Comparison between whey dilution during cheese-making and standardization of milk lactose by ultrafiltration on the properties of low and reduced fat Gouda cheese

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Introduction

Defects associated with low-fat cheeses
Introduction

Defects associated with low-fat cheeses

Acidity
Introduction

Defects associated with low-fat cheeses

- Acidity
- Texture
Introduction

Defects associated with low-fat cheeses

- Acidity
- Texture
- Functionality
Introduction

Defects associated with low-fat cheeses

- Acidity
- Texture
- Functionality
- Flavour
Introduction

Defects associated with low-fat cheeses

- Acidity
- Texture
- Flavour

Directly influence acceptability
Introduction

Use of whey dilution in Gouda cheese

- Milk
- Standardization
- Pasteurization
- Cream
- Starter
- Mixing
- Setting
- CaCl$_2$
- Cutting
- Rennet
- Partial Draining
- Whey
- Whey Dilution
- Water
- Stirring
- Draining
- Pressing
- Moulding
- Brining
- Unripened cheese
- Packing
Use of whey dilution in Gouda cheese
Introduction

Use of whey dilution in Gouda cheese

Cubes of cheese curd immersed in whey
Introduction

Use of whey dilution in Gouda cheese

Partial Removal of Whey

30% of total volume
Introduction

Use of whey dilution in Gouda cheese

Partial Removal of Whey

30% of total volume
Introduction

Use of whey dilution in Gouda cheese

Water Addition
Use of whey dilution in Gouda cheese

Water Addition

Water
Introduction

Use of whey dilution in Gouda cheese

Water Addition

Water
Introduction

Use of whey dilution in Gouda cheese

Water Addition

Water

30% of total volume
Use of whey dilution in Gouda cheese

Continuous Stirring
Introduction

Use of whey dilution in Gouda cheese

Whey dilution
Use of whey dilution in Gouda cheese
Use of whey dilution in Gouda cheese
Introduction

Use of whey dilution in Gouda cheese

Lactose
Use of whey dilution in Gouda cheese
Introduction

Use of whey dilution in Gouda cheese

↓ Lactose → ↓ Acidity → ↑ pH
Introduction

Use of whey dilution in Gouda cheese
Introduction

Use of whey dilution in Gouda cheese
Introduction

Use of whey dilution in Gouda cheese

Water addition $\rightarrow$ Insoluble Ca $\rightarrow$ Softer texture
Increased Melting
Introduction

Problems of whey dilution

- Milk
  - Standardization
    - Pasteurization
  - Starter
  - CaCl₂
  - Rennet
  - Whey
    - Partial Draining
    - Whey Dilution
  - Water

- Cream
  - Stirring
  - Draining
    - Moulding
    - Pressing
    - Brining
    - Packing
    - Unripened cheese
    - Whey
Introduction

Problems of whey dilution

- Milk
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- Unripened cheese

Whey
Introduction

Problems of whey dilution

- Milk
- Standardization
- Cream
- Pasteurization
- Cutting
- Partial Draining
- Whey Dilution
- Stirring
- Draining
- Moulding
- Pressing
- Brining
- Packing
- Unripened cheese
- Whey
- Water
- Size of Curd cubes

Milk → Standardization → Cream

Standardization → Cutting → Partial Draining

Partial Draining → Stirring → Draining

Draining → Moulding → Pressing

Pressing → Brining → Packing

Unripened cheese

Moulding

Whey

Whey Dilution

Stirring

Draining
Introduction

Problems of whey dilution

- Milk → Standardization
- Cream → Standardization
- Rennet
- Whey
- Water
- Size of Curd cubes
- Partial Draining
- Whey Dilution
- Cutting
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- Stirring
- Draining
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- Unripened cheese
- Whey

Dilution Factor
Introduction

Problems of whey:

- Milk
- Pasteurization
- Mixing
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- Partial Draining
- Whey Dilution
- Stirring
- Draining
- Moulding
- Brining
- Pressing
- Setting
- Unripened cheese
- Whey
- Water

Temperature

Dilution Factor

Size of Curd cubes

Starter

CaCl₂

Rennet

Whey

Milk
Introduction

Problems of whey dilution

- Problems of whey dilution
- Standardization
- Pasteurization
- Mixing
- Cutting
- Partial Draining
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- Packing
- Brining
- Pressing
- Setting
- Milk
- Cream
- Starter
- CaCl₂
- Rennet
- Unripened cheese
- Whey
- Size of Curd cubes
- Temperature
- Dilution Factor
- Time

