



Designing Nutritious Future Dairy Products and Alternatives

NFOK24004U

Notes taken during the course, including lectures, exercises, curriculum, and practicals

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Link to Git repo.: https://github.com/DanishUnicorn/dnf_dpa



Course Description

Content

The course will cover:

- The challenge: sustainable and healthy diets - from purpose to practice
- Processing effects on nutrients in dairy products, hybrid products and their vegan alternatives
- Nutritional effects of dairy nutrients: protein, lipids, lactose, calcium, immune-active proteins
- Digestion of dairy and alternative dairy products
- Benefits of minimal processing
- Introduction to human Nutrition and Gut Microbiota

Furthermore the course will describe what drives innovation and new product development, within both traditional and alternative dairy products.

Afterwards, the student will make an individual literature study project on a topic of their own choice within the curriculum of the course.

Learning Outcome

The overall aim of the course is to provide students with in-depth knowledge of the technologies used for processing of non-fermented dairy products.

After completing the course the student should be able to:

Knowledge

- Discuss the major factors influencing the quality of dairy products and relevant manufacturing processes.
- Identify and critically examine the principle(s) underpinning unit operations needed for the production of selected dairy products.

Skills:

- Apply principles of colloid science to processing of dairy products.
- Apply obtained knowledge of dairy technology to pilot plant practicals and analyses on dairy products.
- Analyse data obtained for characterization of processing effects on physical and chemical properties of dairy products.
- Reflect and critically examine the effect of various unit operations on dairy product quality.
- Reflect and critically examine how colloidal interactions can be controlled in order to produce stable dairy products.

Competences:

- Discuss how the technology behind manufacture of dairy products affects final product quality.
- Discuss the contribution of different unit operations to product properties, and the value of different product streams in production of selected dairy products.
- Work effectively in a group for both theoretical and practical assignments.

Litterature

See Absalon for a list of course literature. The curriculum will include lecture notes and scientific papers in addition to parts of textbooks.

Recommended Academic Qualifications

Qualifications corresponding to having completed the Dairy Internship are recommended. Academic qualifications equivalent to a BSc degree is recommended .

Teaching and Learning Methods

Lectures, project work in the dairy pilot plant and laboratory and half/one-day excursions. Minor costs for one-day excursions (e.g. transportation) are paid by the students.

Workload

Table 1: *A table with an overview over the workload for the course.*

Category	Hours
Lectures	30
Preparation	88
Practical exercises	12
Excursions	8
Project work	55
Guidance	12
Exam	1
Total	206

Contents

1	Lecture Notes	1
1	Lecture 01 - 04/08-2025	1
2	Lecture 02 - 04/08-2025	2
2	Literature résumés	3
1	1 st Reading Material from the Curriculum	3
1.1	Milk for Liquid Consumption	3
1.2	Sterilized Milk	4
1.2.1	Description	4
1.3	Reconstituted Milk	4
1.4	Flavour	4
1.5	Nutritive Value	5
1.6	Infant Formulas	5

Chapter 1

Lecture Notes

1 Lecture 01 - 04/08-2025

Topics of the course lectures

The course will be covering the following topics:

- Week 1
Reading materials for self-study and start the project work
- Week 2
Monday 4 August: Introduction to the course and Basic constituents of milk and alternatives (Lilia, Jorg) + project work
Tuesday 5 August: Dairy processing (Jorg) and Introduction and Sustainable Nutrition (Merete & Lea)
Wednesday 6 August: Digestion and Nutritional effects of dairy protein (Lilia, Jorg, Mads) + project work
Thursday 7 August: Lactose, calcium and lipids (Lilia, Jorg, Andreas) + project work / Pitch your idea
Friday 8 August: The challenge: sustainable and healthy diets - from purpose to practice (Thom, Nick Smith) + project work
- Week 3
Monday 11 August: Process-induced changes (Qing Ren)
Tuesday 12 August: Process-induced changes (Qing Ren, Lilia)
Wednesday 13 August: Dairy/Plant-Hybrid Products (Iben, Lilia)
Thursday 14 August: Human Nutrition (Inge, Marta, Jordi)
Friday 15 August: Gut Microbiota (Torben)
- Week 4 & 5
Project work

