

INFLUENCE OF SALT CONTENT ON THE CHEMICAL, RHEOLOGICAL AND SENSORY PROPERTIES OF GOUDA CHEESE

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Abstract

Gouda cheese was made from fresh cow's milk standardized to 3.5% fat by traditional method. The curd blocks were divided into six parts. The first part was soaked in 20% brine at pH 4.8, 15°C for 48 hrs (as control) and the remaining parts were soaked in 20% brine for 12, 24, 30 and 06hrs. The resultant cheese were ripened at 10-12°C for 3 months. Moisture, salt, fat, acidity, TN, WSN, TVFA contents, rheological and sensory properties of cheese were assessed at 0 (fresh), 15, 30, 60 and 90 days. TN% increased by increasing the brining and the maturation time, was the highest after brining for 60 hr and maturing for 90 days. WSN%, WSN/TN and TVFA decreased gradually in the fresh cheese being the lowest value in the sample brined for 60 hr. and increased in the cheese brined for 12 hr. and ripened for 90 days. Hardness, springiness, gumminess and chewiness increased during ripening up to 60 days and then decreased after that. Cheese salted for 48 hr. gained the highest scores of sensory properties followed by the cheese salted for 24hr., 36hr. and 60hr. while the cheese salted for 12hr. gained the lowest score.

Key words: Gouda cheese – Salt content- Chemical composition – Rheological properties

INTRODUCTION

Gouda cheese is a semi-hard cheese originated in Netherlands and resembles Edam cheese, more firm curd and flat shape with minor differences. The demand for this cheese type has been increased in Egypt accordingly some local dairy factories manufactured this type on commercial scale. Cheese has generally been considered to contribute relatively little sodium intake, however, with increasing cheese consumption, the contribution of cheese to dietary sodium is likely to be increased (Guinee, 2004). Salting process is considered one of the main steps in cheese making, where salt has a major influence on cheese proteolysis and play a great role in the development of flavour and texture (Banks et al., 1993, Mistry and Kasperson, 1998).

Saito (2000) found that the strongest depressive effect in the blood pressure (-24.7 mm Hg) and the intensive inhibitory activity to angiotensin I-converting enzyme (75.7%) were detected in the peptides from 8-months-aged Gouda cheese. The salt level markedly influences cheese flavor and aroma. Rheological and texture properties,

cooking performance and, hence, overall quality are also influenced. Probably one of the most effective ways of reducing the salt content of any cheese is to consistently maintain the salt content at the minimum level required for optimal quality of the variety (Guinee, 2004). Salt has three major functions in cheese: it acts as a preservative, contributes directly to flavour, and is a source of dietary sodium. The recommended daily intake for adults is around 2.4 grams of sodium or around six grams of sodium chloride per day (Guinee, 2004). The most significant problems associated with high sodium intake are hypertension and increased calcium excretion, which may lead to osteoporosis (Horton, 2002).

On the other hand, it was well established that salt content in foods influence blood pressure (Gifford, 1993, Guinee, 2004) which increase sharply with increasing salt intake. For preventing and treating hypertension we must do reduction in current daily salt intake (American heart association committee, 1994).

Therefore, this study was carried out to investigate the effect of various salt contents and compare this effect with traditional salting time of Gouda cheese and study the ability of Gouda-cheese with low level of salt content in order to help lowering hypertension.

MATERIALS AND METHODS

Materials

Milk: Fresh cow's milk used in this study was obtained from the herd of Animal production Research Institute, Ministry of Agriculture (Sakha Experimental station).

Starter: Mesophilic mixed culture was obtained from Hansen Laboratories (Denmark).

Rennet: Standard animal rennet powder was obtained from Hansen Laboratories (Denmark).

