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# RHEOLOGICAL AND SENSORY CHARACTERISTICS OF HALF- FAT CREAM CHEESE MADE WITH CARBOHYDRATE BASED FAT REPLACERS

**Abd El-Khair, A.A.**
**Food Sci. and Tech. Dept. Faculty of Agric., Souhag, South Valley Univ., Egypt.**

## ABSRACT

The effects of two types of carbohydrate-based fat replacers involved maltodextrin and inulin on the compositional, rheological and sensory characteristics of half-fat double cream cheese were investigated. Each fat replacer was used at the level of 1, 3 and 5 % respectively to replace the half-fat content of cheese milk. Resultant cheese were compared to full-fat double cream cheese and half-fat cheese made without fat replacers. Rheological characteristics of cheese were established by measuring both apparent viscosity and texture profile analysis. A relationship between the instrumental measurements and sensory data was demonstrated for the particular cheese type. Results revealed that, replacing of milk fat with fat replacers increased the moisture content and decreased the fat content of the resultant cheese compared with full-fat control cheese. All half-fat double cream cheese containing fat replacers exhibited higher viscosity values than full-fat control cheese but different trends were observed for cheese of different treatments. Texture profile analysis of half-fat cheese made with both fat replacers showed that the hardness, springiness and gumminess increased while cohesiveness and adhesiveness decreased with fat replacement. Sensory attributes of half-fat double cream cheese, in particular, hardness and cohesiveness showed acceptance correlation with double compression data. Both fat replacers appear to have a potential to replace the milk fat in half-fat double cream cheese.

**Keywords.** Double cream cheese, Fat replacers, Texture profile analysis).

## INTRODUCTION

As the name indicates, cream cheese is made from pure cream or from mixtures of cream and milk. It has a rich, mildly acidic flavour and a smooth buttery consistency. Many brands of cream cheese are produced and commercially available and large food products carry a wide variety of this cheese. Cream cheese is widely used in sweet desserts, dips, and in baking, especially in cheesecake. It is also available as a spread, filling for fruit tarts and sauce for shell-shaped pasta. Those familiar favorite products can not be eaten by malabsorption consumers who are restricted in the type of dietary fat they able to tolerate. Patients, however, yearn for such food products, that they had been accustomed to eating but are now prohibited from eating because the high level of milk fat present.

The association between the type and level of dietary fat and the risk of health problems has led to greater consumer awareness and demand for reduced-fat foods. Dietary awareness of consumers and their desire to follow nutritional guidelines by reducing total fat intake have encouraged research on low fat foods including cheese. However, the consumption of low fat cheese compared to other low fat foods is still low because of the poor consumer perception of those products, owing to flavour and texture defects. Low fat cheese has a hard, rubbery, dry and grainy texture. It is usually difficult to masticate and lacking typical original flavour. Therefore, the principal challenge in development of low fat cheese is maintaining flavour and texture of its full-fat counterpart (Simard, 1991 and Fenelon & Guinee, 2000).

Problems associated with lowering fat content in cheese may be aggravated in cream cheese because of its higher fat level and the absence of a rigid matrix. Cream cheese has a higher moisture content and a smoother mouthfeel than other cheese, which is low in moisture such as semi-soft, regular and hard cheese (Kalab et al., 1981; Ohashi et al., 1983; Buchheim & Thomasow; 1984 and Sanchez et al., 1994a,b). Moreover, milk fat has an effect on mouthfeel by contributing to the lubricity and perceived moistness caused by the fact that it melts in the mouth at just below body temperature. Adding some ingredients that bind moisture and impart fat-like characteristics when incorporated into the cheese matrix may be simulating these properties.

Fat replacers have been used successfully in a wide variety of cheese especially in Cheddar and Mozzarella cheese (Drake et al, 1996 and Rudan et al., 1998); however, there are few reports of their use in cream cheese. The objective of the present study was to formulate half-fat double cream cheese with a good texture and mouthfeel using two types of carbohydrates based fat replacers involves maltodextrin and inulin. The effect of these additives on the viscoelastic and textural properties of the resultant cheese was also studied using instrumental and sensory evaluation.