Size of Curd cubes

Temperature

Dilution Factor

Unripened cheese

Whey

Stirring

Draining

Moulding

Pressing

Brining

Setting
Introduction

Problems of whey:
- Standardization
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- Water
- Size of Curd cubes
- Temperature
- Dilution Factor
- Time
- Lactose Fermentation
Introduction

Problems of whey dilution

- Standardization
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- Moulding
- Packing
- Brining
- Pressing
- Setting

Milk

Cream

Starter

CaCl$_2$

Rennet

Unripened cheese

Cheesemaker

Size of Curd cubes

Temperature

Dilution Factor

Time

Lactose Fermentation
Solution?

Lactose: Casein standardization

pH of the cheeses

Lactose:Casein Ratio in Cheesemilk

Low

High
What controls cheese pH?

- High Lactose: Same Casein
- More Lactose, More Lactic acid
- pH ~5.0
- Same Buffer: Casein content & Insoluble Ca phosphate
Introduction

What controls cheese pH?

- Low Lactose: Same Casein
- Less Lactose: Less Lactic acid
- Same Buffer: Casein content & Insoluble Ca phosphate

pH ~5.4
Introduction

Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking
Introduction

Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

Step 1

Milk → Ultrafiltration → Retentate

Permeate
Introduction

Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

Step 1

Milk $\rightarrow$ Ultrafiltration $\rightarrow$ Retentate

Permeate

Casein

Lactose
Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking
Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

**Step 1**

- **Milk** → Ultrafiltration → **Retentate** (Casein)
  - **Permeate** (Lactose)

**Step 2**

- **Retentate**
- **Permeate**
- **Water** → **Standardization**
Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

Step 1

Milk $\xrightarrow{\text{Ultrafiltration}}$ Retentate

Permeate

Casein

Lactose

Step 2

Retentate

Permeate

Water $\xrightarrow{\text{Standardization}}$ Milk

Adjusted Lactose to Casein ratio
Introduction

Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

Control Acidity
Introduction

Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking

Control Acidity

Modify cheese texture
Use of ultrafiltration to standardize the ratio of lactose to casein in milk prior cheesemaking.
1. Standardization of lactose to casein in cheesemilk determines the acidity of cheese.

2. Addition of water during lactose to casein standardization reduces levels of insoluble calcium, leading to changes in texture and melting properties of cheese.

Objective

To compare the effect of whey dilution during cheese manufacture and lactose standardization of cheesemilk prior processing on the properties of low-fat and reduced-fat Gouda cheese.
Hypothesis

1. Standardization of lactose to casein in cheesemilk determines the acidity of cheese.

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To compare the effect of whey dilution during cheese manufacture and lactose standardization of cheesemilk prior processing on the properties of low-fat and reduced-fat Gouda cheese.
Cheese Manufacture

Milk

Vat 1

Vat 2

Vat 3
Natural lactose to casein ratio found in milk
Cheese Manufacture

- **Milk**
  - **Vat 1**
  - **Vat 2**
  - **Vat 3**
    - **Ultrafiltration**
    - **Lactose to Casein Standardization**

1.8   1.8   1.2

Natural lactose to casein ratio found in milk
Cheese Manufacture

Vat 1 → 1.8
Vat 2 → 1.8
Vat 3 → 1.2

Natural lactose to casein ratio found in milk

Ultrafiltration
Lactose to Casein Standardization
Reduced lactose to casein ratio
Cheese Manufacture

Lactose to casein ratio

Vat 1: 1.8 → Cheesemaking
Vat 2: 1.8 → Cheesemaking
Vat 3: 1.2 → Cheesemaking
Cheese Manufacture

Lactose to casein ratio

- Vat 1: 1.8 → Cheesemaking
- Vat 2: 1.8 → Cheesemaking
- Vat 3: 1.2 → Cheesemaking

Level of Whey Dilution (WD)

- Vat 1: 30% → WD 30
- Vat 2: 15% → WD 15
- Vat 3: 0% → UF
- Procedure was carried out for Low-Fat (RF) and Reduced-Fat (LF) Gouda cheeses.
- 250 kg scale.
- Ripening period of 6 months (180 d).
- 4 independent trials.
## Cheese Composition

