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Ras Cheese Making with Vegetable Coagulant - a Comparison with Calf Rennet

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Abstract: Ras cheeses were manufactured using aqueous extract of globe artichoke or artichoke flowers (*Cynara scolymus*) proteinase as coagulant were compared to calf rennet. There were slight differences between chemical composition of cheese made using vegetable coagulants or calf rennet. Cheeses manufactured with artichoke extract as coagulant exhibited higher ($p < 0.05$) levels of water soluble nitrogen, water soluble nitrogen coefficient, total volatile fatty acids and free amino acid content than cheese made with calf rennet. The extent of breakdown of α_{s1}- casein as measured by (Urea- PAGE), was greater in cheese made using artichoke extracts as coagulant than in cheese made using calf rennet. Whereas, β – casein were less susceptible to proteolysis than α_s- casein. The most acceptable cheese were cheese made with 1.2 g/ L stigmas of artichoke flower as coagulant characterized as clean – sharp ideal flavour and firm – smooth body & texture followed by cheese made with 1.4g/ L stigmas of artichoke flower as coagulant after 2 months of ripening. It could be concluded that artichoke flower extract (*Cynara scolymus*) is suitable substitute for calf rennet for Ras cheese manufacture and the ripening period of cheese can be reduced to 1-2 months. So, this would reduce the costs of cheese production.

Key words: Ras cheese · Artichoke · Cheese ripening · *Cynara scolymus* · Vegetable coagulants

INTRODUCTION

Milk- clotting enzymes are the primary agents in the manufacture of cheeses [1]. Calf rennet was the first and is the most widely used milk clotting enzyme. The worldwide increase of cheese production and the reduced supply of calf rennet has led to search for alternatives sources of milk coagulants [2]. Increasing attention has been directed toward natural rennet extracted from plants [3]. Plant proteinases are interesting because they are natural products when can easily extracted by aqueous infusion and due to the continuous growth of the vegetarian market [1]. Although several plant proteinases are able to coagulate milk, most of the plant rennet obtained has been found to be inappropriate for cheese production due its excessively proteolytic character which causes bitterness and weakness of the cheese body [4]. An exception is represented by the aqueous extracts of *Cynara cardunculus* flowers, which have been used in the manufacture of several traditional Portuguese and Spanish cheeses [5]. The extracts of the flowers of two other Cynara species, *C. humilis* and *C. scolymus*, have been claimed to be effective as rennet [6 ,7]. Sidrach *et al*. [8] detected high proteinase activity in the stigma of artichoke (*Cynara scolymus*) . Purified proteinases of *C. scolymus* contains three proteinases(cynarases A, B and C) with milk clotting activity [1] and like chymosin have a specific activity for the $Phe_{105} – Met_{106}$ bond of bovine κ- casein [8]. These findings indicate that plant extracts derived from artichoke flowers show great potential for use as coagulants and could be used in industrial cheese making [9]. LIorente *et al*.[9] concluded that the flower extract of *C. scolymus* L., besides being able to coagulate milk, was suitable for the manufacture of Gouda-type cheese. The artichoke was used as a food and medicine by the ancient Egyptians, Greeks and Romans [10]. Globe artichoke (*Cynara scolymus* L.) is a perennial plant of the composite family. In Egypt globe artichoke is becoming one of the most important vegetable crops grown for local consumption and export to European countries [11].

In Egypt, Ras cheese is considered the most popular type of hard cheese, similar to Greek type "Cephalotyre". The popularity of this type of cheese is mainly due its unique taste and aroma [12]. Ras cheese made from cow's milk or a mixture of cow's and buffalo's milk. It is normally marketed after a ripening period of 4-6 months [13].

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The aim of this study is to examine the influence of using vegetable coagulant from *Cynara scolymus*, compared with calf rennet, on changes in the chemical and sensory characteristics of Ras cheese during ripening.

