Minufiya J. Agric. Res. Vol.35 No. 2:515-527 (2010)"http://agri.menofia.edu.eg/megla.html"

EFFECT OF REPLACING SODIUM CHLORIDE WITH POTASSIUM CHLORIDE ON GOUDA CHEESE QUALITY

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(Received: Dec. 24 , 2009)

ABSTRACT: ***Five treatments of Gouda cheese were made to study the effect of replacing sodium chloride (NaCl) with potassium chloride (KCl) in the brine used in salting Gouda cheese. NaCl was replaced with KCl at the rate of 0.0, 20, 40, 60 and 80%. Replacement of NaCl with KCl caused a significant increase of moisture, acidity, soluble nitrogen, total volatile fatty acids, potassium content, while decreased fat, total nitrogen and sodium content. Replacement of NaCl with KCl up to 40% increased the total scores of organoleptic properties. Moisture content and pH values of all cheese treatments decreased while fat, total nitrogen, soluble nitrogen, total volatile fatty acids, acidity contents and scores of organoleptic properties increased as ripening period progressed.***

Key words: ***Gouda cheese, low sodium, potassium, brine.***

INTRODUCTION

Gouda cheese is a semi hard cheese. Six varieties of Gouda cheese are manufactured and ripened for 3 months (Vanrusselt, 1992). Consumption of this cheese in Egypt has been increased in the recent years and it has been manufactured in some Egyptian Dairy factories.

Salt has a major influence on cheese ripening and play a crucial role in developing, flavour, body and texture of cheese (Banks *et al.,* 1993). Sodium intake is primarily associated with hypertension (Dillon, 1987 and Guinee, 2004). The average total daily sodium intake by most persons in developed countries is 4 – 5 g (10 – 12 g of NaCl) (Dillon, 1987). This quantity which is 10 – 35 time greater than the minimum adult requirement (200 mg) is regarded as excessive. Various studies have indicated the ameliorating role of potassium. Animal experiments have shown that potassium protects rat from the effects of high blood pressure by a high salt intake. It is known that potassium has a diuretic effect on the kidney and increases sodium excretion. A better known role for potassium in high blood pressure is as a salt substitute and this attribute could be exploited for more than at present in the development of palatable salt free staple foods such as bread and cheeses. Potassium is a necessary adjunct in therapy of high blood pressure to overcome the excessive renal loss of potassium by thiozide diureties (Salem and Abeid, 1997).

The objectives of this study were to investigate the possibility of making a good quality low salt Gouda cheese by partial replacement of sodium chloride with potassium chloride in salting process and to monitor changes in chemical, microbiological and sensory properties of Gouda cheese.

MATERIALS AND METHODS

1. Materials:

1.1. Milk:

Fresh whole cow's milk was obtained from Tokh Tanbisha Farm, Faculty of Agriculture, Minufiya University, Shibin El-Kom, Egypt.

1.2. Starter culture:

Multiple mixed strain culture containing *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *lactis*, *Leuconostoc mesenteroides* subsp. *cremoris* and *Lactococcus lactis* subsp. *diacetylactis* was used. The culture was obtained from Chr. Hansen's Lab., Denmark.

1.3. Rennet:

Rennet powder (Hannilase L 2235) was obtained from Chr. Hansen's Lab., Denmark.

1.4. Salts:

Commercial fine grade salts (NaCl, KCl and $CaCl_2$) were used.

1.5. Annatto:

Annatto (550) was obtained from Chr. Hansen's Lab., Denmark.

1.6. Coating material:

White plastic 5% Natamycin was obtained from Chr. Hansen's Lab., Denmark.