Structure of the group project

The structure of the report was defined and must adhere to the following:

- 30 +/- 10 pages
- Product description, including the purpose of “why” the product
- Intended nutrition or health benefits
- Description of the ingredients

- Description of the claimed beneficial effect
- Target consumer group
- Dietary pattern of the chosen consumer group, and how the product would fit in that
- Formulation - which raw materials will be used, and why. In case of ingredients, which processes would they already have undergone prior to product formulation?
- Processing - how will the product be processed? Process flow diagram and identify the impact of processing steps on nutritional value (could it impact the nutrition/health benefits)
- Nutritional Quality - To quantitatively or qualitatively estimate the nutritional and sustainability aspects of the novel product

2 Lecture 02 - 04/08-2025

The physical properties of milk are defined by:

Table 1.1: *Examples of physical properties of milk*

Property	Value	Unit
Osmotic Pressure	≈ 700	$[kPa]$
Freezing-Point Depression	≈ 0.54	$[K]$
Electrical Conductivity	≈ 0.5	$[A/(V \cdot m)]$
pH Value	6.7	
Ionic Strength	≈ 0.08	$[molar]$
Water Activity	≈ 0.993	

Chapter 2

Literature résumés

This section of the course notes is designed to streamline access to the key findings from each reading material (RM), providing a concise and accessible overview of essential information. Created through experimentation with various AI platforms, this chapter also serves to enhance prompt engineering skills, exploring diverse methods of note-taking for maximum efficiency and clarity. The procedures for creating these summaries have varied, but all methods share a common approach: each RM has been fully read, with summaries and notes prepared after completing each respective subsection. By using these AI-co-op'ed approaches, these notes aim to be both a reliable reference and a resource for continuous improvement in capturing complex microbiology concepts.

1 1st Reading Material from the Curriculum

1.1 Milk for Liquid Consumption

Liquid milk is treated by pasteurization or sterilization to ensure safety, extend shelf life, and retain flavour. Raw milk is considered unsafe and is restricted in many countries. Pasteurized milk retains better flavour, while sterilized milk offers longer shelf life, especially valued in cooking. Fat content is usually standardized, but low-fat and skim milks are also common. Some products are fortified or processed via ultrafiltration for consistent protein content, although this may be legally restricted. Quality attributes vary by use, and packaging is essential for hygiene [1].

Manufacture

Thermalization reduces lipase activity and psychrotrophic growth, aiding shelf life. Homogenization prevents creaming but increases lipolysis risk, requiring higher heat (e.g., 20 s at 75 °C). Low pasteurization (15 s at 72 °C) kills pathogens while preserving natural inhibitors, though heat-sensitive compounds like agglutinins and immunoglobulins are degraded in high-pasteurized milk. Packaging hygiene is crucial to prevent recontamination and preserve shelf life [1].

Shel Life

Shelf life is influenced by bacterial growth, enzymatic activity, and chemical/physical changes. Key factors include storage temperature, recontamination, and *Bacillus cereus* spore levels. Below 7 °C, psychrotrophs dominate spoilage. Hygiene in packaging is essential; rapid tests help detect recontamination [1].

Extended-Shelf-Life Milk

ESL milk combines long shelf life with near-fresh flavour. One method applies short-time direct UHT treatment (e.g., 2 s at 140 °C) with aseptic packaging; enzymes like plasmin may still affect taste after weeks. The second method involves microbial removal via microfiltration or bacto-fugation, often followed by partial UHT sterilization of retentate and cream. Aseptic packaging is essential. Cooked flavour is minimized by limiting heat to fat-rich fractions [1].

1.2 Sterilized Milk

1.2.1 Description

Sterilized milk must be microbe-free, shelf-stable at ambient temperature, and retain acceptable flavour and nutritional value. UHT sterilization (e.g., 1 s at 145 °C) minimizes browning, off-flavours, and vitamin loss. To prevent spoilage, packaging must be aseptic, and milk free from heat-resistant enzymes. Homogenization avoids creaming and coalescence. Lactulose content is used to identify UHT-treated milk [1].