Salt: Commercial edible grade sodium chloride was obtained from El-Nasr Company for salt, Alexandria, Egypt

Methods:-

Cheese making: Gouda cheese was manufactured as described by Scott (1998) as follows: fresh cow's milk standardized to 3.5% fat, the milk was heated to 72°C for 15-20 sec. then cooled to 31°C. Annatto, Calcium chloride and sodium nitrate were added at the rate of 20-25ml/100 kg milk, 0.02% CaCl₂ (added as 35% solution) and 0.005% respectively. The milk was incubated with 1% commercial starter culture and thoroughly mixed with the milk, when acidity of milk reached 0.19 – 0.20% rennet was added at the rate of 3.0 gm rennet powder/100kg milk. As the curd became firm enough, almost within 25 – 30 minutes, it was cut into 0.5 – 1.5 cm cubes using sharp knives for 10 – 15 minutes with stirring curd to float in whey. Scalding was

accomplished by replacing 30% of the whey with hot water and not more than 80°C to give final temperature of 36 – 38°C in about 30 minutes with continuous stirring. The curd is lightly pressed at 2-4 kg/cm² by using metallic plates under the surface of whey for 15-30 minutes. The whey was then drained off and the curd was filled in the moulds at pH 5.85 – 6.05. The cheese was pressed for 8hr. During this time the cheese was turned and dressed to produce required shape (rounded corners). The press weight was increased when the cheese was returned from 95-195 KPa. The pressed curd pH was 5.1 – 5.2 and the acidity of whey from press was 0.35 – 0.40%. The curd blocks were divided into six parts.

The first part was soaked in 20% brine at pH 4.8 and 15°C for 48hr (as a control) and the other parts were soaked in 20% brine for 12, 24, 36 and 60hr. After salting, the green cheese were weighted and placed for 2 days in ripening room for drying. The cheese was then carefully coated with plastic coat. Resultant cheese was then kept in the ripening room at 10 – 12°C and 85-95% relative humidity for 3 months.

Chemical analysis

Moisture, fat, salt contents of cheeses were determined according to AOAC (1994).

pH value: Two grams cheese were weighed and 50 ml of neutralized boiled distilled water was added and mixed thoroughly with a glass rod, after cooling to 20°C the pH was measured using a digital pH meter model SA 720 (Orion U.S.A).

Titrateable acidity: Titrateable acidity was determined according to the method described by Ling (1963).

Nitrogen distribution: The total nitrogen content (TN), water soluble nitrogen (W.S.N) and non-protein nitrogen (NPN) were estimated according to semi-microkjeldahl method as described by Ling (1963).

Total volatile fatty acids: Total volatile fatty acids (TVFA) were determined by the distillation method described by Kosikowski (1966), values were expressed as ml (0.1 N) NaOH/100gm cheese.

Textural properties: Textural properties such as hardness, springiness, cohesiveness, Textural gumminess and chewiness of cheese were measured with an Instron Universal machine (Model 1195, Instron Corporation, Canton, M. A., U.S.A) by the method of Yang and Tornato (1983).

Sensory evaluation of Gouda cheese: Sensory tests of Gouda cheese were carried out according to scoring sheet proposed by El-Kenawy (1977).

RESULTS AND DISCUSSION

Table (1) revealed that the percentage of moisture became the lowest and the fat % the highest in Gouda cheese brined for 60 hours in all matured Gouda cheese groups and especially in the cheese matured for 90 days. The salt%, salt/moisture increased in the Gouda cheese brined for 60 hours and matured for 90 days. The titratable acidity was the highest in cheese stored for 90 days maturation with different brining times (12, 24, 36, 48 and 60 hours) and also gave higher values in the samples brined for 12 hours compared with those brined for 36 and 48 hours and was the least in Gouda cheese brined for 60 hours.

Table 1. Moisture, Salt, Salt/Moisture, Fat and Titratable acidity of Gouda cheese as affected by salting time.

