# Examining the need for the use of calcium chloride in the processing of Gouda cheese made from pasteurised milk.

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**Abstract**

**Two samples of Gouda cheese were made in triplicate; one without and the other with the addition of 5 grams of calcium chloride per 100 litres of pasteurised milk and compared in terms of their proximate composition (moisture, acid, ash, butter fat and protein contents) and sensory properties (appearance, texture, taste and smell). It was observed that the addition of calcium chloride to pasteurised milk in cheese making promoted greater curd firming and whey expulsion which produced a firmer textured cheese with a drier appearance, lower in moisture content and acidity , but higher in ash, butter fat and protein contents. Most of the sensory panellists, however, preferred the cheese without added calcium chloride as it had a better taste and smell and was softer, more pliable and tender to eat. It was shown that the addition of calcium chloride to pasteurised milk for cheese making was important for marketing, especially when it was desirable to make Gouda cheese with firm appearance and texture which was inevitably linked to higher nutrient content in the final cheese. The addition of calcium chloride however adversely affected the flavour of the cheese and reduced preference for it, especially when a softer textured, more tender Gouda cheese was desired. On storage, the cheese without added calcium chloride, developed greater acidity and harshness in taste giving it a shorter shelf life.**

## Background

Cheese making is a form of food preservation by which the nutrients of milk are selectively concentrated in the form of a palatable food. The concentration of the milk solids is achieved by the co-ordination of procedures of acidification and dehydration. The origin of the art of cheese making can be traced back to more than 10,000 years (Early, 1992). Excellent history account of development and spread of cheese making from the eastern Mediterranean countries as early as 8000 BC, to the western European, Pacific and American, countries which dominate the world cheese market at present, has been published (Early, 1992).

In the middle ages, dozens of agrarian clusters throughout Europe began to develop firm, sliceable cheeses that eventually become models for commercial producers. In dairy producing countries like the Netherlands, excess milk was processed into the classic semi-hard cheeses known as Gouda, Edam and many others. Gouda cheese originated in the Netherlands and was exported to other countries as early as 1600 (Jones, 1980).

In Namibia, Gouda cheese is the most popular variety manufactured by the Namibian Dairies and other small factories, for local and export markets. About 130 tons of this cheese was made during the year 1999 and all of it was made using Calcium Chloride in the processing (Namibian Dairies Ltd).

## Introduction

Cow milk contains on the average 3.3 % protein. This protein is composed of two main constituents, the casein and whey proteins (lactalbumin and lactoglobulin) which are distinguished by their behaviour on lowering the pH to the Isoeletric point of 4.6. The casein proteins will precipitate at pH 4.6 whereas the whey proteins will not. In the manufacture of cheese by traditional methods, the whey proteins are not retained in the curd (Early, 1992).

Almost 80 % of the milk protein is casein. The casein is composed of a number of constituents designated $\alpha$-s1, $\alpha$-s2, $\beta$-, $\kappa$- and $\gamma$-casein, all of which show differences in their polypeptide chain structure. In milk at normal pH, the caseins are bound together in the form of spherical particles called micelles (Early, 1992).

Cheese produced from whole milk, the sum of casein and fat in the milk are the principal factors which determine the cheese yield (Demott, 1990). The relative proportions of casein and fat in milk will also influence the body and texture characteristics of the cheese. Further more the addition of Calcium Chloride in cheese has an influence in the flavour and total nutrient content improvement (Wolfschoon - pombo, 1997). The casein to fat ratio in the milk for Gouda cheese influences the fat in dry matter and the moisture in non-fat solids contents of the cheese. These are the two main factors influencing the quality of Gouda cheese (Early, 1992). The optimum casein to fat ratio for production of Gouda cheese is 0.69 - 0.71. When there is an excess of fat in relation to casein, weak bodied cheese with a higher fat content in the dry matter is produced. High quality Gouda cheese fat-in-dry matter level of 28 - 30 % is recommended, and moisture in non-fat substance levels should be in the region of 39 - 40 % (Lambert, 1975).