MATERIALS AND METHODS

Materials: Fresh cow's milk (4.5 % fat) was obtained from a private farm in Ismailia Governorate. Table salt (NaCl dry coarse, El- Nasr Co., Alex.). Calcium chloride (pure) was obtained from El- Nasr Pharmaceutical chemicals, liquid calf rennet 1N (Mifad, Misr food additives (25 : 50 ml / 100 L milk). Freez – dried lactic culture (FD- DVS phage control R- 700 culture series) contain strains of *Lactococcus lactis* subsp. *cremoris* and *Lactococcus lactis* subsp. *lactis* in the amount of 50 unit/1000L was obtained from CHR Hansens laboratories, Denmark. Globe artichoke (*Cynara scolumus*, L.) were purshased from local market. Artichoke flowers (which not harvested from the plant, the bud will blossom into, blue – violet flower, which is not edible) were obtained from a farm in El-Behira region (Egypt). The stigmas and styles of globe artichoke (the mass of inedible fuzzy part, or choke in the center of the bud) and of artichoke flowers (blue violet – part of the flower) were removed and left to dry (by air) in the laboratory by leaving them in a dark dry place. The styles and stigma were stored in this form prior to extraction. The crude extract was prepared by grinding the styles of artichoke (*Cynara scolymus*, L.) in a mortar and pestle for 1 min, suspending in distilled water (60 ml) and stirring for 10 min at room temperature and then filtering through a fine piece of cloth. All chemicals used were of the recognized analytical grade.

Manufacture of Ras Cheese: Ras cheese was manufactured by conventional method described by Hofi *et al.* [14]. Cow's milk was standardized to 0.7 casein/ fat ratio, heat treated at 72°C for 15s and rapidly cooled to 32°C, then divided to five equal portions. Calcium chloride (0.02%, w/v) and starter culture were added to each portion. All portions were left until titratable acidity reached 0.19%. First portion was renneted with calf rennet (32 ml/ 100kg) and served as control (T1) and the other four portions coagulated with different amounts of vegetable coagulant extracts of *Cynara scolymus*, using the enzyme extracts prepared as above as coagulant. The second portion (T2) was coagulated using 2.4g of crude stylets and stigmas of Globe artichoke per liter of milk (2.4g/ L milk), third portion (T3) was coagulated using 1.2 g of stylets and stigmas of artichoke flowers per liter of milk (1.2g/ L milk). Fourth portion (T4) was coagulated using 1.4 g of crude stylets and stigmas of artichoke flowers per liter of milk (1.4g/ L milk), while the fifth portion (T5) was coagulated using 1.6 g of crude stylets and stigmas of artichoke flowers per liter of milk (1.6g/ L milk). After complete coagulation (40-50 min), the curd was cut vertically and horizontally into cubes using 0.5 inch knives and the curd was stirred and heated gradually to 45°C in 15 min and held at this temperature until the whey acidity reached 0.14%. About 1/3 of whey was drained off and salt was added (2%, w/v of milk), curd re-stirred for 5 min. After complete whey drainage, the curd was then molded and pressed for 24 h. The resultant cheese was turned over every day and rubbed with dry salt for one week. Then cheeses were waxed, stored for three months at 14°C ± 2°C with relative humidity 80-85%. The whole experiment was repeated in duplicate and each analysis in duplicate and average results were tabulated. Cheese samples were taken for analysis at 0, 1, 2 and 3 months of ripening.

Methods of Analysis

Compositional Analysis: Titratable acidity and moisture content were determined according to AOAC [15]. Water soluble nitrogen (WSN), total nitrogen (TN) by micro Kjeldahl method and fat content by Gerber butyrometer according to Ling [16]. The pH value was measured by using (Jenway digital pH meter , Jenway Limited, England). Total volatile fatty acids (TVFA) were estimated by the direct distillation method according to Kosikowski [17], results were expressed as ml N/ 10 NaOH per 100 gm cheese. Free amino acids (FAA) content were estimated using cadmium-ninhydrin method as described by Folkertsma and Fox [18].

Cheese Firmness: Firmness of Ras cheese was determined according to the method described by Abou El- Nour *et al*. [19] using Brabender Structograph model D4100 (Brabender, OHG, Duishburg, Germany) with spindle No: 449650 and force 1000 Cmg. The heights of resultant curve express the firmness.

