



Molecular and Functional Properties of Milk

Exam Question 09: Increased Protein Degradation

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Link to Git repo.: https://github.com/DanishUnicorn/fp_exam_2025



Question 09

Situation

You are the manager of a medium-sized Danish co-operative dairy plant in Northern Jutland and suspect an increased protein degradation occurring in your milk.

Your task

Map out the reasons for this and determine which methods to use to prove that this is happening.

Advice

Explain the possible reasons for protein degradation occurring in milk and which proteins are susceptible, and the consequences for this proteolysis in selected products. List the methods which you would use to determine this and what actions you would take to prevent it occurring in the dairy plant and at the farm level.

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Synopsis for Question 09

1 Introduction

Milk and dairy products are nutritionally important in the diet worldwide. The microbiological quality of raw milk is essential for the quality of the final dairy product. Quality assurance in milk production at herd level is therefore of great economic importance for both the dairy producer and the dairy industry [1].

Degradation of proteins by proteinases in the milk negatively affects cheese yield, but endogeneous proteinases have been found to contribute to the cheese ripening process through casein hydrolysis [2]

Mastitis is a major problem for dairy producers, as it involves great financial losses. The effect of udder health on the yield and quality of milk and, consequently, on cheese production and quality has been established [3].

2 Milk Composition

Bovine milk contains the nutrients needed for growth and development of the calf, and is a resource of lipids, proteins, amino acids, vitamins and minerals. It contains immunoglobulins, hormones, growth factors, cytokines, nucleotides, peptides, polyamines, enzymes and other bioactive peptides [4].

Milk, alongside meat, is one of the basic animal materials of importance in food processing. Dairy production around the world, including Poland, is dominated by cow milk. This is due to the higher productivity of cows compared to other dairy species. Moreover, it is the most universal raw milk for processing due to its specific content and proportions of proteins, fat, and mineral compounds [5]

- The protein content-, and composition of milk depends on various factors [6]

- Most important:

- Breed

- Lactation stage

- Genetic variants

- Cell count

- Of significance, but less important:

- Parity

- Season

- Milk yield

- Feeding

- Cell count and microbiology is tested at arrival of the milk compared [6].

- There are two major groups of milk proteins [6].

- Caseins - apx. 80% of total protein

- α_{s1} -casein

- α_{s2} -casein

- β -casein

- κ -casein

- Whey proteins - apx. 20% of total protein

- α -lactalbumin

- β -lactoglobulin

- Bovine serum albumin

- Immunoglobulins

Enzymes

- Mastitis has a negative effect on the protein composition of milk, appx. 10% of the protein is lost [7].
 - Total casein content is reduced by 10%
 - α_{s1} -casein is reduced by 26-75%
 - β -casein is reduced by 26-75%
 - κ -casein is increased by 101-1000x
 - Total whey protein content is increased by 101-1000x
 - β -lactoglobulin is reduced by 26-75%
 - α -lactalbumin is reduced by 26-75%
 - Immunoglobulins are increased by 101-1000x
 - Proteose-peptones are increased by 11-100x
 - Serum albumin is increased by 101-1000x
 - Lactoferrin is increased by 101-1000x

3 Protein Degradation

Elevated SCC can exhibit a negative correlation with both the yields and percentages of milk protein and fat [8].

Bacteria can survive in milk if it is not pasteurized - Not necessarily harmful, but can cause spoilage e.g. quality of milk due to proteolysis [9].

Some psychrotrophic bacteria can survive pasteurization - Gram-negative bacteria can produce heat-stable proteases [9].

- Heat inactivation of extracellular proteinases from *Pseudomonas fluorescens*, *Pseudomonas* spp., and *Achromobacter* spp. is not complete unless heat treated at 130°C, D-values [s] of 630, 160, and 510, respectively, and with a Q_{10} of 2.1, 1.9, and 2.1, respectively [9]

- Denaturation: The process of partial or total alteration of the native structure of a macromolecule resulting from a loss in tertiary or tertiary and secondary structure that is a consequence of the disruption of stabilizing weak bonds [10].

3.1 Reasons for Protein Degradation

3.2 Susceptible Proteins

4 Consequences of Proteolysis in Milk Products

5 Methods

5.1 Determining Protein Degradation

5.2 Preventing Protein Degradation

5.2.1 Dairy Plant Level

5.2.2 Farm Level

6 Conclusion

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