Cheddar Cheese Fluoridation and Dental Health

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SUMMARY

The main objective of this study was to determine what effect the addition of sodium fluoride would have on the Cheddar cheese quality. Raw milk was pasteurized and separated for three treatments as follows: control, supplemented with 4 ppm and 40 ppm fluoride. Cheddar cheese was processed for each treatment and ripened for 120 days at $7^{o}C$ and sampled at 60 and 120 days.
Analyses performed included both sensory evaluation and gas chromatography with headspace sampling (GCHS). Under conditions of this study significant $P< 0.05$ higher mean flavor and body/texture scores were observed in both the control cheese samples and those with 4 ppm added fluoride than those with 40 ppm added fluorides.
The predominant flavor criticisms in Cheddar cheese treated with 40 ppm added fluoride after 120 days were flat, lacks flavor and bitter. The predominant body/texture criticisms noted in Cheddar cheese treated with 40 ppm added fluoride after 120 days were open, mealy, corky, crumbly, pasty and curdy. GCHS results showed that Acetone, 2- butanone, ethanol, 2-pentanone and propanol increased significantly ($P< 0.05$) with aging of the Cheddar cheese. However after 60 days of ripening, the control cheese had significantly ($P< 0.05$) lower Acetone, 2-pentanone and higher ethanol values than the fluoridated cheese. By 120 days, the control cheese had significantly ($P< 0.05$) higher 2-butanone values than both treated cheese and higher ethanol than the cheese fluoridated at 40 ppm.

فلورة جبن الجدر وصحة الأسنان

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الخلاصة

كان الهدف الرئيسي لهذه الدراسة هو لتحديد تأثير إضافة فلوريد الصوديوم للحليب على نوعية جبن الجدر. تم تقسيم الحليب بعد بسترته إلى ثلاثة معاملات حيث كانت الأولى خالية من الفلورة (سيطرة) بينما تضمنت الثانية والثالثة إضافة فلوريد الصوديوم للحليب وبتركيز 4 ppm و 40 ppm) على التوالي. تم تصنيع جبن الجدر لكل من المعاملات الثلاثة المذكورة ثم نضجت في غرف مبردة على درجة حرارة 7 ^{o}م ثم جمعت منها العينات بعمر 60 و 120 يوماً لإجراء التقييم الحسي لها ومعرفة مركبات النكهة باستخدام التحليلات الكروماتوكرافية (GCHC). أكدت الدراسة بوجود زيادة في معدلات الدرجات الخاصة بصفة كل من النكهة والنسجة والقوام وبصورة معنوية $P < 0.05$ في الأجبان الخالية من الفلورة (سيطرة) والأجبان المفلورة التي حضرت من حليب مضافاً إليه فلوريد الصوديوم بتركيز 4 ppm مقارنة مع نظيرتها المفلورة بتركيز 40 ppm. أبرز صفات النكهة السائدة في الأجبان المفلورة بتركيز 40 ppm بعد مرور 120 يوماً على إنضاجها كانت عديمة الطعم وفقدانها للنكهة بالإضافة إلى مرارتها.

أبرز صفات النسجة والقوام السائدة في الأجبان المفلورة بتركيز 40 ppm بعد مرور 120 يوماً على إنضاجها كانت مفتوح وخشن وخليني ومتفتت وعجيني ومطاطي.

أكدت التحليلات الكروماتوكرافية (GCHs) بأن هناك زيادات معنوية ($P<0.05$) في تراكيز كل من الاسيتون و 2 – بيوتانون والكحول الأيثيلي و 2 – بنتانون والبروبانول مع تقدم الفترة الزمنية لإنضاج جبن الجدر. وبعد مرور 60 يوماً على إنضاجها أحتوت الأجبان الخالية من الفلورة وبصورة معنوية $P<0.05$ على قيم منخفضة من الأسيتون و 2 – بنتانون وقيم مرتفعة من الكحول الأيثيلي مقارنة مع نظيرتها المفلورة.