## MATERIALS AND METHODS

Fresh whole buffalo's milk (7.1% fat and 16.4 % T.S) obtained from El-Sheikh Makram farm, Central administration for agrarian reform, Sohag, Egypt. The milk was divided into eight equal batches. The first seven batches were standardized to 5 % fat and one was left without additives for comparison. The others were used to manufacture of half-fat cheese with adding maltodextrin (partially hydrolysis of corn starch, National Co. for Maize Products, 10$^{th}$ of Ramadan City, Egypt) or inulin (from chicory roots, Sigma Chem. Co., U.S.A) to the cheese milk before coagulation in ratios of 1, 3 and 5 % respectively. Additives were dispersed for 5 min using a high-speed mixer at 45°C. The last batch was standardized to 10 % fat using fresh cream (35% fat) and left without additives to serve as a control for full fat cheese. All batches were heat treated at 63 °C for 30 min then rapidly cooled to 45 °C. To each batch 0.15 % UNI-cream as a stabilizer/ emulsifier agent (United Food Industries Co., 6$^{Th}$ of October City, Egypt), 0.02 % calcium chloride and 1.5 % salt were added to the cheese milk before renneting. Double cream cheese was made from all batches in a similar method as used in conventional cheese making (Robinson and Wilbey, 1998). Cheese was packed in 450-g plastic boxes and stored at refrigerated temperature (5-8°C) for analysis. The whole experiment was duplicated.

**Compositional Analysis:**

Moisture content was determined by drying cheese samples in a drying oven at 105°C to a constant weight and fat content was determined by Gerber butyromerer method. Each sample was measured in triplicate.

**Apparent viscosity:**

The apparent viscosity of fresh cheese samples was determined using a Brookfield viscometer (Model LVDV-II$^+$, Brookfield Engineering Labs Inc., Stoughton, MA, U.S.A). Spindle number $RV_4$ was selected such that during measurements the torque was between 10 and 100%, as suggested by the manufacturer. Shear rate sweeps were conducted from $10^{-1}$ to $10^2$ $s^{-1}$ at 20 ± 1°C. Triplicate measurements were made.

**Texture Profile Analysis (TPA):**

Cheese samples in 150 g plastic boxes were tempered at room temperature (20 ± 1°C) for I hour before the test was conducted. TPA tests were performed using a Texture Analyzer (CNS- Farnell Model TA-1000, formerly known as the Stevens LFRA Texture analyzer, England). Optimized operating conditions were as follows: probe TA-15 (3-cm diameter); tests speed 1 mm/s, and 15-mm distance. The compression test was performed in two successive cycles and a comprehensive range of the texture parameters in terms of hardness, cohesiveness, adhesiveness, springiness and gumminess were calculated as described by Szczesniak (1963 and1987). The instrument is equipped with specialized software so that the attached computer can perform the calculations to generate the resulting data and a graphic representation of the texture profile curve

**Descriptive Texture Analysis:**

Descriptive analysis of cheese texture was performed by a well-trained texture profile panel of ten members composed of staff and technicians of the Food Sci. & Tech. Dept., following previously described procedures (Drake et al., 1999). Panelists were asked to identify and define mouth evaluated texture terms for the cheese. Hardness was identified, as the force required compressing the sample when biting down evenly between molar teeth. The degree to which the sample deforms before rupturing when biting with molar teeth was recognized as cohesiveness. Adhesiveness was judged by placing the sample on tongue and presses it against the palate. The force required to remove it with the tongue was described as adhesiveness. Partial compression between the tongue and the palate without breaking evaluated how the sample returns to its original shape was described as the degree of springiness. The amount of manipulation with the tongue against the palate necessary before the sample disintegrates was evaluated as gumminess. Panelists marked responses on ten-point numerical intensity scales anchored on the left with "not" and on the right with "very". The cheese was presented in three-digit coded plastic sample cups sealed with lids to avoid sample deformation because of the soft consistency of cheese. Samples were allowed to equilibrate at room temperature (20 ± 1°C) for 30 min prior to evaluation. Each cheese was evaluated three times in a randomized complete block design.

**Statistical analysis:**

Half-fat double cream cheese was manufactured in doublicate. All tests were replicated 3 times. PROG GLM of SAS was used to determine differences among treatment means. Treatment means were considered significantly different at $P < 0.05$ unless stated otherwise. A correlation coefficient between instrumental and sensory data was also performed.