Pasteurisation of milk for cheese making has the advantage of destroying pathogenic and other spoilage micro-organisms, but it has the great disadvantage of impairing the renneting ability. Insoluble calcium salts e.g Calcium phosphate, are precipitated, casein losing some of its water hydration capacity and some of the whey proteins precipitate on it. Due to the loss in the water binding properties of the proteins, moisture may consequently be lost during the ripening of the cheese (Kessler, 1981).

Treatment of milk at high temperatures can denature some of the whey protein and bring about the interaction of b-lactoglobulin and k-casein through sulphydryl bonding. This interaction inhibits the action of chymosin (rennet) on casein, thereby interfering with the primary phase of gel formation in cheese manufacture. In addition to this, the heat treatment of milk at high temperatures can bring about changes in the mineral constituents of the milk, principally the calcium, which can interfere with the secondary phase of gel formation, that is the aggregation of the renneted casein micelles. Poor milk quality in terms of protein content, the pH of coagulation and the level of Ca 2+ in the milk, the coagulum will be soft resulting in heavy losses of fines (casein) and fat as well as poor syneresis during cheese making. 5-20 grams of calcium chloride per 100 kg of milk is normally enough to achieve a constant coagulation time and results in sufficient firmness of the coagulum (Early, 1992; Kessler, 1981 and Bylund, 1995). Excessive Calcium chloride may make the coagulum so hard that it will be difficult to cut (Gosta, 1993). When the calcium/casein complex coagulates, it retains most other milk constituents (Chamberlain, 1993).

It is generally recommended that milk for cheese making should be heat treated using a time temperature combination equivalent to that used in pasteurisation, that is 72 0 C for 15 seconds (HTST) or 63 0 C for 30 minutes (LTLT) methods. This treatment is sufficient to destroy pathogenic and spoilage bacteria contaminating the milk, without significantly affecting the physico-chemical properties of milk that influence the cheese making process. Although heat treatment of milk at temperatures lower than those used in the pasteurisation has been used in cheese manufacture in some parts of Europe and America, evidence of the survival of pathogens after lengthy periods of ripening of many different types of cheese would suggest that the use of a heat treatment, at least equivalent to pasteurisation, is essential in safeguarding the consumer (Chamberlain, 1993).

The study was designed to compare the quality of two Gouda cheeses made with and without the addition of Calcium Chloride for the purpose of noting the relevance, influence and importance of $CaCl_2$ chemical additive in cheese making.

## Objective

The objective of the study was to examine the necessity of calcium chloride as a chemical additive in the processing of Gouda cheese in terms of its influence on the proximate composition (moisture, acid, butter fat and protein contents) and sensory properties (appearance, texture, taste and smell) of the cheese made from pasteurised milk.

## Materials

Milk was obtained from Gocheganas private dairy farm about 35 km to the south of Windhoek, Namibia. Calcium chloride, potassium nitrate, rennet, starter culture, salt, annatto colour and packaging materials were obtained from Namibia Dairies (PTY) Ltd in Windhoek. Cheese processing equipments including curing room were also provided by the Namibia Dairies at Gocheganas dairy farm.

## Methods

### Analysis of milk samples

Milk samples for cheese making were analysed in triplicates for butterfat, total solids, freezing point, acidity, specific gravity, pH, and protein content using simple dairy routine tests and AOAC standard methods (1996).

Good quality milk was filtered

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The filtered milk was pasteurised (72°C/15 seconds)

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The pasteurised milk was cooled to 30°C

↓

The following additives were added to the milk and mixed for 10 minutes:
$CaCl_2$: 5 grams/100 kg of milk
Annatto: 3 ml/100 kg of milk
$KNO_3$ : 20 grams/100 kg of milk
Starter culture: 1.5 % (Str. lactis and Str. cremoris)
Rennet was then added at the rate of 20 ml/100 kg or 2 gram/100 kg of milk and then mixed further for a short time (5 minutes).