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<td>LF</td>
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<td>51.94&lt;sup&gt;a&lt;/sup&gt;</td>
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A significant increase of pH was found in UF cheeses.
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A significant reduction of lactic acid content was found in UF lactose standardized cheeses.
A significant reduction of lactic acid content was found in UF lactose standardized cheeses.
Sensory Analysis: Acid taste

Low Fat

Reduced Fat

Ripening time (d)

Acid

0 30 60 90 120 150 180

0 30 60 90 120 150 180

Threshold  Very Slight  Slight  Slight to Def  Definite  Pronounced
Sensory Analysis: Acid taste

WD cheeses exhibited higher acidity than those made with lactose to casein adjustment.
Proportion of insoluble Ca (INSOL Ca)

Low Fat

Reduced Fat
Standardization of lactose to casein ratio showed a lower proportion of INSOL Ca
Cheese firmness

- Texture Profile Analysis (TPA)
- Two-bite compression on cheese cylinders at 30% their original size.
Cheese firmness

- Texture Profile Analysis (TPA)
- Two-bite compression on cheese cylinders at 30% their original size.
Lactose to casein standardized cheeses exhibited a softer texture than WD cheeses.
Lactose to casein standardized cheeses exhibited a softer texture than WD cheeses.
Sensory analysis: Cheese firmness

Low Fat

Reduced Fat

Firmness vs Ripening time (d)

Hard

Soft

Threshold  Very Slight  Slight  Slight to Def  Definite  Pronounced
Sensory analysis: Cheese firmness

Lactose to casein standardized cheeses exhibited a softer texture than WD cheeses.
Melt Temperature

- Rheological Analysis:
  - Cheese heated from 5 to 85°C at 1°C/min
  - 0.5% strain
  - 0.08 Hz frequency

- Parameters measured:
  - Loss tangent (LT)
  
  \[ LT = \frac{\text{Viscous Modulus (G'')}}{\text{Elastic Modulus (G'')}} \]
  
  - LT = 1 (Melt temperature)
Storage and Loss Moduli (Pa)

- Rheological Analysis:
  - Cheese heated from 5 to 85°C at 1°C/min
  - 0.5% strain
  - 0.08 Hz frequency

- Parameters measured:
  - Loss tangent (LT)
  - LT = Viscous Modulus (G’’)
  - LT = Elastic Modulus (G’’)
  - LT = 1 (Melt temperature)
Melt Temperature (LT=1)

Lactose to casein standardized cheeses exhibited a lower melt temperature than WD cheeses.
Lactose to casein standardized cheeses exhibited a lower melt temperature than WD cheeses.
Conclusions

Lactose to Casein Standardization
Conclusions

Lactose to Casein Standardization

Acidity
Conclusions

Lactose to Casein Standardization

- Acidity
- ↓INSOL Ca
Future work

Retail Cheddar Cheese Survey

- Frequency of flavor defects in retail samples of Cheddar cheese purchased in Dane County (Wisconsin) in 2002.

- 91% of the retail cheeses would have been downgraded to B grade or lower.

- Acid was the major flavor defect identified

Smukowski et al. 2003, CDR Dairy Pipeline 15:1-7

<table>
<thead>
<tr>
<th>Defect</th>
<th>% of cheeses</th>
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</thead>
<tbody>
<tr>
<td>Any flavor defect</td>
<td>93</td>
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<tr>
<td>Acid</td>
<td>57</td>
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<tr>
<td>Flat</td>
<td>33</td>
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<tr>
<td>Whey-taint</td>
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<tr>
<td>Bitter</td>
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<td>Utensil</td>
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<td>Metallic</td>
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<tr>
<td>Sulfide</td>
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<tr>
<td>Fermented</td>
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<tr>
<td>Fruity</td>
<td>2</td>
</tr>
<tr>
<td>Old milk</td>
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<tr>
<td>Oxidized</td>
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<tr>
<td>Lipase</td>
<td>1</td>
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<tr>
<td>High salt</td>
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</table>

1 Based on USDA grade standards for mild Cheddar cheese.
Future work

Cheddar cheese
Future work

Cheddar cheese

Lactose
Future work

Cheddar cheese

Lactose

Casein
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Comparison between whey dilution during cheese-making and standardization of milk lactose by ultrafiltration on the properties of low and reduced fat Gouda cheese

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