2. Methods:

2.1. Manufacture of Gouda cheese.

Gouda cheese was manufactured as described by Scott (1998) as follows:

Fresh cow's milk was standardized to 3.0% fat. The milk was heated to 72°C for 15 – 20 sec. then cooled to 31°C. Annatto, calcium chloride were added at the rate of 20 – 25 ml / 100 kg milk, 0.02%, respectively. The milk was inoculated 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 / 100 kg milk. As the curd became firm enough, almost within 25 – 30 minutes, it was cut into 0.5 – 1.5 cm cubes

using the American knives for 10 – 15 minutes with stirring curd to float in whey. Scalding was accomplished by replacing 30% of the whey with hot water at not more than 80°C to give find temperature of 36 – 38°C in about 30 minutes with continuous stirring. The curd is lightly pressed at 2 – 4 kg / cm^2 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 mould, then the cheese was pressed. During pressing the cheese curd was turned and pressed to produce required shape. The curd blocks were then dumped into 20% brine (T_1 100% NaCl, T_2 80% NaCl + 20% KCl, T_3 60% NaCl + 40% KCl, T_4 40% NaCl + 60% KCl and T_5 20% NaCl + 80% KCl) at 15°C for 48 hr. After salting, the green cheeses were 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. All cheese treatments were sampled when fresh and during ripening period for chemical, microbiological analysis and sensory evaluation. The whole experiment was duplicated.

2.2. Chemical analysis:

Cheese were sampled at zero time and after 15, 30, 60 and 90 days of ripening period and analyzed for moisture, fat, total nitrogen (TN), soluble nitrogen (SN), pH value and titratabel acidity according to Ling (1963). Total volatile fatty acids (TVFA) were determined according to Kosikowski (1966), by direct distillation as ml NaOH 0.1 N/100 gm cheese sodium and potassium determined by corning flam photometer 410.

2.3. Bacterriological analysis:

Total bacterial counts were enumerated on standard plat count agar according to Marth (1978). Lipolytic bacteria were determined according to Salle (1961), while proteolytic bacteria determined on nutrient agar medium + 10% sterile skim milk according to Sharf (1970).

2.4. Sensory evaluation:

Organoleptic properties of different cheeses were assessed according to Hammad (2008) out of 100 points for flavour, 30 points for body & texture, and 10 points for appearance. Cheese samples were evaluated by ten panelists.

2.5. Statistical analysis:

Factorial design was used to analyze the obtained data and Duncan's test was used to calculate the multiple comparison (Steel and Torrie, 1980). Significant differences were determined at $p \leq 0.05$ level.

RESULTS AND DISCUSSION

Replacement of sodium chloride with potassium chloride did not affect significantly ($p > 0.05$) the moisture content of Gouda cheese (Tables 1, 6) (Katsiari *et al.,* 1997 and Katsiari *et al.,* 1998). Moisture content of all cheese treatments decreased significantly ($p \leq 0.05$) during ripening period. Moisture content decreased markedly during the first 30 days of ripening period, then decreased gradually as a ripening period progressed up to the end of ripening period (Tables 1, 6).

Substitution of sodium with potassium did not have significant ($p > 0.05$) effect on fat and total nitrogen content of the resultant cheese (Tables 1, 6). These results are in agreement with those reported by Katsiari *et al.* (1997) and Katasirari *et al.* (1998).

Fat and total nitrogen contents on dry matter basis of all cheese treatments did not change significantly ($p > 0.05$) as ripening period advanced (Tables 1, 6). These results are in accordance with those reported by Hammad (2008).

Replacement of NaCl with KCl caused a significant decrease in titratable acidity and this reduction was proportional to the rate of replacement (Tables 2, 6). Titratable acidity of all cheese treatments increased significantly ($p \leq 0.05$) as ripening period proceeded (Tables 2, 6). On the other hand, pH values as affected by ripening period and replacement of NaCl with KCl followed on opposite trends of these of acidity (Tables 2, 6). These results are in agreement with those reported by Hussein (2004).

Substituting of sodium chloride with potassium chloride caused a significant increase in ripening indices and this increase was proportional to the rate of replacement (Tables 2, 6). Control cheese had the lowest SN and TVFA contents, while cheese that salted with brine solution contained 20% NaCl + 80% KCl contained the highest ripening indices. On the other hand, Katsiari *et al.* (2001) reported that, replacement of sodium chloride with potassium chloride did not significantly influenced the lipolysis during cheese ripening. Ripening indices [total volatile fatty acids (TVFA) and soluble nitrogen (SN)] followed similar trends. TVFA and SN of all cheese treatments increased significantly ($p \leq 0.05$) as ripening period progressed (Tables 2, 6)

There were significant difference among cheese treatments in sodium and potassium contents (Tables 3, 6). Replacement of NaCl with KCl caused a significant increase in potassium content while decreased the sodium content and this effect was proportional to the rate of replacement. On the other hand, sodium and potassium contents of all cheese treatments did not change significantly ($p > 0.05$) during ripening period (Tables 3, 6). Similar results were reported by Katsiari *et al.* (1998).