وبعد مرور 120 يوماً على إنضاجها أحتوت الأجبان الخالية من الفلورة وبصورة معنوية $P<0.05$ على قيم مرتفعة من 2– بيوتانون مقارنة مع نظيرتها المفلورة وقيم عالية من الكحول الأيثيلي مقارنة مع نظيرتها المفلورة بـ 4 0 ppm

Introduction

Dental caries is defined as a disease of mineralized structure of the teeth characterized by demineralization of the hard component and dissolution of organic matrix (1, 2, 3). One of the many benefits of consuming milk and cheese is the teeth building since they contain tooth forming nutrients (4, 5). (6) Proved that the enamel of teeth contains more fluorine in the form of calcium fluoride, than any other part of the body. A supply of fluorine, while the development of teeth is proceeding, is essential to the proper formation of the enamel (5). (2) And (7) reported that fluoride fights cavities by slowing down the acid-producing bacteria that generates cavities and promotes remineralization of hard tooth structures. (8) and (9) concluded in their studies that fluoridation of dairy products have value as dental caries inhibitors when consumed in sufficient quantities by the young and present no hazard to the public health.

Materials and Methods

Raw milk was pasteurized at 72^{o}C for 15 sec. and separated for three treatments as follows: control, supplemented with 4 ppm and 40 ppm fluoride. The milk for each treatment was transferred into 250 L stainless steel vats and Cheddar cheese was processed for each treatment as described by Kosikwski (10). The waxed cheese blocks were placed on wooden shelves at 7^{o}C and ripened for 120 days. Fluoride concentration in Cheddar cheese curd was determined potentiometrically by measuring the fluoride Ions by a specific fluoride electrode (by using Orion-Research microprocessor ionalyzer/ 901) in the milk and the whey (at the beginning and at the end of draining). Cheese samples for both sensory evaluation and chemical analysis were taken on days 60 and 120 of ripening.

Flavor, Body and Texture Evaluation:

Cheddar cheese from each treatment was subjected to sensory evaluation by a three- member trained panel at 60 and 120 days. Modified ADSA Cheddar cheese scorecard (11) was used to score the flavor, (1-10 scale), while body / texture were scored on a 1-5 hedonic scale (5 being perfect). A flavor score of less tham 5 was regarded as unacceptable (poor), 5-6 fair, 7-8 good and 9-10 excellent.

Volatile Organic Analysis

Sample for GCHS were prepared in duplicate as follow, two gram cheese sample was weighed into a 10 ml vial and sealed by a hand crimper with special

closures (Perkin-Elmer Corporation). After sealing, samples were frozen and analyzed at a later date. Volatile organics such as Acetone, 2-Butanone, Ethanol, 2-Pentanone and propanol, were monitored by gas chromatography with headspace sampling (GCHS) as described by (12). Slight modifications were made to maximize separation and accuracy without large increases in program time. The following were equipment and operating conditions utilized in this study: Perkin-Elmer model HS6 headspace analyzer; Perkin-Elmer Sigma 3b gas chromotograph with flame ionization detector; Perkin-Elmer Sigma 15 computer console and integrator; samples thermostated at 80^{o} C for a minimum of 15 min prior to vial pressurization for 4 min.; injector and detector temperatures of 140^{o}C and 145^{o} C , respectively; injection time 5 sec.; stainless steel column (4m x 3.2 mm o.d.) packed with 4% Carbowax 20M on chromosorb G AW DMCs, 80 / 100 mesh; isothermal analysis at 70 C^{o} ; and nitrogen carrier gas at a flow rate of 28 ml / min. Standard samples were prepared using the method of standard additions as recommended for milk (13).

Results

Effect of Fluoride on Flavor, and Body / Texture of Cheddar Cheese

In this study, flavor evaluations were conducted on both 60 and 120 days. Mean of flavor scores for the control had non significant differences from the 4 ppm fluoridated Cheddar cheese but had significant difference ($P< 0.05$) from the 40 ppm fluoridated cheese (table 1). In addition, the predominant flavor criticisms in the cheese treated with 40 ppm added fluoride were flat, lacks flavor and bitter (table 2). By 120 d, bitterness was detected in 19 % of Cheddar cheese treated with fluoride. None of the control or 4 ppm added fluoride cheese were criticized as bitter.

Mean body/ Texture scores were conducted on 60 and 120 days (table 3) and revealed that cheese made from 40 ppm added fluoride had significantly ($P< 0.05$) lower scores than both the control and the 4 ppm added fluoride. In addition, predominant body / texture criticisms noted in cheese treated with 40 ppm added fluoride after 120 days were open, mealy, corky, crumbly, pasty and curdy (table 4).

Table(1): Effect of fluoride on flavor scores of Cheddar cheese on both days 60 and 120 of ripening

Treatments	Mean
Control	7.11 A*
4 ppm fluoride	6.87 A
40 ppm fluoride	6.00 B

* Means not followed by the same letter differ significantly (P<0.05)

Table (2): Effect of fluoride on flavor criticisms of Cheddar cheese after 120 days.

