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# QUALITY OF REDUCED FAT RICOTTA CHEESE MADE BY USING DAIRY-LO ®

[34]

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## ABSTRACT

Ricotta cheese was made from standardized buffaloe's milk with 2%, 1% or 0.0% fat with adding 1%, 2% or 3% Dairy- LO ® respectively. This study briefly outlined the chemical composition,cheese yield, caloric value and physical characteristics of the resultant cheese treatments in comparison with control cheese made from the same milk with 3% fat. Results showed that, the cheese yield was the highest for Ricotta cheese made from 1% fat and added 2% Dairy-Lo® and lowest for Ricotta cheese made from 3% fat (control). Also, the fat recovery look the same trend, while total protein recovery showed an opposite trend. The caloric value increased with increasing the fat content and decreased by reducing in the main components. Ricotta cheese made from 2% fat and added 1% Dairy-Lo® give the superior in quality and sensory characteristics and give more whitener and a smooth creamy but cheese made from skim milk and added 3% Dairy-Lo® was rejected as it gained lower score values for all properties. Cheese microstructure by scanning electron microscopy (SEM) showed that, the Dairy-Lo® gave a gel structure in the place of removed fat globules which decrease the junction in the casein matrix and increase the whiteness of the Ricotta cheese.


**Key words**: Ricotta cheese, Buffalo milk, Dairy-Lo®,Cheese microstructure

## INTRODUCTION

Traditionally Ricotta cheese is manufactured prepared in the Mediterranean countries mostly from the whey obtained from cheese manufacture with fortification by skim milk proteins .The demand for softer, creamier product has resulted in a shift of emphasis. so, that a great deal of Ricotta is manufactured from whole milk (**Modler and Emmons, 1989**). Ricotta cheese principally made by heat-acid coagulation of whole or partly skim milk, while the traditional heated whey protein cheese is referred to as Ricotta (**Scott, 1981**). In the Eastern united states, greater consumer acceptance has been achieved by manufacturing Ricotta cheese from whole milk or partially skimmed milk (**Kosikowski, 1982**). Recently, casein and whey proteins are in wide use as therapeutic agents and exhibit a wide range of beneficial function (**Welch *et al* 1997**).

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Ricotta cheese has been considered to be one of the economical way for the utilization of all milk proteins, easy to produce and suitable for most of consumers taste. Thus a great need for controlling the production techniques and type of milk must be considered in Ricotta cheese manufacture **(Cosseddu *et al* 1999 and Sieber, 1998)**.

Electron microscopy has been used to study microstructure of the individual components in milk products and the changes which these components under go either alone or by interaction with each other or with additional ingredients such as stabilizers, thickeners, emulsifiers, lactic bacterial cultures etc. during manufacturing process **(Kalab and Emmons, 1978)**. The development of microstructure in a cream cheese spread based on acid coagulated whey protein curd (Ricotta cheese) was described earlier **(Kalab and Modler, 1985)** it was noted that Ricotta and Queso Blanco cheeses significantly differed in microstructure.

Generally, different types of cheese made from buffalo milk considered preferable by most of the Egyptian consumers.

Recently, researches conducted by food marketing institutes show fat reduction is now the No. 1 concern of nutritionally minded consumers. This explains the recent trend on the market of new ingredients presented as fat substitutes and fat replacers. Dairy-Lo® is an all natural dairy ingredient (a milk protein concentrate) produced from sweet whey, that helps to create great tasting foods which are lower in fat. It has a uniquely clean taste, which enhances products flavour. Furthermore, Dairy-Lo® function in such a way to improve products overall quality.

The aim of this research was to manufacture reduced fat Ricotta cheese with good properties from buffaloe's milk by replacing milk fat with Dairy- Lo® with different fat ratios.

## MATERIAL AND METHODS

### Materials

Fresh buffaloe's milk was obtained from the farm of Faculty of Agriculture, Cairo Univ. The average values of buffaloe's milk gross composition were: total solids 15.53%; protein 3.8%; milk fat 6.0%; lactose 4.6%; ash 0.97%; acidity 0.18% and pH 6.6.

Citric acid was obtained from Misr Company for Pharmaceutical Industries, Cairo.

Dairy-Lo® from Pfizer Inc. New York, USA.

Stabilizer, three commercial products of Dalriloid 100 stabilizer were purchased from Kelco, Division of Merck and Co. Inc., Rahway, New Jersy, USA.