Gel Electrophoresis (Urea – Page): Urea – Page was performed by the method of Andrews [20]. The gels were stained by the method of Blakesly and Boezi [21]. Cheese samples (0.1g) were dissolved in 1 ml samples buffer and (11 µl) were applied to the gel. Electrophoresis in polyacrylamide (12.5% separation, 4.2% stacking) gels was performed in a Double - Slab Vertical Cooling Gel System (JVD- 80) Shelton Scientific Mfg., Inc. USA.

Sensory Evaluation: Organoleptic properties of cheese samples were evaluated according to the method of Pappas *et al*. [22]. Cheese were assessed by means of seven panelists of the staff members of the Dairy Department, with maximum score points (50 points) for flavour, body and texture (40 points) and appearance (10 points).

Statistical Analysis: All data were analyzed by ANOVA using the general models procedure of Costat [23] under windows software version 6.311. Differences among means were tested for significance at ($p < 0.05$). The data presented in tables, are the mean of 3 experiments.

RESULTS AND DISCUSSION

Gross Chemical Composition: Data presented in Table 1. illustrate that the composition of the cheese coagulated with aqueous extracts of artichoke (*Cynara scolymus*) as coagulant was rather close to the control except that (T4 and T5) had higher ($p< 0.05$)moisture content and this was associated with decreasing ($p < 0.05$) fat content. These results were in accordance with those found by Chen *et al*. [24]. As Ras cheese ripening prolonged moisture content of all cheese treatments decreased significantly ($p < 0.05$). These results were in agreement with those reported by Fahmy [25]. It is observed from the obtained results that the fat content, on a dry basis, of all treatments increased significantly ($p < 0.05$) throughout the ripening period. This increase was related to the changes in their moisture content due to the progressive loss in moisture during ripening. It could be seen from Table 1, that total nitrogen content (TN) was increased pronouncedly ($p < 0.05$) during ripening period. Also, there is a marked ($p < 0.05$) variation between T4 and T5 and other cheese treatments. As shown from Table 1, there was an increase in the acidity values of all treatments during the ripening period. This could be due to the production of acidic compounds as a result of fermentation of residual lactose and degradation of intermediates components of protein and fat (Fahmy [25]. It was noticed that titratable acidity of Ras cheese made using artichoke flower extract as coagulant (T4 and T5) were significantly higher ($p < 0.05$) than control (T1) and other cheese treatments (T2 and T3). An opposite trend were found with pH values, the pH of control Ras cheese was higher ($p < 0.05$) among all cheese treatments. The pH of all cheeses decreased significantly ($p < 0.05$) as ripening period progressed. Although slight differences were observed in chemical parameters studied for cheese made with calf rennet and vegetable coagulant, most data were comparable throughout the ripening process. These results are in agreement with those reported by Galán *et al*. [26].

Ripening Indices: The water soluble nitrogen is regarded as a ripening index for cheese as it reflects the extent of proteolysis Chen *et al*. [24]. The release of WSN in cheese is primarily a result of casein breakdown by proteolytic enzymes [24]. The water soluble nitrogen (WSN) content (Table 2) was markedly ($p < 0.05$) different among all cheese treatments. Cheese made used 1.6 g/ L artichoke flower extract (T5) was found to have the highest ($p < 0.05$) levels of WSN, followed by cheese made using 1.4g/ L (T4), 1.2 g/ L (T3), finally cheese made using extract of globe artichoke stylets and stigmas 2.4 g/ L (T2), while cheese made with calf rennet had the lowest levels of water soluble nitrogen. Chen *et al*. [24] and Galán *et al*. [26] reported that the much higher levels of WSN found in cheeses made with cardoon extract (*C. cardunculus*) suggest an elevated proteolysis activity of proteases in the vegetable coagulants. Moreover, there were significant ($p < 0.05$) differences in water soluble nitrogen coefficient (WSN/ TN) among all treatments. It could be noticed that the WSN and WSN/ TN increased significantly ($p < 0.05$) during the ripening period for all Ras cheese treatments (Table 2).

In respect of total volatile fatty acids (TVFA), the obtained data showed that Ras cheese made with vegetable coagulants (*Cynara scolymus*) contained more volatile acids ($p < 0.05$) compared to control cheese at each period of ripening (Table 2). The total volatile fatty acids were significantly ($p < 0.05$) increased throughout cheese ripening.