Table 1

Table 2

Table 3

Replacement of NaCl with KCl increased the total bacterial, lipolytic bacterial and proteolytic bacterial counts, which might be due to the inhibitory effect of NaCl on bacterial growth (Hussein, 2004).

Control cheese that salted with NaCl only exhibited the lowest counts of these bacteria, while T_5 which salted with the highest ratio of KCl exhibited the highest counts of these bacteria (Table 4). Changes in counts of total bacteria, proteolytic and lipolytic bacteria are presented in Table (4). Counts of these bacteria in all cheese treatments increased during the first 30 days of ripening period then decreased as ripening period proceeded.

Total scores of organoleptic properties of all cheese treatments increased as storage period progressed. On the other hand, cheese treatments T_2 and T_3 those salted by replacing 20 and 40% of NaCl with KCl gained scores higher than those of control cheese (Tables 5, 6). Increasing the replacement rate above than 40% decreased the scores of the resultant cheese (Tables 5, 6) where bitter metallic flavour, creasy body and crumbly texture were developed. These results agree with those of Ramadan (1995).

It could be concluded that is possible to make a good quality low sodium Gouda cheese by using a brine solution that 40% of NaCl was replaced by KCl.

Table 4

Table 5

Table 6

REFERENCES

Bankes, J. M., E. A. Hunter and D. D. Muir (1993). Sensory properties of low fat Cheeder cheese. Int. Dairy J., 46: 113 – 119.

Dillon, J. (1987). Cheese in the diet. In A ECK, cheese making. Science and Technology, pp. 499 – 512. New York; Lavoisier Publishing Inc.

Guinee, T. P. (2004). Salting and the role of salt in cheese. Int. J. Dairy Technol., 57 (2 – 3): 99 – 109.

Hammad, M. N. A. (2008). Some attempts to accelerate Gouda cheese ripening using different starters. M.Sc. Thesis, Fac. Agric. Moshtohor, Zagazig Univ., Benha Branch.

Hussein, S. A. (2004). Effect of sodium chloride and potassium chloride on the growth and activity of microentrapped and free cells bifidobacteria. Proc. The 9th Egyptian Conf. for Dairy Sci. & Tech., pp. 297 – 308.

Katsiari, M. C., L. P. Voutsinas, E. Alichanidis and I. G. Roussis (1997). Reduction of sodium content in feta cheese by partial substitution of NaCl by KCl. Int. Dairy J., 7 (6 – 7): 465 – 472.

Katsiari, M. C., L. P. Voutsinas, E. Alichanidis and I. G. Roussis (1998). Manufacture of Kefalograviera cheese with less sodium by partial replacement of NaCl with KCl. Food Chem., 61 (1 – 2): 63 – 70.

Kosikowski, F. V. (1966). Cheese and fermented milk foods. 2nd Ed., Edward Brothers, Inc., Ann. Arbor., Mi., USA.

Ling, E. R. (1963). A Text Book of Dairy Chemistry. Vol. II, Chapman and Hall Ltd. London.

Marth, E. H. (1978). Standard method for the examination of dairy products 14th ed. Am. Public Health Assoc. Washington, D.C.

Ramadan, F. A. M. (1995). Parital replacent of sodium by potassium in the manufacture of Domiati cheese Egyptian J. Dairy Sci., 23 (2): 259 – 270.

Salem, A. S. and Abeid, A. M. (1997). Low sodium and cholesterol Domiati cheese. Egyptian J. Dairy Sci., 25: 123 – 134.

Sall, A. J. (1961). Laboratory Manual of Fundamental Principle of Bacteriology, 3rd ed. McGraw-Hall Co., New York.

Scott, R. (1998). Cheese making practice. 3rd Ed., Aspen Publishers, Inc., Gaithersburg, Maryland, USA.

Sharf, M. (1970). Recommended Method for the Microbial Examination of Food. 2nd ed. American Public Health Association, Inc., New York.