↓

The milk was allowed to set for 30 minutes to coagulate

↓

Formed curd was cut and stirred gently for 20 minutes

↓

A third of whey was removed and replaced with potable water

↓

The curds were then stirred gently and scalded to 37-38°C over a period of about 1 hour

↓

The whey was then drained away and replaced with potable water to cool the curds and wash away some of the acid

↓

The wash water was drained away. The curds were dipped, pressed to mat and cut in blocks for moulding and pressing at 0.1 % lactic acid.

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The curds were then moulded with cheese cloth, pressed or 20 min; turned and re-pressed overnight.

↓

The cheese balls were salted in 23% brine at 10°C for one day (small balls of 1.4 kg) dried and vacuum packed.

↓

Curing was done for 5 weeks at 15°C and 90% RH after which the cheese balls were ready for proximate and sensory analyses.

**Procedure used for making Gouda cheese**

### Proximate composition analysis of the cheese samples

The proximate composition of the cheeses was done using AOAC Approved Methods of Analysis (1996)

### Sensory analysis of the cheese samples

Cheese samples with and without added CaCl2 were sensorically analysed in triplicate for their appearance, texture, smell, taste and preference using a hedonic scoring scale of 1-9 in which 1, 2,3,4,5,6,7,8 and 9 represented dislike very much, dislike much, dislike moderately, dislike little, neither like nor dislike, like little, like moderately, like much and like very much respectively. The samples of each category of cheese were presented to the panellists (students and lecturers of Food Science) who were asked to score each sample against the scale to indicate their degree of liking or disliking of each sample for each of the sensory characteristics listed above. Panellists were then asked to indicate in an independent remark which of the two samples they preferred or liked best in overall. The data obtained was then subjected to statistical analysis to determine if the differences amongst scores for each characteristic were significant or not.

## Results and Discussions

Quality of raw milk used in the cheese making

**Table 1** shows the results of proximate analysis of milk used for cheese making. Results for butterfat, specific gravity, total solids, pH, developed acidity, freezing point and protein were found to be within the normal range (Fredrick, 1992) except lactose which appeared to be slightly on the higher side than normal (4.7%).

The proximate composition of the two samples of cheese are presented in Table 2. The recommended final moisture content in Gouda cheese is 39-40 % (Lambert, 1975). The results in Table 2 indicate that although both samples A and B contained moisture within the recommended range, sample A containing calcium chloride retained normal

**Table 1.** Proximate composition of milk used in cheese making

| Component | Results | Range |
|---|---|---|
| Butter fat (%) | 3.7 ± 0.1 | 2.9 - 4.2 |
| Specific gravity | 1.030 ± 0.002 | 1.028 -1.032 |
| Total solids (%) | 12.25 ± 0.75 | 12.0 - 13.0 |
| pH | 6.5 ± 0.3 | 6.5 - 6.8 |
| Acidity (%) L.A. | 0.15 ± 0.02 | 0.14 - 0.17 |
| Freezing point (oK) | 540 ±15.00 | 530 - 550.0 |
| Protein | 3.3 ± 0.4 | 3.0 - 3.7 |
| Lactose | 5.3 ± 0.1 | 4.8 - 5.4 |

**Table 2.** Proximate composition of cheese A and B after 5 weeks of curing

| Component | Moisture | pH | Ash | Butter Fat | Protein |
|---|---|---|---|---|---|
| Sample A | 43.94±0.07 | 4.8±0.2 | 4.53±0.02 | 15.20±2.18 | 35.52±2.8 |
| Sample B | 38.29±0.50 | 5.2±0.2 | 5.81±0.18 | 26.95±2.6 | 42.44±2.5 |

*Sample A: No calcium chloride added; Sample B: Calcium chloride added*

**Table 3.** Analysis of variance between appearance scores from the sensory panelists

| Source | DF | SS | MS | Fcalculated | F p=0.01 | F p=0.05 |
|---|---|---|---|---|---|---|
| Treat | 1 | 16.02 | 16.02 | 7.71 | 7.08 | 4.00 |
| Error | 58 | 120.57 | 2.08 | | | |
| Total | 59 | 136.58 | | | | |
| **Sample** | **N** | **Mean** | **SD** | | | |
| A | 30 | 6.400 | 1.773 | | | |
| B | 30 | 7.433 | 1.006 | | | |