## RESULTS AND DISCUSSION

**Chemical composition:**

Replacing of milk fat by both fat replacers caused a significant ($P < 0.05$) increase in the moisture content of half-fat cheese (Table 1). The increased moisture content of half-fat cheese made using fat replacers, suggested that, curd syneresis was retarded during cheese making. This can occur as a result of water being bound directly to the fat replacer, or the fat replacer may interfere with shrinkage of the casein matrix, thus lowering the driving force involved in expelling water from the curd particles. The moisture content of half-fat cheese increased as the level of fat replacers increased. So that, the differences in moisture content may reflect the level of fat replacer used in cheese manufacture. These results are in the same trend with that reported by McMahon et al., (1996). Cheese made with adding maltodextrin had a relatively higher moisture content than that made with inulin, which might be due to the higher water holding capacity of maltodextrin compared with inulin.

**Table 1: Chemical composition of half-fat double cream cheese made with carbohydrate-based fat replacers**

| Cheese samples | Moisture % | Fat % | F/DM % |
|---|---|---|---|
| Full-fat control cheese | $54.5^{f}$ | $33.1^{a}$ | $72.7^{a}$ |
| Half-fat cheese without fat replacers | $61.3^{d}$ | $15.7^{b}$ | $40.6^{e}$ |
| Half-fat cheese with 1% Inulin | $63.1^{c}$ | $15.3^{b,c}$ | $41.5^{e}$ |
| Half fat cheese with 3% Inulin | $67.3^{b}$ | $14.3^{c,d}$ | $43.7^{c,d}$ |
| Half-fat cheese with 5% Inulin | $69.8^{e}$ | $13.2^{c,d}$ | $43.7^{c,d}$ |
| Half-fat cheese with 1% Maltodextrin | $64.0^{c}$ | $15.2^{b,c,d}$ | $42.2^{e}$ |
| Half-fat cheese with 3% Maltodextrin | $68.1^{b}$ | $14.2^{c,d}$ | $44.5^{c,d}$ |
| Half-fat cheese with 5% Maltodextrin | $71.3^{a}$ | $13.1^{d}$ | $45.6^{b}$ |

**Mean values of three replicates**
**Means with the same letter are not significantly different ($P < 0.05$)**

The fat content of half-fat double cream cheese decreased significantly ($P < 0.05$) by increasing the level of fat replacer. The type of fat replacer not affected significantly the fat content of half-fat cheese, which might be due to the absence of fat in both fat replacers. The fat contents of the half-fat cheese made with fat replacers were all between 13.1 and 15.3 % fat compared with 33.1% fat in full-fat control cheese.

**Apparent viscosity:**

Apparent viscosity of soft cheese such as double cream cheese depends on the shear rate at which shear stress is determined and the time for which the shear is applied (Sanchez et al., 1996a and b). Representative plots for apparent viscosity values versus shear rate and shear stress versus shear rate plots are shown in Figures 1 and 2, respectively. A hysteresis characteristic behavior of flow curves can be observed for all cheese. The half-fat cheese made without fat replacers was found to be the least viscosity of all half-fat products. This can be attributed to the tendency of this sample to fracture at the lower shear rate rather than begin to flow. Earlier works (Massaguer-Roing et al., 1984 on Neufchatel, which may considered a low fat cream cheese and Sanchez et al., 1994 on Double cream cheese) are in agreement with these results. The other half-fat cheese containing fat replacers did not exhibit such severe fracturing behavior, and overall had higher viscosity values than the control full-fat cheese. This may be due to the ability of both fat replacers to act as thickening and gelling agents that build body and add viscosity to the product. The gels formed improve emulsion stability and control texturizing properties of the resultant cheese. Increasing the level of both fat replacers resulted in variable increase in the gel strength indicating that the relation between shear stress and the level of fat replacer was nonlinear. Truong and Daubert (2000) also found that fracture of structured gels during the vane test seems not to be just pure shear, as in fluid-like material. Cheese samples containing inulin was slightly had a lowered viscosity than multodextrin containing cheese. This may be due to the different gelling characteristics (gel strength and firmness) in the two cases. For all half-fat double cream cheese, the apparent viscosity fell as shear rate increased. The decreased apparent viscosity of the half-fat double cream cheese was due probably to the disruption of structures when the shear rate increased. Many foods exhibit irreversible thixotropic behavior resulting from sensitive structures that can be disrupted by fluid movement (Steffe, 1992). The decrease in apparent viscosity due to increased shear rate was typical of a non- Newtonian fluid exhibiting pseudoplastic behavior. Apparent viscosity in the region of high shear rate showed marked effects that were due to level of fat replacer.

