{bA}	23.81±1.78^{bcA}
	DM %	41.36 ±1.35^{aA}	44.05± 1.89^{bA}	43.88±1.09^{bA}	43.58±1.01^{cA}
	pH	5.65 ±0.035^{aA}	5.63± 0.035^{aA}	5.63±0.035^{abA}	5.64±0.045^{abA}
	Weight	121.46±0.198^{aA}	116.22± 2.72^{bB}	116.13±1.85^{bB}	115.33±3.35^{bB}
32 °C	Protein%	9.67±0.33^{aB}	10.23± 0.65^{aB}	10.68± 0.49^{abAB}	11.46±0.65^{aA}
	Fat %	22.46±1.55^{aB}	23.93± 1.25^{bAB}	24.83±1.05^{abAB}	26.16±1.15^{abA}
	DM %	41.36± 1.35^{aC}	44.33± 1.05^{abB}	46.46±1.45^{aAB}	48.56±1.35^{aA}
	pH	5.65 ±0.035^{aA}	5.50±0.035^{cB}	5.50±0.035^{cB}	5.55±0.045^{cB}
	Weight	121.46±0.198^{aA}	114.33± 2.55^{cB}	107.73±2.45^{cC}	101.96±1.95^{dD}
37 °C	Protein%	9.67±0.33^{aB}	10.63± 0.65^{aAB}	11.06±0.85^{aA}	11.56± 0.45^{aA}
	Fat %	22.46±1.55^{aB}	27.07± 1.25^{aA}	26.23±1.25^{aA}	27.43±1.45^{aA}
	DM %	41.36± 1.35^{aC}	46.33± 1.03^{aB}	48.33±1.05^{aB}	50.76±1.25^{aA}
	pH	5.65 ±0.035^{aA}	5.56± 0.035^{bB}	5.56±0.050^{bcB}	5.58±0.025^{bcAB}
	Weight	121.46±0.198^{aA}	108.26± 2.35^{dB}	100.96±1.95^{dC}	94.96±2.95^{eD}
Room temp.	Protein%	9.67±0.33^{aA}	9.66± 0.75^{aA}	9.77±0.39^{bA}	10.63±0.65^{abA}
	Fat %	22.46±1.55^{aB}	22.83± 1.05^{bB}	23.06±1.15^{bcB}	25.56±1.35^{bA}
	DM %	41.36± 1.35^{aB}	42.23± 1.25^{cB}	42.73±1.05^{bB}	46.13±1.15^{bA}
	pH	5.65 ±0.035^{aA}	5.61± 0.045^{abA}	5.61±0.035^{bA}	5.60±0.035^{bA}
	Weight	121.46±0.198^{aA}	119.63± 2.65^{abA}	118.13±2.85^{abA}	106.96±2.95^{cB}

Table 2: Effect of storage times and temperatures on physicochemical analysis of UHT- processed cheese*.

*Values are mean ± SD (n = 3). The level of significant was present at $p < 0.05$. Means with the same letter(s) are not significant. Capital letters refer to differences among storage times in the same row. Small letters: refer to differences among storage temperatures in the same column.

trix [39]. The increasing in hardness, springiness and chewiness values of processed cheese may be due to the decrease in cheese moisture content.

Also, water, protein and fat are one of the main factors affecting cheese hardness [40]. During the production of cheeses, many factors can contribute to the final texture of cheese. These factors include the moisture content of the curd (the moisture content of