Treatment	Flat %	Lack flavor %	Bitter %	Unclean %
Control	0	0	0	0
4 ppm fluoride	58	42	0	0
40 ppm fluoride	39	34	19	8

Table (3): Effect of fluoride on body / texture scores of Cheddar cheese on both days 60 and 120 of ripening.

Treatments	Mean
Control	4.00 A*
4 ppm fluoride	3.84 A
40 ppm fluoride	3.00 B

* Means not followed by the same letter differ significantly (P<0.05)

Table (4): Effect of fluoride on body / texture criticism of Cheddar cheese after 120 days.

Treatment	Open %	Pasty %	Curdy %	Crumbly %	Corky %	Mealy %
Control	35	36	29	-	-	-
4 ppm fluoride	46	28	26	-	-	-
40 ppm fluoride	45	11	6	6	16	16

Effect of added fluoride to milk on Volatile organic chemicals and flavor of Cheddar cheese

Results of GCHS for cheese at 60 and 120 days are shown in Tables 5 and 6, respectively. Acetone, 2-butanone, Ethanol, 2-pentanone and propanol increased with aging of the Cheddar cheese. By 60 days, the control cheese had significantly ($P< 0.05$) lower acetone and 2-pentanone values and higher ethanol values than the fluoridated cheese (Table 5). By 120 days, the control cheese had significantly ($p<0.05$) higher 2-butanone than both treated cheese and higher ethanol than the cheese fluoridated at 40 ppm (Table 6).

Table (5): Effect of fluoride on organic volatiles of Cheddar cheese at 60 days of ripening

Treatment	Acetone ppm	2-butanone ppm	Ethanol ppm	2-pentanone ppm	Propanol ppm
Control	1.00 A*	2.10 A	26.60 A	0.28 A	0.01 A
4 ppm fluoride	1.80 B	2.07 A	20.75 B	1.22 B	0.09 B
40 ppm fluoride	1.60 B	2.12 A	18.90 B	1.54 B	0.00 A

* Means in a column not followed by the same letter differ significantly ($P<0.05$)

Table (6): Effect of fluoride on organic volatiles of Cheddar cheese at 120 days of ripening

Treatment	Acetone ppm	2-butanone ppm	Ethanol ppm	2-pentanone ppm	Propanol ppm
Control	1.66 A*	2.25 A	35.40 A	1.26 A	0.10 A
4 ppm fluoride	1.87 A	2.00 B	32.08 A	0.96 A	0.08 A
40 ppm fluoride	1.82 A	2.02 B	20.90 B	1.07 A	0.06 A

* Means in a column not followed by the same letter differ significantly ($P<0.05$)

Discussion

Fluoride is considered toxic if consumed in excessive amount. Ingestion of 20-80 mg of fluoride has been reported to cause fluorosis (17). The normal daily intake of fluoride should not exceed 2 mg. Fluoride intakes above the level of 10 mg per day are not recommended for adults (17).

Results indicated that 75% of the total fluoride added to the pasteurized milk was lost in the whey and only 25% of the total fluoride was left in the curd, therefore, with the level of 4 ppm being added, a residual of 1 ppm remained with the curd which give an indication that Cheddar cheese can be an effective vehicle for carrying fluoride to the human body (5). In most instances, there were no major differences between the control cheese (no added fluoride) and cheese with 4 ppm fluoride. Higher mean flavor and body / texture scores were observed in control cheese and cheese with only 4 ppm added fluoride. The treatment with 40 ppm added fluoride resulted in significantly ($P<0.05$) lower flavor and body / texture scores. A realistic explanation for such result could be related to the effect of fluoride (40 ppm) on the metabolic activity of the starter culture. This means that the starter bacteria may actually have been injured by the added fluoride.

Bitter flavor develops in Cheddar cheese when the starter bacteria during the ripening period being unable to degrade the bitter peptides produced by the rennin to non- bitter products (14). The flavor of Cheddar cheese is attributed to a delicate balance of volatile organic chemicals produced as metabolites by starter bacteria during fermentation (12). Manning (15) indicated that 2-pentanone concentrations in normal cheese are a good index of cheese age, but the compound is not necessarily involved in flavor. The compound 2-butanone is never found in concentration higher than its threshold and tends to disappear as cheese ages (16). From these data, the limit 4 ppm sodium fluoride should not

be exceeded when adding the fluoride to the milk from which the Cheddar cheese will be made.

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