Shear stress for full-fat control cheese showed only a slight increase as shear rate increased from 5 to 100 $s^{-1}$. Cheese containing both fat replacers showed a slight but reproducible decrease in shear stress from 5 to 10 $s^{-1}$ and then steady increase as shear rate increased from 10 to 100 $s^{-1}$. The observed shear-thinning behavior may be attributed to the deference in molecular structure of the two fat replacers. Inulin is a linear fructan consisting of β-(2› 1)-linked D-fructofuranose units and one terminal α-(1› 2)-linked D-glucopyranose unit. Maltodextrin is a short-chain polysaccharide consisting of D-glucose units linked primarily by α-1,4 bonds with dextrose equivalence.

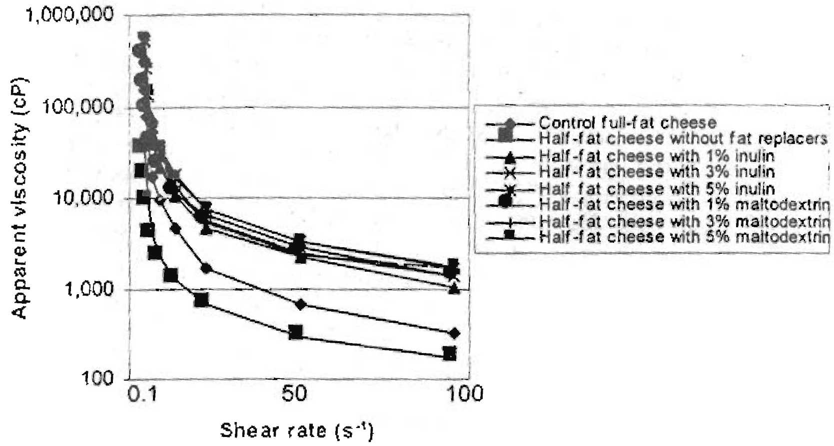


Fig. 1: Representative plot of apparent viscosity (η) versus shear rate (γ) for half-fat double cream cheese made with carbohydrate-based fat replacers.

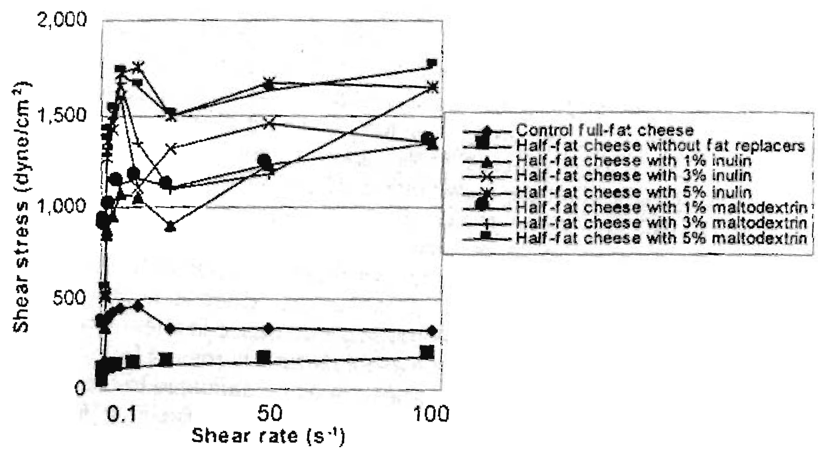


Fig.2: Representative plot of shear stress (σ) versus shear rate (γ) for half-fat double cream cheese made with carbohydrate-based fat replacers.