Manufacture

Sterilized milk is made via in-bottle, mild in-bottle, or flow-through UHT processes. Psychrotroph enzymes (esp. from *Pseudomonas*) are heat-resistant, so raw milk must be fresh. UHT heating (>140 °C) ensures safety but risks casein aggregation, off-flavors, and vitamin loss. Aseptic homogenization and deaeration are crucial to prevent oxidized flavor. Oxygen- and light-tight packaging prolongs shelf life [1].

Shelf Life

Spoilage of in-bottle sterilized milk may result from surviving spores (e.g., *B. subtilis*, *B. stearothermophilus*) or leaky packaging. UHT milk mainly deteriorates via recontamination or residual heat-resistant enzymes, causing gelation, off-flavors, or plasmin-induced bitterness. Nonenzymatic spoilage includes oxidation, Maillard reactions, and light effects. Shelf life is tested via incubation, oxygen pressure, or ATP bioluminescence [1].

1.3 Reconstituted Milk

Reconstituted milk is made by dissolving milk powder in water; recombined milk adds anhydrous milk fat to reconstituted skim milk. It mimics whole milk but lacks natural fat globule membrane components. Filled milk uses vegetable oil instead of milk fat. Toned milk blends buffalo milk with skim milk to reduce fat content [1].

1.4 Flavour

Good flavour means a bland taste without off-flavours. Sources include microbial growth (e.g., *B. cereus*, *P. fragii*), plasmin, lipoprotein lipase, and oxidation by Cu or light. Heat causes cooked, UHT ketone, or sterilized-milk flavour, depending on thermal load. Sunlight flavour arises from methionine oxidation with riboflavin present [1].

1.5 Nutritive Value

This section addresses changes in nutritive value due to deliberate changes in composition, processing, and storage. For details on the nutritive aspects of milk components, see Subsections 2.1.2, 2.2.4, 2.3.3, 2.4.5, and Table 2.18 in the book [1].

Modification of Composition

Milk of modified composition includes low-fat, skim, or vitamin-fortified types. Filled milk uses vegetable oils, often rich in vitamins D and E, with added antioxidants. Calcium may be added as lactate or whey permeate. Lactose-free milk, produced by adding lactase after UHT treatment, has limited success due to cost and sweet taste. Functional foods and specialised products are also being developed [1].

Loss of Nutrients

Pasteurized and UHT-sterilized milk lose few nutrients, while in-bottle sterilized milk shows greater loss, especially of lysine and vitamins due to Maillard reactions. Losses mainly affect vitamin C and B vitamins (B_1 , B_2 , B_6 , B_9 , B_{12}). Oxygen and light accelerate degradation, with riboflavin acting as a catalyst. Packaging permeability is crucial to prevent losses [1].

1.6 Infant Formulas

Breast feeding is preferable, but when not possible, infant formulas based on cows' milk fractions are used. Unmodified cows' milk is unsuitable. Due to higher risk of microbial contamination, strict hygiene is essential during preparation and storage. Liquid formulas should be refrigerated [1].

Human Milk

Human milk differs from cows' milk in composition and varies by individual and lactation stage. It contains more essential fatty acids, cholesterol, and oligosaccharides, but less protein, casein, and minerals. It includes immunoglobulin A, lysozyme, and lactoferrin, and lacks β -lactoglobulin. Infant formulas require significant adjustment to mimic its properties [1].

Formula Composition and Manufacture

Infant formulas use skim milk and sweet whey (e.g., 1:5 ratio), often with added lactose, vegetable oils, vitamins, Fe, and Cu. Whey is partly desalted. Oligosaccharides or lactulose may be added. Manufacture involves wet mixing, pre-emulsification, pasteurization, and homogenization. Products may be UHT-sterilized, canned, or spray-dried [1].

Bibliography

- [1] P. Walstra, J.T.M. Wouters, and T.J. Geurts. *Dairy Science and Technology*. 2nd ed. CRC Press, 2005. DOI: [10.1201/9781420028010](https://doi-org.ep.fjernadgang.kb.dk/10.1201/9781420028010). URL: <https://doi-org.ep.fjernadgang.kb.dk/10.1201/9781420028010>.