Steel, R. G. D. and J. H. Torrie (1980). Principles and Procedures of Statistics: A Biometrical Approach, 2nd ed. McGraw-Hill, New York.

Vanurusselt, R. (1992). Gouda cheese ripening lait-et Nous, 4: 13.

تأثير استبدال كلوريد الصوديوم بواسطة كلوريد البوتاسيوم على صفات جبن الجودا

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الملخص العربى :

يهدف هذا البحث إلى محاولة تصنيع جبن جودا منخفض الصوديوم لذلك فقد تم تصنيع خمس معاملات من جبن الجودا حيث تم التمليح فى محلول ملحى ثم استبدال كلوريد الصوديوم فيه بواسطة كلوريد البوتاسيوم بنسب إحلال صفر ، ٢٠ ، ٤٠ ، ٦٠ و ٨٠% على التوالى . ولقد أوضحت النتائج المتحصل عليها بعد تحليلها إحصائياً ما يلى :

- أدى استبدال كلوريد الصوديوم بواسطة كلوريد البوتاسيوم إلى زيادة نسب كلٍ من الرطوبة، الحموضة ، النيتروجين الذائب والأحماض الدهنية الطيارة الكلية وتركيز البوتاسيوم . بينما لم تتغير نسب كل من الرطوبة والدهن والبروتين وانخفضت نسبة الصوديوم وقيم الـ pH للجبن الناتج .
- أدى استبدال كلوريد الصوديوم بواسطة كلوريد البوتاسيوم حتى نسبة إحلال ٤٠% إلى تحسين الخواص الحسية . بينما أدت زيادة نسبة الاستبدال أعلى من ذلك إلى خفض درجات التحكيم .
- انخفضت نسبة الرطوبة وقيم الـ pH بتقدم فترة التسوية فى حين لم تتغير نسب كل من الصوديوم والبوتاسيوم والدهن والنيتروجين الكلى بينما ازدادت نسبة كل من النيتروجين الذائب والأحماض الدهنية الطيارة الكلية والحموضة ودرجات التحكيم .
- ازدادت نسبة كل من النيتروجين الذائب والأحماض الدهنية الطيارة والحموضة ودرجات التحكيم فى الجبن الناتج أثناء التخزين .

Table (1). Effect of replacing sodium chloride with potassium chloride on moisture, Total nitrogen and fat contents of Gouda cheese.

Cheese treatments	Moisture content (%)					Total nitrogen / dry matter (%)					Fat / dry matter (%)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90
T_1	46.80	44.50	43.30	41.30	40.40	5.60	5.72	5.83	6.06	6.27	44.18	44.54	44.69	44.86	45.13
T_2	47.00	44.80	43.58	41.62	40.75	5.59	5.70	5.84	6.09	6.21	44.09	44.20	44.31	44.53	45.20
T_3	47.50	45.26	43.82	42.10	41.20	5.57	5.69	5.80	6.13	6.20	44.20	44.70	44.82	45.10	45.28
T_4	47.95	45.60	44.26	42.70	41.66	5.63	5.71	5.83	6.19	6.20	44.09	44.31	45.00	45.20	45.59
T_5	48.30	46.00	44.75	43.22	42.20	5.62	5.74	5.82	6.23	6.22	44.10	44.40	44.60	44.91	45.32

T_1: Control treatment made by 100% NaCl.
T_2: treatment made by replacing 20% NaCl with KCl.
T_3: treatment made by replacing 40% NaCl with KCl.
T_4: treatment made by replacing 60% NaCl with KCl.
T_5: treatment made by replacing 80% NaCl with KCl.

Table (2). Effect of replacing sodium chloride with potassium chloride on titrtable acidity, pH, soluble nitrogen (SN) and total volatile fatty acids (TVFA) of Gouda cheese.