Fig. 1 showed changes in the level of free amino acids, as cheese ripening progressed and the results indicated that the concentration of free amino acids increased markedly ($p < 0.05$) for all cheese treatments . These results were consistent with the determination of WSN, which increased in all cheese throughout ripening period (Table 2 & Fig. 1)Whereas, there were significant ($p < 0.05$) differences in the free amino acids (FAA) content of cheese from different treatments. The amount of total free amino acids in cheese made with artichoke extracts as coagulant were greater ($p < 0.05$) as compared to control cheese. At the end of ripening (3 months), Ras cheese made using 1.6 g/ L of artichoke flower extract (T5) gave the highest ($p < 0.05$) values of FAA followed by cheese made using 1.4g/ L (T4) whereas control cheese had the lowest ($p < 0.05$) concentration of FAA.

Table 1: Changes in chemical composition of Ras cheese made using artichoke extracts as coagulant during ripening period

	Moisture (%)					Fat (%)				
	Storage period (months)					Storage period (months)				
Treatments	Fresh	1	2	3	Mean	Fresh	1	2	3	Mean**
T1	40.20	39.20	37.58	35.28	38.09^{B}	28.30	29.55	30.75	31.91	30.12^{A}
T2	40.40	39.35	37.95	35.28	38.15^{B}	28.20	29.53	30.74	31.91	30.09^{A}
T3	40.19	39.34	37.58	35.31	38.10^{B}	28.30	29.55	30.75	31.89	30.12^{A}
T4	41.32	39.80	37.84	35.40	38.59^{A}	27.95	29.35	30.65	31.88	29.95^{B}
T5	41.43	39.83	37.86	35.44	38.64^{A}	27.95	29.35	30.65	31.87	29.95^{B}
Mean**	40.70^{a}	39.52^{b}	37.69^{c}	35.34^{d}		28.14^{d}	29.46^{c}	30.70^{b}	31.89^{a}	
	F/ DM*					*TN (%)				
	Storage period (months)					Storage period (months)				
	Fresh	1	2	3	Mean**	Fresh	1	2	3	Mean**
T1	47.32	48.70	49.26	49.30	48.64^{C}	3.93	4.04	4.14	4.35	4.11^{A}
T2	47.31	48.69	49.25	49.30	48.63^{C}	3.92	4.03	4.14	4.35	4.11^{A}
T3	47.31	48.71	49.26	49.29	48.64^{C}	3.93	4.04	4.14	4.35	4.11^{A}
T4	47.63	48.75	49.30	49.35	48.75^{B}	3.90	4.03	4.13	4.34	4.10^{B}
T5	47.72	48.77	49.32	49.36	48.79^{A}	3.90	4.03	4.13	4.33	4.09^{B}
Mean**	47.45^{d}	48.72^{c}	49.27^{b}	49.32^{a}		3.91^{d}	4.03^{c}	4.13^{b}	4.34^{a}	
	Acidity (%)					pH				
	Storage period (months)					Storage period (months)				
	Fresh	1	2	3	Mean**	Fresh	1	2	3	Mean**
T1	0.91	1.19	1.32	1.57	1.24^{C}	5.35	5.22	5.19	5.14	5.22^{A}
T2	0.93	1.29	1.53	1.69	1.36^{B}	5.28	5.20	5.16	5.00	5.16^{B}
T3	0.91	1.30	1.56	1.69	1.36^{B}	5.30	5.19	5.16	5.01	5.16^{B}
T4	0.93	1.32	1.57	1.74	1.39^{A}	5.30	5.19	4.99	4.97	5.11^{C}
T5	0.93	1.32	1.57	1.76	1.39^{A}	5.33	5.19	4.96	4.94	5.10^{C}
Mean**	0.92^{d}	1.28^{c}	1.51^{b}	1.69^{a}		5.31^{a}	5.198^{b}	5.09^{c}	5.01^{d}	

*F / DM : fat on dry matter *TN : total nitrogen

**a, b, c & d and A, B & C: means with the same letters among treatments and storage period respectively are not significantly different ($p< 0.05$)

T1: Cheese renneted using calf rennet

T2: Cheese coagulated using (2.4g /L milk) stylets and stigmas of globe artichoke.