Parameters	Cheese age (days)	Treatment (Salting time)				
		12hr	24hr	36hr	48hr (control)	60hr
Moisture(%)	Fresh	51.30	50.21	48.46	46.66	44.54
	15	48.32	47.51	46.87	44.11	43.00
	30	47.63	45.85	43.33	42.81	41.03
	60	44.05	43.65	41.67	40.40	39.02
	90	42.08	41.81	40.28	39.68	37.82
Salt%	Fresh	1.20	1.47	1.68	2.31	2.58
	15	1.42	1.60	1.93	2.54	2.75
	30	1.55	1.85	2.01	2.72	2.99
	60	1.68	1.92	2.34	2.94	3.23
	90	1.83	2.00	2.57	3.33	3.56
Salt/Moisture	Fresh	2.34	2.93	3.47	4.95	5.78
	15	2.94	3.37	4.12	5.76	6.39
	30	3.25	3.93	4.64	6.35	7.29
	60	3.81	4.40	5.62	7.28	8.28
	90	4.35	4.78	6.38	8.39	9.41
Fat%	Fresh	21.08	22.21	23.58	24.29	25.00
	15	22.63	23.32	24.63	25.38	26.13
	30	23.78	24.09	25.26	26.61	27.43
	60	24.04	25.08	26.48	28.21	28.67
	90	26.13	27.08	28.11	29.00	30.08
Titratable acidity%	Fresh	1.01	0.99	0.89	0.88	0.73
	15	1.38	1.24	1.18	1.16	0.98
	30	1.62	1.39	1.32	1.29	1.01
	60	1.84	1.68	1.63	1.58	1.32
	90	2.01	1.96	1.92	1.89	1.46

Results are the average of 3 replicates

In the present study, a moisture content of 39.02% and 39.68% was obtained after ripening for 60 days and salting time treatment of 60 hours, or after ripening for 90 days and salting for 48 hours respectively. This is consistent with the results of Lampert (1975) who stated that the recommended final moisture content in Gouda cheese should be 39-40 %.

A level of S/M ratio of 4.64 at 36 hours salting and after 30 days ripening (equivalent to 2.01% level of salt) or S/M ratio of 5.62 after salting time for 36 hours and ripening for 60 days (equivalent to 2.34% content of salt) was obtained in this work. This is coinciding with fat% of 25.26 and 26.48% respectively. Guinee, 2004 found that the reduction of salt in dry matter (SDM) in Gouda cheese by ~20 % (from 4 to 3 % salt in dry matter) is claimed to increase the susceptibility to butyric acid fermentation. To prevent such undesirable fermentation in cheeses at salt levels of below 3.8% it requires process modifications i.e. bactofugation of milk and reduction of moisture levels.

In this study, the least level of salt% was 1.2% (corresponding to moisture of 51.3% and S/M of 2.34) and was detected only in the fresh Gouda cheese treated for 12 hours while the highest level of salt% was detected in the Gouda cheese salted for 60 hours and ripened for 90 days (3.56%) (Corresponding to moisture level of 37.82% and S/M of 9.41) while the highest titratable acidity (2.01%) was obtained after salting time of 12 hours in Gouda cheese ripened for 90 days and generally, the highest level of acidity has been obtained in cheese ripened for 90 days irrespective of the salting time, on the other hand the lowest acidity was obtained in the fresh cheese brined for 60 hours (0.73%). Bille *et al.*, 2001 stated that with acidity greater than 0.17%, lactic acid is known as developed acidity. The acidity of a substance is basically due to the hydrogen ion concentration in it. On storage, cheese samples became more acidic and more harsh in taste during maturation, therefore a shorter shelf life. The results could be compared to the present study where the acidity ranged from 0.73% in the fresh Gouda cheese salted for 60 hr to 1.46% in the Gouda cheese salted for 60 hours and ripened for 90 days.

Table (2) presents the nutritional parameters during all of the brining periods (12, 24, 36, 48 and 60 hours). It is shown that TN% increased by increasing the brining and the maturation time, it was the highest (3.99%) after brining for 60 hours and maturing for 90 days. On the other hand, WSN%, WSN/TN and TVFA decreased gradually in the fresh cheese reading the lowest value in the sample brined for 60 hours, and increased gradually reaching the maximum value in the cheese brined for 12 hours and ripened for 90 days.

Table 2. Effect of salting time Gouda-cheese on some parameters during ripening.