Cheese treatments*	Titratable acidity (%)					pH values					Soluble nitrogen (%)					Total volatile fatty acids (ml NaOH 0.1 N/100 g cheese)				
	Storage period (days)					Storage period (days)					Storage period (days)					Storage period (days)				
	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90
T_1	0.98	1.30	1.45	1.75	1.96	6.20	5.92	5.75	5.66	5.50	0.37	0.39	0.40	0.63	0.70	9.8	15.2	17.6	26.6	35.0
T_2	0.99	1.35	1.48	1.79	1.99	6.18	5.86	5.67	5.59	5.45	0.38	0.39	0.41	0.65	0.71	9.8	16.8	18.8	28.2	37.2
T_3	1.00	1.39	1.53	1.84	2.02	6.18	5.82	5.61	5.52	5.40	0.39	0.42	0.45	0.69	0.73	10.0	17.9	20.2	29.9	39.8
T_4	1.01	1.46	1.60	1.95	2.10	6.16	5.76	5.55	5.43	5.38	0.40	0.46	0.50	0.74	0.78	10.1	19.0	22.5	32.6	40.6
T_5	1.01	1.50	1.65	1.99	2.12	6.15	5.70	5.48	5.35	5.30	0.40	0.49	0.52	0.76	0.79	10.1	20.8	23.7	34.0	41.5

*** see Table (1).**

Table (3). Effect of replacing sodium chloride with potassium chloride on Na and K contents of Gouda cheese.

Cheese treatments*	Na content / moisture (%)					K content / moisture (%)				
	Storage period (days)					Storage period (days)				
	Zero	15	30	60	90	Zero	15	30	60	90
T_1	2.59	2.73	2.81	2.96	3.03	0.10	0.11	0.12	0.13	0.14
T_2	2.03	2.13	2.20	2.31	2.37	0.19	0.21	0.22	0.24	0.24
T_3	1.32	1.40	1.45	1.51	1.55	0.84	0.89	0.93	0.97	0.99
T_4	1.02	1.08	1.11	1.16	1.19	1.25	1.34	1.39	1.45	1.49
T_5	0.71	0.76	0.78	0.82	0.84	1.67	1.76	1.82	1.89	1.94

*** see Table (1).**

Table (4). Effect of replacing sodium chloride with potassium chloride on micropiological analysis of Gouda cheese.

Treatments*	Total bacteria (cfu / gm × 10^6)					Proteolytic bacteria (cfu / gm × 10^6)					Lipolytic bacteria (cfu / gm × 10^6)				
	Storage period (days)					Storage period (days)					Storage period (days)				
	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90
T_1	63.0	76.0	82.0	57.0	40.0	3.7	5.6	7.0	2.1	1.6	3.0	5.5	7.9	4.2	2.8
T_2	64.0	79.0	83.0	58.0	42.0	3.8	5.8	7.1	2.3	1.7	3.1	5.7	8.0	4.4	2.9
T_3	65.0	81.0	86.0	60.0	46.0	3.9	6.0	7.4	2.5	1.9	3.1	5.8	8.3	4.5	3.0
T_4	65.0	82.0	88.0	61.0	48.0	4.0	6.5	7.5	2.7	2.1	3.3	6.1	8.6	4.6	3.2
T_5	66.0	84.0	89.0	61.0	49.0	4.0	6.9	7.6	2.9	2.3	3.4	6.3	8.7	4.6	3.3

*** see Table (1).**

Table (5). Organoleptic evaluation of Gouda cheese made by replacing sodium chloride with potassium chloride.

Cheese treatments*	Flavour (60)					Body and texture (30)					Appearance (10)					Total scores (100)				
	Storage period (days)					Storage period (days)					Storage period (days)					Storage period (days)				
	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90	Zero	15	30	60	90
T_1	–	29	39	51	55	–	20	23	25	26	–	6	7	7	8	–	55	69	83	89
T_2	–	30	40	52	56	–	21	24	27	28	–	6	7	8	8	–	57	71	87	92
T_3	–	28	39	52	56	–	21	23	26	27	–	6	7	8	9	–	55	69	86	92
T_4	–	30	34	47	47	–	20	20	24	25	–	6	7	7	7	–	56	61	78	79
T_5	–	30	33	44	45	–	20	20	21	22	–	5	6	7	8	–	55	59	72	75

*** see Table (1).**

Table (6). Statistical analysis of the results obtained for Gouda cheese made by replacing sodium chloride with potassium chloride.