The average molecular weight and degree of hydrolysis of maltodextrins varies up to dextrose equivalence (DE) of 20. It was reported that, molecular weight and DE determine maltodextrin functional properties, such as viscosity and bodying ability (Duxbury, 1992 and Akoh, 1998).

Shear stress and apparent viscosity trends for double cream cheese containing fat replacers were consistent with the results of Mangold et al., (1999) for two brands of commercial cream cheese with regular, light and fat-free formulations as determined by Brookfield viscometer at the shear rate range of 0.34-67.7 $s^{-1}$. These current results are also in good agreement with the texture map of cream cheese constructed from vane yield stress and apparent strain by Breidinger and Steffe (2001). The authors reported that although there is no direct correlation between the percentage of fat contained in cream cheese and the yield stress, different trends observed for a variety of commercially available cream cheese contained different fat contents.

**Texture profile analysis:**

A typical force deformation curve obtained from double cycled compression for the full-fat control cheese as an example is shown in Fig.3. The texture parameters calculated were as follows:

- Hardness = Maximum force recorded during the first compression cycle (g).
- Cohesiveness = Positive area under pick $A_2$ / area under pick $A_1$.
- Adhesiveness = Negative area for the first bite (g/sec).
- Gumminess = Hardness x Cohesiveness (g/mm).
- Springiness = Width of the down stroke in pick $A_2$ (mm).

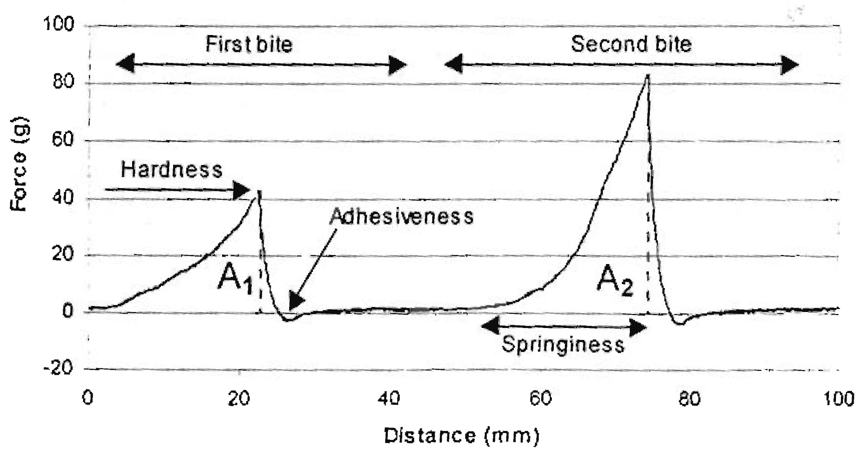


**Fig. 3: Typical texture profile curve obtained for full-fat control cheese**

The results of instrumental measurements of cheese texture are given in Table 2. In the case of cheese, hardness is usually considered to be the most important texture attribute. Significant ($P < 0.05$) differences in hardness were observed between the full-fat control cheese and the half-fat cheese made with or without fat replacers. The half-fat cheese made without fat replacers appeared much harder than full-fat control cheese that may be due to its lower fat content. Mistry and Anderson, (1993) found that lowering fat content forms a more compact protein network, resulting in a hard, rubbery cheese. Bryant *et al*., (1995) found also that the hardness of Cheddar cheese increased as the fat content reduced despite the concomitant increase in the moisture content. Cream cheese as evidenced by electron microscopy can be thought of as a filled gel. The fat globules act as filler, disrupting the protein matrix and forming a more porous structure (Kalab *et al*., 1981; Kalab & Modler, 1985 and Sargant *et al*., 1985). Addition of both fat replacers to the cheese milk resulted in an increase of the cheese hardness. The higher hardness values of cheese containing fat replacers may be due to the ability of the fat replacers to hydrogen bonding and subsequent gel formation. The gel formed is not quite firm as with many starches, but soft and fairly easy to reverse or deform. However, cheese samples containing maltodextrin required greater force to penetrate the cheese curd than did those containing inulin.