T3: Cheese coagulated using (1.2 g /L milk) stylets and stigmas of artichoke flower.

T4: Cheese coagulated using (1.4g /L milk) stylets and stigmas of artichoke flower.

T5: Cheese coagulated using (1.6g /L milk) stylets and stigmas of artichoke flower

These results was consistent with the result that cheese (T5 and T4) contained higher levels of WSN than calf rennet (Table 2 & Fig. 1). Free amino acids levels of Ras cheese made with 1.2 g/ L of artichoke flour extract (T3) was comparable to cheese made with 2.4 g/ L globe artichoke aqueous extract (T2).

The firmness data Table 3, illustrates that Ras cheese firmness increased pronouncedly ($p < 0.05$) with prolonged ripening period then decline significantly ($p < 0.05$) after 2 months of ripening. The increase in cheese firmness during ripening period could be related to decreasing moisture content. The lower firmness values ($p < 0.05$) of treatment 5 was consistent with its higher moisture content (when fresh) compared to other cheese treatments, Also, related to the higher ($p < 0.05$) levels of WSN as a result of elevated proteolytic activity throughout ripening period. The higher proteolytic activity in the breakdown of caseins in cheeses made with vegetable coagulant led to a softer texture [26]. Whereas cheese made with 1.4 g/ L of artichoke flour extract (T4) had the highest ($p < 0.05$) firmness value and treatments (T1, T2, T3) were comparable and exhibited intermediate firmness values.

Polyacrylamide Gel Electrophoresis: Urea- PAGE electrophoregrams of Ras cheese manufactured with artichoke extract as coagulants as compared to cheese made using calf rennet (Fig. 2) showed progressive and

Table 2: Effect of using artichoke extracts as coagulant on water soluble nitrogen, water soluble nitrogen coefficient and total volatile fatty acids of Ras cheese during ripening period

		Storage period (months)				
Treatments	Parameter	Fresh	1	2	3	Mean**
T1	Soluble nitrogen (WSN%)	0.22	0.29	0.35	0.52	0.34^{E}
T2		0.24	0.56	0.67	0.72	0.54^{D}
T3		0.27	0.61	0.67	0.73	0.57^{C}
T4		0.28	0.67	0.73	0.81	0.62^{B}
T5		0.28	0.67	0.76	0.85	0.64^{A}
Mean **		0.258^{d}	0.560^{c}	0.636^{b}	0.726^{a}	
T1	WSN/TN (%)	5.59	7.18	8.45	11.95	8.30^{E}
T2		6.12	13.98	16.18	16.58	13.19^{D}
T3		6.87	15.09	16.18	16.82	13.74^{C}
T4		7.17	16.62	17.67	18.70	15.04^{B}
T5		7.17	16.62	18.40	19.63	15.45^{A}
Mean**		6.58^{d}	13.88^{c}	15.37^{b}	16.74^{a}	
T1	TVFA*	6.75	9.40	13.47	14.88	11.12^{D}
T2		6.88	9.40	13.51	15.16	11.23^{D}
T3		6.88	9.90	13.82	15.54	11.53^{C}
T4		7.12	10.15	13.88	17.25	12.10^{B}
T5		7.23	12.65	17.73	20.40	14.50^{A}
Mean**		6.97^{d}	10.30^{c}	14.48^{b}	16.64^{a}	

See Table 1 for treatments designation

*TVFA: total volatile fatty acids expressed as ml NaOH 0.1N/ 100g cheese

** a, b, c & d and A, B, C, D & E: means with the same letters among treatments and storage period respectively are not significantly different ($p < 0.05$)