Freeze dried starter cultures of *Streptococcus Salivarius ssp. thermophilus and lactobacillus delbrulki ssp. bulgaricus* used in this study were obtained from Ch. Hansen's Laborites Denmark.

Food grad salt was obtained from the local market.

### Manufacture of Ricotta Cheese

Four treatments for replacing milk fat with Dairy-Lo® were adopted for Ricotta cheese manufacture:

milk with 3% fat (control)
milk with 2% fat + 1% Dairy-lo®
milk with 1% fat + 2% Dairy-lo®
Skim milk + 3% Dairy-lo®

Ricotta cheese was made according to **Scott (1981)**.

### Methods of analysis

Total solids, determined according to **IDF method (1982)**, fat content and salt (sodium chloride) as given by **Ling (1963)**, total protein as described in **IDF Standard (1986)**. Lactose was estimated by the method described by **Nickerson *et al* (1976)**, ash content and titratable acidity were determined according to the official methods of analysis **(AOAC, 1984)**, while pH value was determined using pH meter, type (Digitel Meter M4 1150) equipped with a combined glass electrode.

### Cheese Yield and recovery

Yields and recoveries were calculated according to the formula given by **Vandeweghe and Maubois (1987)**.

### Caloric value

The caloric value of resultant cheese expressed as Cal / 100 g was calculated using the equation of **Walstra and Jenness (1984)**. E= 3.70F + 1.70 P + 1.68 L + 18 Where: E= Total energy (Cal / 100 gm)

F= Fat content (%)
P= Protein content (%)
L= Lactose content (%)

### Cheese firmness

The firmness of Ricotta cheese was measured at 15°C using Koehler K 19500 penetrometer (Sycamor AVE USA) according to **Abd El-Gawad (1998)**.

### Microstructure

The cheese microstructure was examined by scanning electron microscope as described by **Taneya *et al* (1980)**.

### Cheese Scoring

The cheese samples were organoleptically evaluated according to the test scheme described by **ADSA (1987)** for sensory evaluation of Cottage cheese.

### Statistical analysis

The obtained data were statistically analyzed according to **SAS (1996)**.

## RESULTS AND DISCUSSION

Dairy-Lo® was used as a fat replacer in manufacture of low fat Ricotta cheese from standardized buffaloe's milk. Table (1) indicates that chemical composition of both Ricotta cheese with 3% milk fat (control) and cheese treatments with Dairy-Lo®. Moisture content of control Ricotta cheese was lower in comparison with that made from reduced fat to 1% and 2% Dairy-Lo®. These results might be due to the high water holding capacity of denatured whey proteins present in Dairy- Lo® **(Abd El-Salam *et al* 1996 and Mangino, 1984)**. Statistical analysis showed significant differences in moisture content between the treatments which may be a result of Dairy-Lo® addition to the Ricotta cheese milk , giving high bound moisture. These results were confirmed by **Kebary *et al* (1998) and Abd El-Gawad and Hassan (2000)** who mentioned that Dairy-Lo® leads to in-

creasing moisture content of low fat cheese.

The acidity of cheese (Table 1), increased while pH value decreased with decreasing the levels of fat content of cheese milk. The formentioned data showed that, high fat cheese had lower acidity and higher pH value compared with that low fat cheese. These differences, however, were significant ($P \leq 0.05$). These results are in agreement with those reported by **Patel *et al* (1986)**.

The fat content on dry matter of Ricotta cheese treatments decreased significantly ($P \leq 0.05$) by reducing the fat content of cheese milk. These decreases are a result to the lower fat content of Dairy-Lo® treatments (**Kebary *et al* 1998**).

On the other hand Diary-Lo® a (Protein - based fat replacers) caused a significant ($P \leq 0.05$) increase in total protein of Ricotta cheese which was proportional to the amount of Dairy -Lo® added to cheese milk. These results are in agreement with those of **Abd El-Gawad and Hassan (2000)**.

With regard to lactose content on dry matter, it is clear that, significant differences ($P \leq 0.05$) could be observed in lactose content between control and reduced fat cheese. Control cheese contained the lower lactose which increased with increasing Dairy-Lo® percentage.

Concerning ash content on dry matter of Ricotta cheese made from buffaloe's milk treated with Dairy-Lo® (Table, 1), it is clear that the ash content increased significantly ($P \leq 0.05$) with increasing the levels of Dairy-Lo® amount added to milk and decreasing the levels of fat content. These results could be attributed to the high ash content of Dairy-Lo®.