**Table 2:Instrumental texture attributes of half-fat double cream cheese made with carbohydrate-based fat replacers**

| Cheese samples | Objective texture attributes | | | | |
|---|---|---|---|---|---|
| | Hard-ness (g) | Cohesive-ness (ratio) | Adhesive-ness (g/sec) | Springi-ness (mm) | Gummi-ness (g/mm) |
| Full-fat control cheese | $42.7^{g}$ | $1.21^{d}$ | $6.4^{a}$ | $13.5^{f}$ | $51.7^{e}$ |
| Half fat cheese without fat replacers | $59.4^{e}$ | $1.73^{a}$ | $3.7^{d}$ | $19.8^{e}$ | $102.8^{c}$ |
| Half fat cheese with 1% Inulin | $63.6^{d}$ | $1.64^{a,b}$ | $3.9^{c,d}$ | $20.5^{d,e}$ | $104.3^{c}$ |
| Half fat cheese with 3% Inulin | $77.6^{b}$ | $1.50^{a,b,c}$ | $4.5^{b,c}$ | $21.7^{c,d}$ | $116.4^{b}$ |
| Half fat cheese with 5% Inulin | $47.5^{f}$ | $1.31^{c,d}$ | $5.1^{b}$ | $23.1^{b,c}$ | $62.2^{d}$ |
| Half-fat cheese with 1% Maltodextrin | $66.7^{c}$ | $1.58^{a,b}$ | $3.8^{c,d}$ | $21.1^{d,e}$ | $105.4^{c}$ |
| Half-fat cheese with 3% Maltodextrin | $90.9^{a}$ | $1.42^{b,c,d}$ | $4.1^{c,d}$ | $23.8^{a,b}$ | $129.1^{a}$ |
| Half-fat cheese with 5% Maltodextrin | $49.4^{f}$ | $1.26^{c,d}$ | $4.3^{c}$ | $25.2^{a}$ | $62.2^{d}$ |

**Mean values of three replicates**
**Means with the same letter are not significantly different (P< 0.05)**

An incremental increase in the level of any fat replacer up to 5 % resulted in a pronounced decrease in the cheese hardness. This may be attributed to the relative contribution of hydrophobic interactions and hydrogen bonds. Hydrogen bonding seems to contribute more in gels with less fat replacer level while hydrophobic interactions seem to increase with the increase in fat replacer level. It has been suggested that when too much fat replacer was present, protein aggregation occur before protein unfolding and three-dimensional structure could not be formed. A large amount of water being bound to the excessive quantity of fat replacer added might be another factoring in decreasing the cheese hardness. At the high moisture content, the fat replacer tends to form more like a smooth paste rater than a quite firm gel leading to a more open matrix, which could produce a softer cheese. Also important in first bite is the amount of moisture released from the sample and the amount of particles resulting from the bite or that are detected in the sample's center. Hori, (1982) reported that the hardness of cream cheese decreased as both the amount and the structural strength of bound water increased.

Cohesiveness value reflects the strength of the internal bonds making up the cheese body (Szczesniak, 1963). The half-fat cheese made with or without fat replacers had significantly ($P < 0.05$) higher cohesiveness values than the full-fat control cheese possibly due to its lower fat content. These results are in agreement with those of Bryant *et al.*, (1995) who reported that the cohesiveness of Cheddar cheese increased as the fat content reduced. All half-fat cheese containing fat replacers had significantly lower cohesiveness than the half-fat cheese made without fat replacers. The reduction in cohesiveness was proportional with the level of fat replacer. This may be due to the presence of fat replacer and to the lower protein content. Bhaskaracharya and Shah (1999) have reported a positive correlation between protein content and cohesiveness of Mozzarella cheese. The differences in cohesiveness values between cheese containing maltodextrin and those containing inulin may be due to the differences in particle size and the water holding capacity of each. It was reported that, The larger particle size coupled with the higher water holding capacity of a fat replacer possibly appears to have cause a disruption of the cheese matrix resulting in fracturing of the cheese protein network and lead to a lower cohesiveness product (Mounsey and O'Riordan, 2001).