Parameters	Cheese age (days)	Treatment (Salting time)				
		12hr	24hr	36hr	48hr (control)	60hr
TN(%)	Fresh	2.60	2.96	3.02	3.11	3.20
	15	2.74	3.01	3.13	3.25	3.39
	30	2.83	3.19	3.24	3.37	3.51
	60	3.05	3.28	3.32	3.48	3.68
	90	3.42	3.56	3.65	3.77	3.99
WSN%	Fresh	0.189	0.175	0.168	0.165	0.155
	15	0.229	0.211	0.201	0.201	0.187
	30	0.392	0.283	0.277	0.265	0.223
	60	0.441	0.359	0.353	0.343	0.308
	90	0.533	0.522	0.514	0.510	0.424
WSN/TN	Fresh	7.27	5.91	5.56	5.31	4.84
	15	8.36	7.01	6.42	6.18	5.52
	30	10.23	8.87	8.55	7.86	6.35
	60	14.46	10.95	10.63	9.86	8.37
	90	15.58	14.66	14.08	13.53	10.63
T.V.F.A.*	Fresh	13	12	12	11	9
	15	15	15	14	12	11
	30	25	24	23	22	21
	60	33	32	31	29	29
	90	39	38	38	36	35

Results are the average of 3replicates .

*Expressed as ml (0.1N) NaOH/100gm cheese.

Different dynamics of proteolysis (N-soluble) and peptolysis (N-amino acid) during ripening caused different sensory properties of gouda-type cheeses. The flavor of cheese after 6-week of ripening depended to maximum content of amine N and soluble N. The effect of the content of peptide N on cheese flavor was minor bitterness but statistically significant. Moreover, the smell of Gouda cheese was most obvious correlated to the content of amine N. Dependence between smell and the content of peptide N was found only in the cheeses after 4-week ripening. None of the sensory quality parameters of the examined cheeses depended on the content of amino acid N. (Cichosz *et al.*, 2003). Luyten (1988) tried to characterize flavor differences between short-ripened Gouda -type cheeses. Volatiles play an important role in flavor perception of cheese. Typical cheese aroma is the result of volatiles formed by lipolysis, proteolysis and metabolism of lactose, lactate and citrate (Marilley and Casey, 2004, Smit *et al.*, 2002). The fat-derived flavor volatiles in Gouda cheese were clearly described by Alewijn *et al.*, (2005) Ketones, especially methyl ketones, are produced slightly and do not contribute substantially to the flavor of Gouda -type cheeses (Alewijn *et al.*, 2005). The contribution of (ethyl) esters to cheese flavour is concentration-dependent (Liu *et al.*, 2004). During ripening of cheese, the enzymatic degradation of amino acids leads to the formation of flavor-impact volatiles. Besides lipids and proteins, lactose is also major milk constituent for the formation of cheese aroma (Marilley and Casey, 2004).

Table (3) illustrates the rheological properties (hardness, springiness, cohesiveness, gumminess and chewiness) of gouda cheese. The maximum hardness, springiness, gumminess and chewiness were obtained in the Gouda cheese brined for 60 hours and ripened for 60 days and these properties were highest between 30-60 days of ripening when brined for 60 hours, while cohesiveness was highest in the cheese brined only for 12 hours. All these properties decreased at the end of the ripening period (90 days) at all brining times and gave the lowest value after being brined for 12 hr except for cohesiveness which was the least in the samples brined for 60 hours and ripened for 90 days (inversely correlated with the salt content) being highest in the Gouda cheese aged and ripened for 60 days. From the effect of variation in composition (fat, water, NaCl and Ca content, pH) and maturation on the behavior of Gouda cheese, it may be concluded that this cheese may be considered as a composite material. Fat particles act as filler in a swollen protein matrix. The amount of fat and the rigidity of the fat particles affect the rigidity of the cheese. Factors like pH, water and NaCl content, that change the properties of the protein matrix, clearly affect the rheological and fracture behavior of the cheese (Luyten, 1988). Our results are in agreement with Okazaki and Kato (1998), who stated that all the cheese types in their study showed an increase of softness with a decrease in hardness, cutting strength and cutting energy, along with the ripening progress.

Table 3. Hardness , Springiness , Cohesiveness , Gumminess and chewiness of Gouda-cheese during ripening as affected by salt content.