On the other hand, results of (Table, 1) indicate that no much difference could be observed in the salt content of Ricotta cheese of all treatments.

Protein and fat recovery of Ricotta cheese are illustrated in Table (2). It could be seen that the fat recovery was ranged between 92.72 in control cheese and increased gradually to research 97.30% in Ricotta with 1% fat and 2% Dairy-Lo®. Therefore, it is clear that increasing added Dairy-Lo® led to increase fat recovery. These results may be due to the emulsifying and stabilizing properties of Dairy-Lo®. Concerning the protein recovery opposite results were observed. The protein recovery decreased with increasing added Dairy-Lo® to cheese milk. Protein recovery in control cheese was 98.33% decreased to 96.03 when 1% Dairy-Lo® was added, then reached the lower value of 94.64% when 2% Dairy-Lo® was added. These results are in agreement with those reported by **Abd El-Rafee and Salem (1997)**.

The yield results of Ricotta cheese are summarized in Table (2). Replacement of milk fat by Dairy-Lo® resulted in a significant ($P \leq 0.05$) increase in cheese yield, which parallel with the amount of added Dairy-Lo®. The yield of cheese made with adding 2% Dairy-Lo® was higher than control one and than that made with adding 1% Dairy- Lo®.

Concerning, the caloric value it was observed that the caloric value decreased pronouncedly ($P<0.05$) by reducing the fat content of cheese milk in spite of addition of Dairy-Lo®. This reduction was proportional to the fat reduction of cheese milk. These results are in

Table 1. Chemical composition of control and fat replaced Ricotta cheese treatment

| Fat % | Added Dairy-Lo® % | pH | Acidity | Moisture % | TP% | Fat% | Lactose % | Ash % | Salt % |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | On dry matter | | | | |
| 3 | 0.0 (control) | 6.05c | 0.31c | 63.814c | 44.55c | 33.162a | 13.13a | 6.01c | 0.96a |
| 2 | 1 | 5.95b | 0.33b | 65.851b | 53.15b | 20.50b | 15.87b | 6.97b | 0.87a |
| 1 | 2 | 5.76a | 0.35a | 67.384a | 60.89a | 9.20c | 17.88c | 8.00a | 0.85a |

Means with the same letter are not significant at (P<0.05) level but the different letters are significant at (P<0.05) level.

Table 2. Protein and fat recovery, yield and caloric value of reduced fat Ricotta cheese manufactured by different Dairy-Lo® percentages.

| Fat % | Added Dairy-lo® % | Protein Recovery % | Fat Recovery % | Cheese Yield % | Caloric value (Cal/100gm) |
|---|---|---|---|---|---|
| 3 | 0.0 (Control) | 98.332 a | 92.72 a | 23.18 a | 97.784 a |
| 2 | 1 | 96.03 b | 95.56 b | 27.31 b | 83.861 b |
| 1 | 2 | 94.641 c | 97.30 c | 32.50 c | 72.656 c |

Means with the same letter are not significant at (P<0.05) level , but the different letters are significant at (p<0.05) level .

agreement with **Salem *et al* (2001) and Mehanna *et al* (2000).**

They found that the decrease in main components (fat) gradually decreased the caloric value.

Ricotta cheese firmness made from buffaloe's milk with different levels of fat content are shown in Table (3). It could be observed from these results that the addition of different levels of Dairy-Lo® to milk caused significant increase in firmness of the resultant cheese.

Cheese made from buffaloe's milk with 1% fat and 2% Dairy-Lo® had the highest firmness which may be due to its higher protein content compared to the cheese made from 3% fat (control) or cheese made from 2% fat and 1% Dairy-Lo® due to an approximately linear relation between the protein content in milk and firmness of the cheese.

Table 3. Firmness of reduced fat Ricotta cheese manufactured by different Dairy-Lo® percentage.

| Fat % | Added Dairy-Lo® % | Cheese firmness (as PE* units) |
|---|---|---|
| 3 | 0.0 (Control) | 84.3 c |
| 2 | 1 | 80.2 b |
| 1 | 2 | 75. a |

* The higher PE unit means the less firmness.
Means with the same letter are not significant different at($p<0.05$) level but the different letters are significant at ($P<0.05$) level

Also, Dairy-Lo® addition to the Ricotta cheese process resulted in yield increase by direct protein addition. These results are in agreement with those reported for Ricotta cheese by **Shahani (1979) and Mathur and Shahani (1981),** who found that addition of small quantities of milk solids in the form of either whole milk or SMP caused better firmness cohesive properties to the curd mass. **Abdel-Rafee (1995)** found that the Ricotta cheese made from reconstitute retentate powder (RRP) had higher firmness than that made from reconstituted skim milk powder (RSMP).