**Table 4.** Analysis of variance between texture scores from the sensory panelists

| Source | DF | SS | MS | Fcalculated | F p=0.01 | F p=0.05 |
|---|---|---|---|---|---|---|
| Treat | 1 | 0.02 | 0.02 | 0.01 | 4.00 | 7.08 |
| Error | 58 | 101.63 | 1.75 | | | |
| Total | 59 | 101.65 | | | | |
| **Sample** | **N** | **Mean** | **SD** | | | |
| 1 | 30 | 7.133 | 1.106 | | | |
| 2 | 30 | 7.167 | 1.510 | | | |

**Table 5.** Analysis of variance between smell scores from the sensory panelists

| Source | DF | SS | MS | Fcalculated | F p=0.01 | F p=0.05 |
|---|---|---|---|---|---|---|
| Treat | 1 | 1.67 | 1.67 | 1.07 | 7,08 | 4.00 |
| Error | 58 | 90.27 | 1.56 | | | |
| Total | 59 | 91.93 | | | | |
| **Sample** | **N** | **Mean** | **SD** | | | |
| A | 30 | 7.200 | 1.270 | | | |
| B | 30 | 6.867 | 1.224 | | | |

**Table 6.** Analysis of variance between taste scores from the sensory panelists

| Source | DF | SS | MS | Fcalculated | F p=0.01 | F p=0.05 |
|---|---|---|---|---|---|---|
| Treat | 1 | 1,35 | 1.35 | 0.67 | 7.08 | 4.00 |
| Error | 58 | 117.63 | 2.03 | | | |
| Total | 59 | 118.98 | | | | |
| **Sample** | **N** | **Mean** | **SD** | | | |
| A | 30 | 7.333 | 1.061 | | | |
| B | 30 | 7.033 | 1.712 | | | |

moisture (38.29%) in it than sample B (43.94%) containing no added calcium chloride. Calcium chloride accelerated moisture loss from the cheese during its processing almost to the lowest recommended level while its absence resulted in cheese with water-holding-capacity remaining close to the highest level recommended. Thus the cheese with calcium chloride had a drier appearance and hand-feel than the cheese without calcium chloride.

The results also show that sample B with no added calcium chloride developed higher final acidity than sample A with calcium chloride (pH 5.2 and 4.8 respectively). The acidity of fresh milk depends on many factors such as cattle breeds, milk composition etc and ranges from 0.14 to 0.17 % lactic acid (pH 6.5-6.7) (Kosikowski, 1997). Acidity greater than 0.17% lactic acid is known as developed acidity.The results show that the sample of cheese without added calcium chloride was more prone to development of higher acidity.

From literature (Kosikowski,1995 and Early, 1992), it is known that when milk is coagulated, the acidity of the whey (the liquid phase) drops down to 0.08-0.09 % LA.The curds are basically the casein proteins and carry a lower pH than the whey. There is thus a great pH change during coagulation of milk. The curds increase in acidity while whey drops in acidity.

Although the pH of cheese is mainly due to fermentation of lactose to lactic acid and proteolytic break down of some proteins to amino acids and acid acting substances, the effect on curd acidity and texture of the addition of calcium chloride to milk for cheese making deserves some explanation. When calcium chloride is added to milk, it ionises into Ca+ and Cl- ions. Some of the cross bonds the calcium ions make in the curds release hydroxyl (-OH) ions which pick up hydrogen (H+) ions from the system to make water molecules which are lost into whey and the water used to wash the curds. At the same time, calcium ion cross bonding in the curd matrix reduces water binding capacity of the curd due to the depletion of the sites where water molecules would normally be bound in the curd through hydrogen bonding. The chloride ions similarly pick up hydrogen ions to make traces of hydrochloric acid which is also washed from the curds. The result is a cheese with a dry appearance. Since the acidity of a substance is basically due to the hydrogen ion concentration in it, it is obvious that the addition of calcium chloride to milk reduces the potential of the curds to develop acidity after coagulation.