Gouda cheese properties	Means square	Effect of treatments▪					Means square	Effect of storage (days)▪				
		Multiple comparison						Multiple comparison				
		T_1•	T_2	T_3	T_4	T_5		1	3	6	9	12
Moisture (%)	4.34*	A	A	A	A	A	61.75*	A	B	C	D	E
Fat (%)	0.43*	A	A	A	A	A	13.30*	E	D	C	B	A
Total nitrogen (%)	9.18*	A	A	A	A	A	0.66*	E	D	C	B	A
Acidity (%)	0.05*	E	D	C	B	A	1.65*	E	D	C	B	A
pH values	0.06*	A	B	C	D	E	0.92*	A	B	C	D	E
Soluble nitrogen (%)	0.02*	E	D	C	B	A	0.27*	E	D	C	B	A
TVFA (ml 0.1 N NaOH/100 g)	43.12*	E	D	C	B	A	1259.75*	E	D	C	B	A
Sodium content (mg/100 g)	1290620.03*	A	B	C	D	E	145.03*	A	A	A	A	A
Potassium content(mg/100 g)	1047510.20*	E	D	C	B	A	674.65*	A	A	A	A	A
Organoleptic properties:												
Flavour (60)	71.35*	B	A	B	C	D	962.26*	–	D	C	B	A
Body & texture (30)	31.90*	A	A	A	B	C	164.10*	–	D	C	B	A
Appearance (10)	5.15*	A	A	A	B	C	14.77*	–	D	C	B	A
Total score (100)	270.28*	C	A	B	D	E	2222.22*	–	D	C	B	A

• see Table (1). * Significant at 0.05 level.

▪ For each different letters (the same row) means the multiple comparison are different from each others letter A is the highest followed by B, C… etc.

Table (15). The sensory evaluation of Ras cheese as affected by gamma irradiation during ripening period.

Ripening period (Months)	Sensory evaluation	control	Irradiation dose (kGy)				Irradiation dose (kGy)				Irradiation dose (kGy)				Irradiation dose (kGy)				Irradiation dose (kGy)				Irradiation dose (kGy)			
			2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
Fresh	Appearance	8	7.5	7	6	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Body&Text.	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
	Flavour	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	total	62	61.5	61	60	59	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
1	Appearance	8	7.5	7	6	5	7	7	6	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Body&Text.	28	27	28	29	29	29	29	29	29	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	Flavour	30	28	28	28	28	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Total	66	64.5	63	63	62	66	66	65	64	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
2	Appearance	8	7.5	7	6	5	7	7	6	5	7	7	6	5	8	8	8	8	8	8	8	8	8	8	8	8
	Body&Text.	29	29	29	30	31	30	30	32	33	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
	Flavour	30	30	29	28	28	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Total	67	66.5	65	64	64	67	67	68	68	66	66	65	64	67	67	67	67	67	67	67	67	67	67	67	67
3	Appearance	9	7.5	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	9	9	9	9	9	9	9	9
	Body&Text.	30	31	31	33	33	34	35	36	36	33	33	34	34	30	30	30	30	30	30	30	30	30	30	30	30
	Flavour	32	30	30	29	28	31	30	30	30	31	31	30	30	32	32	32	32	32	32	32	32	32	32	32	32
	Total	71	68.5	68	68	66	72	72	72	71	71	71	70	69	69	69	68	67	71	71	71	71	71	71	71	71
4	Appearance	9	7.5	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	9	9	9	9
	Body&Text.	33	33	34	36	37	35	35	37	38	35	35	36	36	34	35	35	35	33	33	33	33	33	33	33	33
	Flavour	35	32	30	30	29	33	32	31	31	33	32	31	31	32	32	32	32	35	35	35	35	35	35	35	35
	total	77	72.5	74	72	71	75	74	74	74	75	74	73	72	73	74	73	72	75	75	74	73	77	77	77	77
5	Appearance	9	7.5	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5
	Body&Text.	35	35	36	37	38	36	36	38	38	38	38	38	38	37	38	38	38	34	34	34	34	35	35	35	35
	Flavour	38	32	30	30	29	34	33	31	31	33	32	31	31	33	33	33	33	35	35	35	35	38	38	38	38
	Total	82	74.5	73	73	72	77	76	75	74	78	77	75	74	77	78	77	76	76	76	75	74	80	80	79	78
6	Appearance	9	7.5	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5	7	7	6	5
	Body&Text.	35	35	36	37	38	36	36	38	38	38	38	38	38	37	38	38	38	34	34	35	35	35	35	35	35
	Flavour	39	33	30	31	29	34	33	31	31	33	32	31	31	33	33	33	33	36	35	35	35	38	38	38	38
	Total	83	75.5	73	74	72	77	76	75	74	78	77	75	74	77	78	77	76	77	76	76	75	80	80	79	78