Results in Table (4) show the organoleptic properties of Ricotta cheese. It is clear that Ricotta cheese made from milk with 2% fat and 1% added Dairy-Lo® obtained the highest scores for organoleptic properties and was acceptable. It had a good body and texture; more whitener and provide a smooth creamy mouthful. Furthermore it had the highest flavour score with rich nutty and creamy flavour than either the control or cheese containing 2% Dairy-Lo®. In contrary cheese made from skim milk and added 3% Dairy-Lo® was rejected as it gained lowest score values for all prop-

erties and thus its data were excluded from all the tables. These results are in agreement with those reported by **Mitchell and Berge (1994)** who mentioned that, Dairy-Lo® which separated by ultrafiltration from whey protein had a higher water binding capacity and gives a smooth texture to low-fat cheese.

From the pictures illustrated in Fig. (1, 2 & 3) it could be seen that the percentages of cheese fat content led to the junction which came from the presence of fat as a hander in the casein matrix. With decreasing the fat content, the fat globule renders decrease, in the same time the Dairy-Lo® gave a gel structure in the place of removed fat globules which decrease the junction in the casein matrix Fig. (2). Also, with decreasing the fat content and increasing the Diary-Lo® (fat replacer) the junction decreased and gave a matrix as the homogenized curd Fig. (3). Also, Dairy-Lo® led to increase the whiteness of the cheese. These results are in agreement with those reported by **Kalab (1995)**.

In conclusion, reduced fat Ricotta cheese from buffaloe's milk with acceptable flavour and texture properties could be made by using 2% and 1% added Dairy-Lo® as fat replacer.

Table 4. Organoleptic properties of reduced fat Ricotta cheese manufactured by different Dairy-Lo® percentage.

| Fat % | Added Dairy-Lo®% | Flavour (10) | Appearance and color(5) | Body &Texture (5) | Total score (20) |
|---|---|---|---|---|---|
| 3 | Control | 10 b | 4.5 b | 4.5 b | 19 a |
| 2 | 1 | 10 a | 5 a | 5 a | 20 a |
| 1 | 2 | 8 a | 4.5 b | 4.5 b | 17 b |

Means with the same letter are not significant at ($P<0.05$) level but the different letters are significant at ($p<0.05$) level.

Fig. 1. Microstructure of Ricotta cheese made from buffaloes' milk with 3% of fat (control)

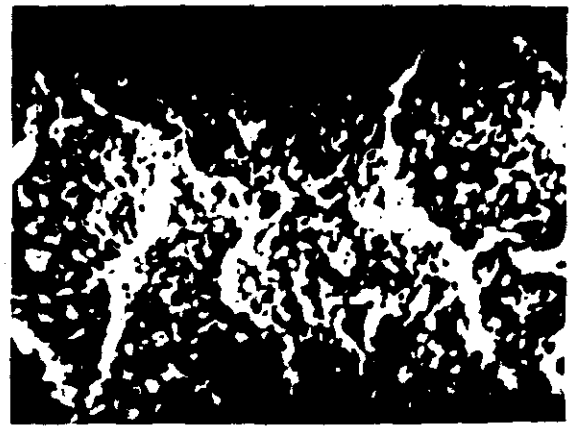

Fig. 2. Microstructure of Ricotta cheese made from buffaloe's milk with 2% fat and added 1% Dairy-LO®.

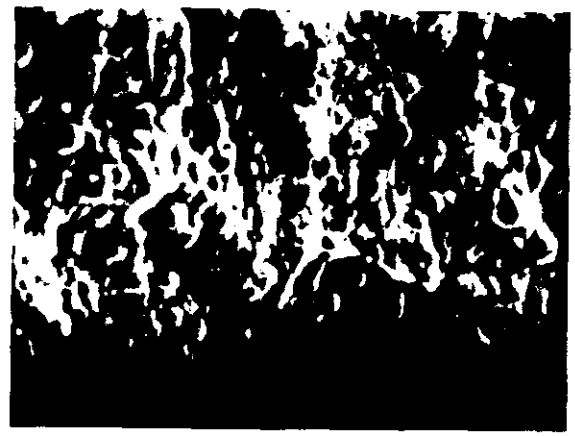

Fig. 3. Microstructure of Ricotta cheese made from buffaloe's milk with 2% fat and added 1% Dairy-LO®.