Temp.	Parameters	Storage Times (days)			
		1	30	60	120
4 °C	Hardness (g)	426 ±5.51^{aC}	483±8.50^{eB}	498 ±7.51^{eA}	499 ±8.51^{eA}
	Adhesiveness(g/s)	81.03 ±4.05^{aA}	62.63 ±3.35^{aB}	63.53 ±2.95^{aB}	63.57 ±3.55^{aB}
	Springiness (m)	0.656 ±0.0135^{aA}	0.643 ±0.009^{bA}	0.647 ±0.045^{bA}	0.657 ±0.0351^{cA}
	Cohesiveness	0.323 ±0.0351^{aA}	0.325 ±0.0245^{aA}	0.327 ±0.0252^{aA}	0.327 ±0.025^{bA}
	Gumminess	136.31 ±5.30^{aB}	157 ±5.05^{cA}	164 ±4.35^{dA}	165 ±4.35^{eA}
	Chewiness	89.41 ±4.40^{aB}	101 ±3.05^{cA}	107 ±4.90^{eA}	109 ±3.40^{eA}
18 °C	Hardness (g)	426 ±5.51^{aC}	506±5.51^{dB}	515 ±6.51^{dA}	536 ±5.51^{dA}
	Adhesiveness(g/s)	81.03 ±4.05^{aA}	56.87 ±5.85^{aB}	57.83 ±2.75^{abB}	58.33 ±3.35^{abB}
	Springiness (m)	0.656 ±0.0135^{aA}	0.673 ±0.025^{abA}	0.657 ±0.045^{abA}	0.647 ±0.045^{cA}
	Cohesiveness	0.323 ±0.0351^{aA}	0.333 ±0.035^{aA}	0.353 ±0.045^{aA}	0.343 ±0.045^{bA}
	Gumminess	136.31 ±5.30^{aC}	167 ±4.30^{bB}	180 ±3.25^{cA}	182 ±2.25^{dA}
	Chewiness	89.41 ±4.40^{aB}	112 ±3.25^{bA}	119 ±5.27^{dA}	118 ±2.55^{dA}
32 °C	Hardness (g)	426 ±5.51^{aD}	578 ±8.51^{bC}	621 ±6.51^{bB}	654 ±9.50^{baA}
	Adhesiveness(g/s)	81.03 ±4.05^{aA}	59.47 ±4.4^{5a}B	53.23 ±3.37^{bB}	43.23 ±3.25^{cC}
	Springiness (m)	0.656 ±0.0135^{aB}	0.687 ±0.045^{abAB}	0.713 ±0.015^{abA}	0.723 ±0.025^{bA}
	Cohesiveness	0.323 ±0.035^{aA}	0.333 ±0.035^{aA}	0.347 ±0.045^{aA}	0.357 ±0.035^{abA}
	Gumminess	136.31 ±5.30^{aD}	191 ±4.25^{aC}	217 ±4.55^{bB}	235 ±5.45^{bA}
	Chewiness	89.41 ±4.40^{aD}	132 ±5.10^{aC}	154 ±3.10^{bB}	170 ±5.55^{bA}
37 °C	Hardness (g)	426 ±5.51^{aD}	623 ±8.50^{aC}	698 ±7.51^{aB}	756 ±5.51^{aA}
	Adhesiveness(g/s)	81.03 ±4.05^{aA}	45.17 ±4.85^{bB}	41.47 ±3.55^{cBC}	35.65 ±4.45^{dC}
	Springiness (m)	0.656 ±0.0135^{aC}	0.723 ±0.0252^{aB}	0.723 ±0.0252^{aB}	0.837 ±0.0351^{aA}
	Cohesiveness	0.323 ±0.0351^{aB}	0.313 ±0.0153^{aB}	0.357 ±0.0351^{aB}	0.423 ±0.0252^{aA}
	Gumminess	136.31 ±5.30^{aD}	193 ±2.75^{aC}	251 ±3.70^{aB}	318 ±5.50^{aA}
	Chewiness	89.41 ±4.40^{aD}	139 ±5.05^{aC}	181 ±4.10^{aB}	267 ±3.30^{aA}
Room temp.	Hardness (g)	426 ±5.51^{aC}	523 ±10.50^{cB}	545 ±5.51^{cA}	554 ±5.51^{cA}
	Adhesiveness(g/s)	81.03 ±4.05^{aA}	56.17 ±4.85^{aB}	54.33 ±4.35^{bB}	55.33 ±4.35^{bB}
	Springiness (m)	0.656 ±0.013^{aB}	0.667 ±0.035^{abAB}	0.697 ±0.045^{abAB}	0.727 ±0.025^{bA}
	Cohesiveness	0.323 ±0.035^{aA}	0.323 ±0.025^{aA}	0.343 ±0.045^{aA}	0.357 ±0.045^{abA}
	Gumminess	136.31 ±5.30^{aD}	167 ±4.35^{bC}	185 ±4.9^{cB}	199 ±4.65^{cA}
	Chewiness	89.41 ±4.40^{aD}	112 ±4.12^{bC}	130 ±4.29^{cB}	146 ±4.55^{cA}

Table 3: Effect of storage times and temperatures on texture profile analysis of UHT- processed cheese*.