Parameters	Cheese age (days)	Treatments (Salting time)				
		12hr	24hr	36hr	48hr (control)	60hr
Hardness (N)	Fresh	2.1	2.15	2.25	2.38	2.55
	15	-	-	-	-	-
	30	2.25	2.30	2.36	2.42	2.68
	60	2.36	2.41	2.51	2.54	2.89
	90	1.79	1.98	2.15	2.26	2.40
Springiness (m.m.)	Fresh	4.60	4.80	5.25	5.62	5.85
	15	-	-	-	-	-
	30	4.85	5.00	5.42	5.84	6.00
	60	5.00	5.25	5.56	6.1	6.32
	90	4.25	4.65	5.15	5.38	5.42
Cohesiveness	Fresh	0.66	0.64	0.62	0.59	0.56
	15	-	-	-	-	-
	30	0.69	0.67	0.63	0.62	0.58
	60	0.72	0.70	0.68	0.66	0.62
	90	0.68	0.64	0.62	0.60	0.54
Gumminess (N)	Fresh	1.39	1.38	1.40	1.40	1.43
	15	-	-	-	-	-
	30	1.55	1.54	1.49	1.50	1.54
	60	1.70	1.69	1.71	1.68	1.79
	90	1.21	1.27	1.33	1.36	1.30
Chewiness (N.mm)	Fresh	6.38	6.61	7.32	7.89	8.35
	15	-	-	-	-	-
	30	7.53	7.71	8.06	8.76	9.26
	60	8.50	8.86	9.49	10.22	11.33
	90	5.17	5.89	6.87	7.30	7.02

Results are the average of 3 replicates.

N=Newton m.m=millimeter.

Comparative sensory evaluation presented in table (4) revealed that the 90 days matured Gouda cheese exhibited a more firm texture and body, better appearance and more pronounced flavor giving the best scores at all brining times. The Gouda cheese treated for 12 hours and ripened for 30 days exhibited the lowest score for appearance, texture and flavor.

Table 4. Sensory evaluation of Gouda-cheese as affected by salting time .

Ripening Period (days)	Cheese Properties	Treatments (Salting time)				
		12hr	24hr	36hr	48hr (control)	60hr
30	Appearance (15)	11	11	11	11	11
	Body& Texture (35)	22	25	28	30	23
	Flavour (50)	28	32	33	36	31
	Total	61	68	72	77	65
60	Appearance (15)	11.5	12	11.5	12.5	11.5
	Body& Texture (35)	24	28	30	32	25
	Flavour (50)	30	34	35	38	32
	Total	65.5	74	76.5	82.5	68.5
90	Appearance (15)	12	12.5	12.5	12.5	11.5
	Body& Texture (35)	25	30	32	33	26
	Flavour (50)	32	35	37	42	33.5
	Total	68	77.5	81.5	87.5	71

The present study showed that the best scores of sensory evaluation for the Gouda cheese (appearance, body, texture and flavor) have been obtained from cheese brined for 48 hours in all the samples (fresh, ripened for 60 days or ripened for 90 days) while the highest score (82.5-87.5) was obtained for Gouda cheese when brined for 48 hours combined with ripening for 60 or 90 days. This is in agreement with Guinee, (2004) who found that the sensory evaluation showed that a flavor of the composite cheese at 90 days ripening were maintained in both taste and aroma of Gouda cheese. The composite cheese ripened for 90-120 days gradually lost in both typical taste and aroma of Gouda cheese and seemed to progressively create a distinct flavor. Our results are also in agreement with Toelstede *et al.*, 2009 who stated that comparative sensory analysis revealed that a 44-week-matured Gouda cheese (GC44) exhibited a much more pronounced mouthfulness and long-lasting taste complexity when compared to a young Gouda cheese ripened for only 4 weeks (Toelstede *et al.*, 2009). The bitterness of the cheese matured for 44 weeks was found to be induced by CaCl_2 and MgCl_2 , as well as various bitter-tasting free amino acids, whereas bitter

peptides were found to influence more the bitterness quality rather than the bitter intensity of the cheese. (Toelstede and Hofmann, 2008).

Several parameters determine flavor formation in cheese including cheese making technology, salt, fat content and the ripening period (Banks *et al.*, 1993, Mistry and Kasperson, 1998, Kieronczyk, *et al.*,2004, Smit *et al.*,2005).

Guinee, 2004 stated that, at salt levels below 0.7 per cent, cheeses became excessively adhesive (sticky), acid, bitter, and soft, lacked saltiness, and had unpleasant aftertaste. The latter changes coincided with large increases in proteolysis. A consumer panel was unable to detect differences in the flavor, texture or overall desirability between cheeses with salt levels of 1.4 (~4.1% S/M and 35% moisture) and 1.1 percent (3.1% S/M and approximately 36 per cent moisture) at various times over a seven month storage period at 4.5°C.