## REFERENCES


**Abd El-Gawad, M.A.M. (1998).** ***Manufacture and properties of Mozzarella cheese made from Buffaloe's Milk. p. 103.*** Ph.D. Thesis, Fac. of Agric. Cairo Univ. Egypt.

**Abdel-Gawad, M.A.M. and F.A.M. Hassan (2000).** Manufacture of low fat soft white cheese by using fat replacers. ***Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo, 8 (1): 235-261.***

**Abdel-Rafee, S. (1995).** ***Studies on the use of retentate powder in cheese making*** **pp. 85-132.** Ph.D. Thesis, Ain Shams Univ., Cairo, Egypt.

**Abdel-Rafee, S. and A. S. Salem (1997).** Yield and quality of buffalo Ricotta cheese. ***Annals Agric. Sci., Ain Shams Univ., Cairo, 42 (1): 187-193.***

**Abd El-Salam, M.H.; A.F. Al-Khamy; G.A. El- Garawany; A. Hamed and A. Khader (1996).** Composition and rheological properties of processed cheese spread as affected by the level of added whey protein concentrates and emulsifying salt. ***Egypt. J. Dairy Sci., 24: 309-322.***

**ADSA (1987).** ***American Dairy Science Association. Evaluation of Dairy Products. Score card for Cheese,*** **pp. 196-197.** Champaign, TL,

**Association of Official Analytical Chemistry (1984).** ***Official Methods of Analysis 14th Ed pp. 132-138.*** Assoc. Offic. Anal. Agr. Chem. Washington

**Cosseddu, A.M.; G. Lai; Eple-de Santis and R. Mazzette (1999).** Fresh, packed cows Ricotta, composition and energy value. ***Latte., 24 (1): 76-80.***

**International Dairy Federation (1982).** Cheese and processed cheese: determination of the total solids content (Reference method) **International Dairy Federation, Standard 4A.**

**International Dairy Federation Standard (1986).** Milk: Determination of nitrogen content (Kjeldahl method) and calculate of curd protein content. ***International Dairy Federation Standard 20A.***

**Kalab, M. (1995).** Practical aspects of electron microscopy in cheese research. ***Chemistry of Structure - Function Relationships in Cheese, pp. 247-276.*** Edited by Malin , E. L. and M. H. Tunick, Plenum Press, New York.

**Kalab, M. and D.B. Emmons (1978).** Milk gel Structure. IX Microstructure of Cheddar curd, **Milchwissenschaft 33: 670-673.**

**Kalab, M. and H.W. Modler (1985).** Development of microstructure in a cream cheese based on Queso Blanco cheese. ***Food Microstructure 4: 89-98.***

**Kebary, K.M.K.; A.M. Abeid and R.M. Badawi (1998).** Impact of fat replacers on proteins of low fat processed cheese spread. ***Egyptian Conf. Dairy Sci., and Technol. pp. 383-401.***

**Kosikowski, F.V. (1982).** ***Cheese and Fermented Milk Foods 3rd. Ed., pp. 179-212.*** Published by Kosikowski , F.V. and Associates. Brooktondale, New York

**Ling, E.R. (1963).** ***A Text Book of Dairy Chemistry.*** 3rd Ed. Vol. 2. pp. 84-86. Chapman and Hall, London.

**Mangino, M.E. (1984).** Physico - chemical aspects of whey protein functionality. ***J. Dairy Sci., 67: 2711-2718.***

**Mathur, B. N. and K.M. Shahani (1981).** Ricotta cheese could be your best vehicle for whey. ***Dairy Field, 164 (11): 110-114.***

**Mehanna, N.M.; M.S. Thanaa; S.A. Mehanna and M.A. Susu El-Asfory (2000).** The quality of low caloric buffalo

Zabady. *Egyptian J. Dairy Sci., 28 (1): 59-71.*

**Mitchell, H.L. and E. Berge (1994).** New milk protein for low fat milk products. *Meieriposten. 83: 5, 138-139.*

**Modler, H.W. and D.B. Emmons (1989).** Production and yield of whole milk Ricotta manufacture by a continuous process. 2-Results and Discussion. *Milchwissenschaft, 44 (11):753-756.*

**Nickerson, T.A.; I.F. Vujicie and A.Y. lin (1976).** Calorimetric estimation of lactose and its hydrolytic products. *J. Dairy Sci., 59: 386-393.*

**Patel, G. C.; S.H. Vyad and K.G. Upadhyay (1986).** Evaluation of Mozzarella cheese made from buffalo milk using direct acidification technique. *Indian J. Dairy Sci., 39(4): 394-403.*

**Salem, A.S.; A.M. Ismail and S. Abdel Rafee (2001).** Biological and nutritional evaluation of Ricotta cheese from whey, buffalo or cow milk. *Proc. 8th Egypt. Conf. Dairy Sci., & Technol. pp. 665-673.*

SAS **(1988).** Statistical Analysis System. *SAS User's Statistics.* SAS Institute Inc. Editors, Cary. NC.