Table (1٤): Lipolytic bacterial count (cfu g^{-1}) of Ras cheese as affected by gamma irradiation during ripening period.

Treatment / Ripening period (month)	Control	Irradiation dose (kGy)											
		2	3	4	5	٢	٣	٤	٥	٢	٣	٤	٥
		The second group				The third group				The fourth group			
Fresh	19×10^3	7×10^2	5×10^2	2.5×10^2	1×10^2	18×10^3	19×10^3	20×10^3	19×10^3	17×10^3	19×10^3	19×10^3	20×10^3
١	30×10^3	11×10^2	7×10^2	3×10^2	2×10^2	15×10^2	12×10^2	5.5×10^2	2×10^2	31×10^3	30×10^3	32×10^3	29×10^3
٢	37×10^3	16×10^2	10×10^2	3.6×10^2	2.9×10^2	17×10^2	14×10^2	6×10^2	3×10^2	12×10^2	10×10^2	5×10^2	2×10^2
٣	47×10^3	19×10^2	12×10^2	4×10^2	3×10^2	20×10^2	15×10^2	7×10^2	3.6×10^2	13×10^2	11×10^2	5.5×10^2	2.2×10^2
٤	60×10^3	22×10^2	15×10^2	5.2×10^2	4×10^2	21×10^2	17×10^2	7.9×10^2	4.7×10^2	16×10^2	14×10^2	7.2×10^2	3×10^2
٥	92×10^3	27×10^2	16×10^2	6×10^2	4.8×10^2	22×10^2	19×10^2	9×10^2	5.9×10^2	19×10^2	17×10^2	8.5×10^2	3.8×10^2
6	15×10^4	30×10^2	20×10^2	7×10^2	5.7×10^2	25×10^2	20×10^2	10×10^2	7×10^2	22×10^2	19×10^2	9×10^2	4.2×10^2
		The fifth group				The sixth group				The seventh group			
Fresh	19×10^3	18×10^3	21×10^3	19×10^3	19×10^3	20×10^3	19×10^3	20×10^3	21×10^3	19×10^3	18×10^3	20×10^3	19×10^3
١	30×10^3	31×10^3	29×10^3	30×10^3	30×10^3	30×10^3	31×10^3	32×10^3	28×10^3	30×10^3	30×10^3	29×10^3	29×10^3
٢	37×10^3	37×10^3	37×10^3	36×10^3	38×10^3	35×10^3	38×10^3	37×10^3	37×10^3	37×10^3	37×10^3	35×10^3	35×10^3
٣	47×10^3	18×10^2	12×10^2	6×10^2	3×10^2	47×10^3	49×10^3	48×10^3	47×10^3	46×10^3	47×10^3	47×10^3	45×10^3
٤	60×10^3	22×10^2	15×10^2	6.5×10^2	3.2×10^2	20×10^2	17×10^2	8×10^2	3.5×10^2	60×10^3	60×10^3	59×10^3	57×10^3
٥	92×10^3	26×10^2	17×10^2	8.2×10^2	4×10^2	23×10^2	19×10^2	9×10^2	4×10^2	35×10^2	30×10^2	١$4 \times 10^2$	8×10^2
6	15×10^4	32×10^2	20×10^2	9.5×10^2	4.5×10^2	25×10^2	20×10^2	10×10^2	5×10^2	37×10^2	33×10^2	16×10^2	10×10^2

Control : Non irradiated treatment.
The second group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy when fresh
The third group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy after 30 days.
The fourth group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy after 60 days
The fifth group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy after 90 days
The sixth group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy after 120 days
The seventh group : Cheese wheels irradiated with doses 2,3,4, and 5 kGy after 150 days