*Values are mean ± SD (n = 3). The level of significant was present at $p < 0.05$. Means with the same letter(s) are not significant. Capital letters refer to differences among storage times in the same row. Small letters: refer to differences among storage temperatures in the same column.

curd is affected by scalding temperature, curd fineness, stirring time, etc.), pH value, and acidity %. The higher temperature during the curd scalding leaves the curd springy, and the resulting cheese rubbery [37]. Protein, fat and moisture were the three major constituents of cheese, which comprise more than 80% mass and directly affected textural and functional properties of cheese [41,42].

Zheng., *et al.* [28] found that the decrease in moisture in nonfat substances (MNFS), Fat in dry matter (FDM), or storage temperature contributed to an increase in the firmness of sliced cheese. Also, Adhikari., *et al.* [43] found that the lower-moisture cheeses (44% moisture) had higher intensities of hardness, springiness and chewiness, but were lower in cohesiveness than the higher-moisture cheeses (48% moisture). In this study, the UHT-processed cheese stored at 4°C showed an increase in hardness during storage time, however the change in DM% was very slightly. These results were in agreement with El-Attar., *et al.* [38] who reported that the slight differences in moisture of processed cheese may cause major differences in its rheological parameters.

The effect of storage time and temperature on sensory properties of UHT- processed cheese

The results in figure 1 showed the effect of storage times and temperatures on sensory properties of UHT- processed cheese. The color of processed cheese samples not changed during the storage period (120 days) at all temperatures except at 37°C the color score was decreased during storage. No significant ($P \geq 0.05$) changes were observed in smell, taste, texture and appearance of UHT- processed cheese during the storage period (120 days) at all temperatures (4, 18, 32, 37°C, and room temperature). The results of flavor and color are consistent with El-Assar., *et al.* [29] who found that the color and flavor scores of low-fat processed cheese (control sample) stored for 2 months at 6°C not changed. And differ with them in the decrease of texture scores during storage. To have a balance between flavor and texture of the processed cheese, the ingredients are chosen according to their flavor, chemical composition (water content, fat, protein, and calcium), their extent of ripening (protein degradation degree) and their texture stability in addition to pH [36].

Figure 1: Effect of storage times and temperatures on sensory evaluation of UHT-processed cheese (n= 20).

SDS-PAGE of UHT-processed cheese

Electrophoresis technique is one of the approved methods that explain the changes that occur in cheese proteins during storage. The processed cheese samples shows 5 prominent bands, i.e. β-Casein, α-Casein and κ-Casein, β-Lg and α- La (Figure 2). According the results of gel electrophoresis analysis (Figure 3 and 4), no remarkable differences were observed in protein bands of UHT-processed cheese samples stored at 4, 18, 32, 37°C and room temperature for 120 day in compare with fresh sample. Meanwhile, the pattern of fresh sample was different than that of stored samples in percentage, area and volume. No degradation was observed in any samples at 120 days of storage. AlSaadi and Deeth [44] observed that the electrophoretic patterns of UHT milk samples stored at 5 and 20 °C were different from those stored at 37 and 45°C. From these results, it could be concluded that no proteolysis caused in the major proteins of UHT- processed cheese during storage times at different temperatures.

Figure 2: SDS-PAGE of UHT-processed cheese samples stored for 120 days at different temperatures.

Figure 3: Total lab analysis of SDS-PAGE of UHT-processed cheese samples stored for 120 days at (1) 37°C; (2) 32°C and (3) 18°C.

Figure 4: Total lab analysis of SDS-PAGE of UHT-processed cheese samples stored for 120 days at (4) 4°C; (5) room temperature, (6) fresh sample.

Conclusion

The effects of storage time and temperature on physicochemical, textural and microbiological properties of UHT-processed cheese were investigated. The physicochemical properties of UHT-processed cheese were significantly changed by storage at temperature higher than 18°C. The best storage conditions were observed at 4°C followed by storage at 18°C. The texture properties of processed cheese were affected by increasing the dry matter during storage. All samples of UHT-processed cheese during storage period (4 months) were free from aerobic spore forming bacteria, coliform bacteria, yeast and mold at all storage conditions used in this study. Form the above results and discussion, it could be concluded that the best storage temperature of UHT-processed cheese is 4°C and the storage temperature should not be more that 18°C.

Conflict of Interest

The authors declare no conflict of interest.

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