**Scott, R. (1981).** *Cheese Making Practice. pp. 461-363.* Applied Sci. Publishers LTD, London,

**Shahani, K.M. (1979).** Newer techniques for making and utilization of Ricotta cheese. *Proc. First Biennial Marschall Int. Italian Conf. Pp. 77-87.*

**Sieber, R. (1998).** Composition of Swiss Ricotta type cheese Mitteilungenaus-dem. *Gebieteder – Lebensmitt - Ersuchungund- Hygine 89 (3): 294-300.*

**Taneya, S.T.; T. Kimura; T. Izutsu and W. Buchheim (1980).** The submicroscopic structure of processed cheese with different melting properties. *Milshwissenschaft 35(8): 479-481.*

**Vandeweghe, J. and J.L. Maubois (1987).** The yield of cheese predetermination and measurement *In: Cheese Making Science and Technology.* Edited by Eck, A. Part 7, Chapter 23. pp. 469-477.

**Walstra, P. and R. Jenness (1984).** *Dairy Chemistry and Physics, pp. 270-276.* John Wiely and Sons Pub. Inc. N.Y.

**Welch, R.A.S.,; D.J.W. Burns; S.R. Davis; A.I. Popay and C.G. Prosser (Editor) (1997).** *Milk Composition, Production and Biotechnology.* **pp.581-590.** Wallingford , UK: CAB international.

مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ،م(٤٧)، ع(٢) ، ٥٣٩-٥٤٩، ٢٠٠٢

# جودة جبن الريكوتا المنخفض الدهن المصنع باستخدام الـ Dairy-Lo®

# [٣٤]

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تم صناعة جبن الريكوتا من اللبن الجاموسى المعدل فى نسبة الدهن بمستوى ٢% و ١% وصفر % مع أضافه المستحضر التجارى Dairy-Lo® بديلاً للدهن بنسبة ١% و٢%و٣% على الترتيب وصنعت باستخدام بادئ *Streptococcus Salivarius* ssp. *thermophilus* and *lactobacillus delbruki ssp. bulgaricus.*

وتم حساب تصافى الجبن الناتج وكذا التركيب الكيماوى ودراسة التركيب البنائى الدقيق بالميكروسكوب الإلكتروني الماسح والخواص الحسية للجبن الناتج مع مقارنه النتائج بجبن المقارنه المحتوى على ٣% دهن . وأوضحت النتائج أن تصافى جبن الريكوتا الناتج عن تصنيعه من لبن ١% دهن + ٢% Dairy-Lo® كانت أعلى نسبة بينما الجبن المصنع من ٣% دهن (كنترول) أعطيت أقل نسبة تصافى. كما أن الجبن الناتج من ٢% دهن + ١%Dairy-Lo® حصل على أعلى درجات التحكيم وأدى إلى تحسين نكهة وقوام وتركيب الجبن الناتج بالمقارنة بالجبن المصنع من ٣% دهن والجبن المصنع من ١% دهن + ٢% Dairy-Lo®. كما أن درجة الصلابة (Firmness) زادت فى الجبن المصنع من ١% دهن + ٢% Diary-Lo® مقارنة بجبن (الكنترول) والجبن المصنع من ٢% دهن+ ١% Diary-Lo®. وأوضحت صور الميكروسكوب الإلكترونى الماسح أن وجود الدهن فى الخثرة عمل على وجود عوائق بين شبكة الكيزين بسبب تواجد حبيبات الدهن مما يؤدى إلى وجود فواصل بين جسيمات الكازين داخل شبكة البروتين. ومع خفض نسبة الدهن وزيادة نسبة الـ Dairy-Lo® المضافة أدى ذلك إلى تقليل الفواصل بين شبكة البروتين وزيادة اندماج التركيب البنائى الدقيق للمكونات المختلفة مع بعضها. وكذلك أدى إلى إعطاء الخسرة مظهر اكثر بياضاً.

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