To conclude, Salt content has a major effect on Gouda cheese composition, biochemical changes that occur during ripening and markedly influences the cheese flavor and aroma together with the rheological properties. The need to obtain as much as low salt content in Gouda cheese production can certainly be beneficial for patients with hypertension and coronary heart disease patients as well as helping the trend to decrease the daily salt intake in food. Accordingly, The study recommends the production of Gouda cheese with high biochemical, rheological and sensory quality, and low salt content using the treatment of salting for 36 hours.

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تأثير محتوى الملح على الخواص الكيميائية والريولوجية والحسية للجبن الجودا

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معهد تكنولوجيا الأغذية - مركز البحوث الزراعية - الجيزة

تم تصنيع جبن جودا بالطريقة التقليدية مع تعديل نسبة الدهن في اللبن البقرى إلى ٣,٥% وتم تقسيم الأقراص بعد تشكيلها وكبسها إلى ٦ أجزاء. الجزء الأول غمر في محلول ملحي ٢٠% على درجة pH ٤,٨ ودرجة حرارة ٥١٥م لمدة ٤٨ ساعة (كونترول) أما بقية الأجزاء فتم غمرها تحت نفس الظروف لمدد تتراوح بين ١٢ ، ٢٤ ، ٣٦ ، ٦٠ ساعة على التوالي حيث أوضحت نتائج الدراسة ما يلي:

- ١- ارتفاع نسبة الرطوبة بانخفاض المحتوى الملحي في كل المعاملات وسجلت الجبن المملحة لمدة ١٢ ساعة أعلى نسبة رطوبة كما انخفضت نسبة الرطوبة في كل المعاملات بتقدم فترة التسوية
- ٢- ارتفاع المحتوى الملحي للجبن بزيادة زمن الغمر في المحلول الملحي وارتفاع نسبة الملح في كل المعاملات بتقدم فترة لتسوية
- ٣- زادت الحموضة في كل المعاملات بتقدم فترة التسوية وكانت أعلى قيم لها في الجبن المملح لمدة ١٢ ساعة وقل القيم كانت في المعاملة بالتمليح لمدة ٦٠ ساعة
- ٤- سجلت الجبن المملحة لمدة ٦٠ ساعة أعلى نسبة من النيتروجين الكلى (T.N) بينما سجلت الجبن المملحة لمدة ١٢ ساعة اقل معدل وفي جميع المعاملات زاد النيتروجين الكلى بتقدم التسوية لتصل إلى أقصاها بعد ٩٠ يوم
- ٥- البروتين الذائب سجل أعلى قيمة له مع الجبن المملح لمدة ١٢ ساعة وزادت القيم بتقدم عمر الجبن
- ٦- أظهرت الأحماض الدهنية الطيارة الكلية أكبر قيمة مع الجبن المملح لمدة ١٢ ساعة وقل قيمة مع الجبن المملح لمدة ٦٠ ساعة وازدادت في جميع المعاملات بتقدم عمر لتسوية
- ٧- حدث زيادة في كلا من الصلابة Hardness و Springiness وكذلك Cohesiveness في جميع المعاملات بعد ٣٠ ، ٦٠ يوم من التسوية ثم عادت إلى الانخفاض مرة أخرى عند ٩٠ يوم
- ٨- زادت قيم الصلابة بارتفاع المحتوى الملحي للجبن وكذلك Springiness الذي اظهر قيم مرتفعة بزيادة زمن التمليح
- ٩- الجبن المملح لمدة ٣٦ ساعة كانت اقرب المعاملات من حيث الخواص الحسية لعينة المقارنة (كونترول) بينما كان الجبن المملح لمدة ١٢ ساعة هي الأقل في درجات التقييم الحسي بالنسبة لعينة المقارنة .

لذلك توصى الدراسة إلى إمكانية إنتاج جبن جودا على درجة من الجودة الكيميائية والريولوجية والحسية ومنخفض في محتواة من الصوديوم باستخدام طريقة التمليح لمدة ٣٦ ساعة