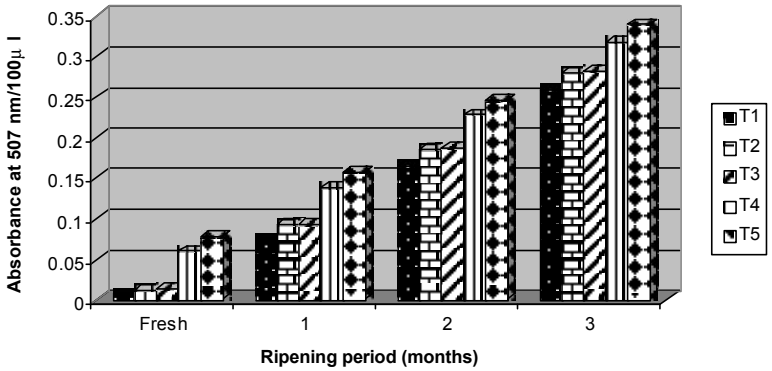

Fig. 1: Changes in free amino acids (expressed as A_{507}) during ripening of Ras cheese made with artichoke extracts as coagulant

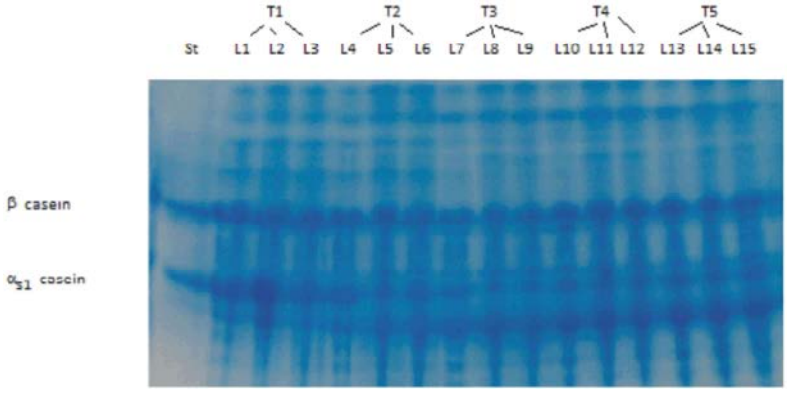

Fig. 2: Urea- PAGE of Ras cheese using artichoke extracts as coagulant at 1, 2 and 3 months of ripening
Lane (1) sodium caseinate (ST); Lanes (1&2&3) control (T1); Lanes (4&5&6) T2; Lanes (7&8&9) T3; Lanes (10&11&12) T4; Lanes (13&14&15) T5

Table 3: Effect of using artichoke (*Cynara scolymus*, L.) extracts as coagulant on the firmness (Bu) of Ras cheese during ripening period

	Storage period (months)				
Treatments*	Fresh	1	2	3	Mean**
T1	140	220	225	220	201.25^{B}
T2	140	220	225	220	201.25^{B}
T3	180	220	225	180	201.25^{B}
T4	180	225	220	205	207.5^{A}
T5	110	230	220	205	191.25^{C}
Mean**	150^{c}	223^{a}	223^{a}	206^{b}	

*See Table 1 for treatments designation

** a, b & c and A, B & C: means with the same letter among the treatments and storage period respectively are not significantly different ($p < 0.05$).

Table 4: Sensory evaluation of Ras cheese made with artichoke (*Cynara scolymus* L.) extracts as coagulant during ripening period .

	Storage period (months)			
Treatments*	1	2	3	Mean**
	Flavour (50 points)			
T1	39.16	41	42	40.72^{D}
T 2	44	42.5	41	42.50^{C}
T 3	43.4	45.75	46	45.05^{A}
T 4	44.5	46.25	45.3	45.35^{A}
T 5	44.5	45.5	39.3	43.10^{B}
Mean**	43.11^{b}	44.2^{a}	42.72^{b}	
	Body& Texture (40points)			
T1	32	34.5	36.6	34.36^{B}
T 2	33	33.5	33	33.16^{C}
T 3	36	36.75	35	35.91^{A}
T 4	36	36	34.3	35.43^{A}
T 5	35	36	31	34^{B}
Mean**	34.4^{b}	35.35^{a}	33.98^{b}	
	Appearance (10 points).			
T1	8.5	8.25	8.3	8.35^{A}
T 2	8.8	7.75	6.6	7.71^{B}
T 3	9	9	8.3	8.76^{A}
T 4	9	9	8.3	8.76^{A}
T 5	8.6	9	8	8.53^{A}
Mean**	8.78^{a}	8.6^{a}	7.9^{b}	
	Total acceptance (100 points)			
T1	79.66	83.75	86.9	83.43^{C}
T 2	85.80	83.75	80.6	83.38^{C}
T 3	88.40	91.50	89.3	89.73^{A}
T 4	89.50	91.25	87.9	89.55^{A}
T 5	88.10	90.50	78.3	85.63^{B}
Mean**	86.29^{b}	88.15^{a}	84.6^{c}	