The results in Table 2 agrees with the above view since the cheese from the milk sample to which calcium chloride had been added developed lower acidity than the cheese from the milk sample to which no calcium chloride had been added. The original sample of milk from which both cheeses were made had precisely the same composition (**Table 1**).

Table 2 above also shows that sample B contained more nutrients in terms of ash (minerals), butter fat and protein than sample A on dry matter basis. This was attributed to the fact that sample A contained higher moisture content than sample A as it is also given in Table 2. All these observations appear to be related to the addition of calcium chloride to sample B, the original milk sample having been the same (Table 1). However, the over all butterfat content of any of the cheeses was lower than anticipated (30 %) (Lambert, 1975) due to problems of grinding and stickiness, which did not allow the cheese samples to dissolved properly in ether during soxhlet extraction. The higher protein content of the cheese sample with added calcium chloride could also, apart from denaturation of whey protein with heat, be due to the formation of calcium paracaseinate in the curd resulting in more retention of the casein in the curd instead of losing it in whey. Calcium paracaseinate has poorer solubility in whey than pure casein (Kessler, 1981 and Kosikowski, 1977).

### Sensory evaluation

The sensory evaluation results are summarised and presented in Tables 3-6. According to the statistical results in Table 3, the mean score for appearance was 7.433 for sample B and 6.400 for sample A. According to the hedonic scale used, the mean score for sample B lay between "like moderately" and "like much", but closer to "like moderately". The mean score for sample A lay between "like little" and "like moderately", but closer to "like little" at 6.400. Analysis of variance amongst the scores for appearance was found significant at both p=0.01 and p=0.05. This meant that the mean score of 7.433 for sample B differed significantly from the mean score of 6.400 for sample A. Thus "like little" for sample A differed significantly from "like moderately" for sample B. It was concluded that addition of calcium chloride to pasteurised milk for cheese making produced cheese with a superior quality.

Statistical analysis results for cheese texture, smell and taste are presented in Tables 4, 5 and 6. They show that calculated F ratios were in all the three cases less than the corresponding F ratios at p=0.01 and p=0.05 indicating that any variations observed in each set of scores were purely random. Consequently, no significant differences were observed in the sensory scores for texture, smell and taste. It was concluded that the addition of calcium chloride to pasteurised milk for cheese making did not have a significant effect on the texture, smell and taste of the final cheese.

However, when the scores based on independent remarks from the panellists were examined, it was observed that the panellists preferred sample A to sample B (Table 7) regarding cheese tenderness (texture), smell and taste.

Thus cheese sample A originating from milk without calcium chloride added to it was more tender and tasted and smelt better. However cheese sample A became more acidic and harsher in taste during maturation, thus attaining a shorter shelf life than the cheese sample from milk containing added calcium chloride. It became obvious that addition of calcium chloride to milk during cheese making resulted in cheese with a longer shelf life than when the calcium chloride was not added to the milk

**Table 7.** Analysis of preference scores from panelists independent remarks

| Sample | Texture | Smell | Taste |
|---|---|---|---|
| A | 56.7 % | 60 % | 63.3 % |
| B | 43.3 % | 40 % | 36.7 % |

## Conclusion

With the above results, it is obvious that cheese can be made from pasteurised milk with or without the addition of Calcium Chloride. However, cheese without the addition of $CaCl_2$ tended to retain more moisture, matured faster and developed higher acidity, and was prone to flavour change during storage period as exemplified by the hash acid flavour. With high water activity more bacteria will develop and may threaten the safety of the product and of the consumer. However, in the short run, one may be able to make more money from selling cheese with high moisture content but in the long run it may jeopardize the business. For better quality cheese in terms of firmness, texture, appearance, nutrients and acidity, the advantages resulting from the addition of $CaCl_2$ to pasteurised milk can not be underestimated or ignored.

## Recommendations

It is recommended that the practice of adding $CaCl_2$ to pasteurised milk in cheese making should continue. However, good cheese for short storage (home use) and short handling time can still be made without the addition of calcium chloride to the milk.

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