Adhesiveness recognized as the work required overcoming attractive forces between surface of the food and surface of other materials with which the food comes into contact. Reducing of milk fat, in general, resulted in reduction of adhesiveness of half-fat double cream cheese. The adhesiveness values for cheese ranged from 3.7 to 6.4 g/mm, being the maximum in full-fat control cheese and the minimum in half-fat cheese made without fat replacers. Adhesiveness values varied between cheese made using the two types of fat replacers. Half-fat cheese containing inulin showed relatively higher adhesiveness values than those containing maltodextrin. This may be attributed to the different characteristics of gel formed in the two cases. Inulin has the tendency to form a cream consistency gel whereas maltodextrin forms a cuttable gel (Duxbury, 1992 and Cho & Dreher, 2001).

For all half-fat cheese containing fat replacer, the springiness values were significantly higher than that of full-fat control cheese, indicating the dominant viscoelastic properties of the resultant cheese. The springiness values for all fat replacer-containing cheese ranged from 20.5 to 25.2 mm compared with 13.5 mm for the full-fat control cheese. The dominant viscoelastic properties may be attributed to the presence of a network arrangement formed in the continuous phase such as cross-linkages or entanglement of polymeric fibers added as fat replacers leading to a stronger structure organization. Similar results were found for imitation cheese containing native starches by (Mounsey and O'Riordan, 2001).

half-fat cheese with desired properties. Varying the type of fat replacer and the level permits the textures to be tailored for a specific application (such as cheesecake, dips, toppings, pastry and various recipes). Depending on the application, half-fat double cream cheese containing fat replacers may be also added to foods to increase viscosity, add mouthfeel or bind other added ingredients. Whether a food manufacturer chooses maltodextrin or inulin depends on the further application but both can be used to develop innovative and healthy products.

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**عبد العال عابدين علي عبد الخير**

**قسم علوم وتكنولوجيا الأغذية - كلية الزراعة بسوهاج - جامعة جنوب الوادى**

أستهدف هذا البحث دراســة تأثير استبدال دهن اللبن المعد لصناعة جبـــن القشـــــدة جزئيا بنوعين من بدائل الدهن ـــ كلاهما من أصل كربوهيدراتـــي ـــ همـــا المالتودكســـترين والانيولين على خواص الجبن الناتج ، حيث تم خلط كل منهما على حـــدة بنســـب ١ ، ٣ ، ٥ % على الترتيب مع لبن جاموسي معدل إلى ٥ % دهن مع المقارنة بمعاملتين إحداهما من نفس اللبـــن بدون إضافة بدائل الدهن والأخرى من لبن جاموسي معدل إلى ١٠ % دهن ، وتم تقدير الـتركيب الكيميائي والخواص الريولوجيـــة والحسيـــة للجبن الناتج من جميع المعاملات ، كمـــا تـــم مقارنة نتائج التحكيم الحسي إحصائيا بالقياسات الريولوجيـــة المتحصل عليها. وقـــد أشـــارت النتائج إلى أن استبدال دهن اللبن ببدائل الدهن أدى إلى حدوث ارتفاعا ملحوظا في نسبة الرطوبـــة مع انخفاضا ملحوظا في نسبة الدهن في عينات الجبن الناتج بالقياس إلى عينة المقارنة. كمـــا أدى هذا الاستبدال إلى زيادة اللزوجـــة في الجبن الناتج عنه في جبن المقارنة أو الجبن المنخفض فـــي نسبة الدهن المصنع بدون استخدام بدائل الدهـــن و ارتفعـــت هـــذه الزيـــادة مـــع زيـــادة نســـبة الاستبدال.أيضا أدى استبدال دهن اللبن بوجه عام إلى زيادة درجة الصلابة والمر ونـــه والقابليـــة للبلع مع انخفاض درجة التماسك وقوة الالتصاق في الجبن الناتج عنه فـــي جبـــن المقارنـــة وقـــد أظهرت نتائج التقييم الحسي ارتباطا قويا بالقياسات الريولوجيـــة لمعظـــم الخـــواص التـــي تـــم دراستها في عينات الجبن الناتج خاصة من حيث درجة الصلابة وقوة تماسك الخثرة. هـــذا وقـــد أظهرا كلا النوعين من البدائل كفاءة عالية في استبدال دهن اللبن جزئيا لانتاج جبن قشدة نصـــف دسم ذو نطاق واسع من الخواص التركيبية والوظيفية تسمح باستخدامه في العديد من التطبيقات.