*See Table (1) for treatments designation

** a, b & c and A, B, C & D: means with the same letter among the treatments and storage period respectively are not significantly different ($p<0.05$)

extensive breakdown of α_s – casein from the first month onwards, throughout 3 months of ripening. After 2 months α_s – casein hydrolyzed very extensively compared to the control cheese. The reduction in intensity of the bands representing α_s – casein coincided with appearance of smaller peptides (Lanes 5 – 15). These results indicate the higher degree of proteolysis in the cheese made using artichoke extracts as coagulant(T5, T4, T3 and T2) in order (Lanes 15- 5). Comparison of the electrophoretic patterns of Ras cheese made with calf rennet and with artichoke extracts allows some distinct differences. No major changes were observed on β- casein, remaining constant throughout 3 months of ripening for all cheese treatments. These results were agreed with those reported by Pino *et al*. [27]. A series of unidentified slowly migrating peptides appeared at the very top of the gels.

Sensory Evaluation: Data presented in Table 4, summarized the score recorded for flavour, body & texture and appearance of Ras cheese as affected by using artichoke aqueous extracts as coagulant. The use of vegetable proteinase significantly ($p < 0.05$) increased the total scores gained by the cheese during ripening. Treatments (T3) and (T4) gained the highest ($p < 0.05$) total scores followed by T5, T2 and control cheese in order. Control cheese (T1) was characterized after 1, 2 months of ripening for flavour as slight flat, lacking of flavour and for body as short and it possessed a total scores 79.66 and 83.75 points out of 100. After 3 months of ripening , control cheese acquired more improvement and was characterized as mild flavour and firm - smooth body & texture and scored a total score of 86.9 points. Treatment (T2) made with (2.4 g/ L) globe artichoke extract was characterized after 1, 2 months of ripening for flavour as flavoured cheese and for body & texture as short and scored a total scores 85.80 and 83.75 points out of 100 respectively. After 3 months of ripening, was characterized as off flavour (unlike flavour) and as firm – slight brittle for body & texture and scored a total scores 80.6 points. Cheese manufacture with aqueous extracts of artichoke flower (T3 and T4) was rated significantly ($p < 0.05$) higher in overall preferable scores by the panelists than other treatments throughout 3 months of ripening . The flavour intensity of cheese produced with vegetable coagulant was significantly higher ($p < 0.05$) than with calf rennet except on day 60, the cheese made with 1.6 g/ L of artichoke flower extract (T5) had more flavour intensity, acidic and characterized as over ripening cheese. No significant ($p > 0.05$) were observed in respect of Ras cheese appearance among all treatments except treatment (T2) which had the lowest ($p < 0.05$) score for its appearance.

A positive correlation ($p < 0.05$) was found between flavour intensity for cheeses made with calf rennet or vegetable rennet and their respective amounts of WSN.

CONCLUSIONS

The results obtained in this study indicate that artichoke flower extract (*Cynara scolymus*) is suitable substitute for calf rennet for Ras cheese manufacture. Both the proteolysis and the sensorial characteristics of the cheese made with the aqueous extracts of artichoke flower were higher than with calf rennet. The cheese obtained using 1.6 g/ L stigmas of artichoke flower as coagulant underwent a considerable increase in proteolysis and characterized of over ripened cheese after a ripening period of 2 months. While cheese made using 1.2 g/ L stigmas of artichoke flower as coagulant (T3) characterized as the most preferable cheese with ideal flavour and firm – smooth body & texture followed by cheese made with 1.4g/ L stigmas of artichoke flower as coagulant after 2 months of ripening. Thus the ripening period of Ras cheese can be reduced to 1-2 months. So, this would reduce the costs of cheese production.

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