Production of raw milk cheese from organic milk

Acronym: RAWMICHEESE

Date: 26th november 2001

Summary in Danish:

Produktionen af økologiske oste er hovedsageligt baseret på at fremstille en række ostetyper, som også fremstilles af konventionel mælk. Såfremt at man skal kunne øge markedsandelen af økologisk producerede oste, er det vigtigt at disse er af en kvalitet, der berettiger til øget merpris i forhold til konventionelt producerede oste. Det hævdes ofte at oste baseret på rå mælk kan opnå en rigere sensorisk kvalitet end konventionelle produkter, dette kræver en dokumentation af at disse oste har en anden flavour end pasteuriserede oste.
I Danmark har man en yderst restriktiv politik for produktion af oste baseret på upasteuriseret mælk begrundet i de potentielle problemer med mikrobiologisk sikkerhed. For i fremtiden at kunne vurdere den mikrobiologiske sikkerhed ved ostning af upasteuriseret mælk er det nødvendigt at fastlægge en række kritiske kontrolpunkter i produktionen fra råvare til det færdige produkt samt angive forslag til monitorering af disse. Dette vil kunne gøres i form af en generisk Hazard Analysis Critical Control Point (HACCP) fra stald til bord, som vil kunne give retningslinier for en sikkerhedsmæssig optimal produktion. De mikrobiologiske data genereret i projektet vil indgå i en risiko simuleringsmodel, der inddrager variation i forekomst og niveau af specifikke patogener samt i proces-og produktparametre af betydning for vækst og overlevelse.
Med udgangspunkt i rødkit oste fra et specifikt mejeri er det derfor nærværende projekt mål, at undersøge og sammenligne flavour og textur udviklingen i rød kit oste baseret på rå og pasteuriseret mælk ved hjælp af textur målinger, flavour analyse baseret på høj vacuum distillation, peptid profilering og under anvendelse af elektronisk næse for derigennem at kunne dokumentere upasteuriserede ostes kvalitet samt at udvikle en HACCP model og en specifik risiko simuleringsmodel, der kan understøtte virksomheders og offentlige myndigheders evalueringsprocedurer for etablering af osteproduktion baseret på upasteuriseret mælk.

1. Summary

The production of organic cheese is mainly based on the production of a number of cheese types, which are also produced from conventional milk. In order to be able to increase the market share of organically produced cheese, it is important that these cheese types are of a quality that justifies an additional price in relation to the conventionally produced cheese. It is often maintained that cheese made from raw milk can obtain a richer sensory quality than conventional products. However, documentation is needed to demonstrate that the flavour of organic cheese is different from cheeses made from pasteurised milk.
In Denmark, the production of cheese based on unpasteurized milk is subject to a very restrictive policy owing to the potential problems with microbiological safety. In order to be able to evaluate the microbiological safety of cheese manufacturing with raw milk, a number of critical control points in the production from raw material to finished product must be established, and suggestions for their monitoring must be made. This can be solved by using a Hazard Analysis Critical Control

Point (HACCP) from stable to table which will provide guidelines for safe processing procedures. The specific data generated in the project will further be used in a risk simulation model which will take into account the variations in prevalence and concentration of specific pathogenic bacteria encountered in the production, as well as the variations observed in the process- and product parameters which may influence growth or inactivation.
The present project will – based on the production of red-lead putty cheese made with raw and pasteurized organic milk, respectively, from a specific dairy - compare the flavour and texture development by means of texture measurements, flavour analyses based on high vacuum distillation, peptide profiling and electronic nose measurements. It will further develop a generic HACCP model and a risk simulation model for the specific cheese which may serve as a tool for public safety managers.

2. Research group

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3. Introduction

The production of organic cheese is mainly based on the production of a number of cheese types, which are also produced from conventional milk. If the market share of organically produced cheese is to increase in the future, it is important that these cheese types are of a quality that justifies an additional price in relation to the conventionally produced cheese. Careful and minimal processing are two important parameters in the organic production. Cheese production based on unpasteurized milk is therefore a natural development within organic production. Often gourmets point out

that cheese made from raw milk can obtain a richer sensory quality, and several EU countries have a proud tradition within this field. Flavour development of Münster –type cheese based on raw milk has to the applicants knowledge never been performed and the identification of enzymes and mechanisms responsible for the flavour development in the Münster cheese based on raw milk has not been studied.

The major obstacle to production of raw milk cheeses is the restrictive policy of the health authorities. This is due to the recognized, increased risk of foodborne disease associated with raw milk cheeses compared with cheeses made from pasteurised milk. By far the majority of the published cheese-associated outbreaks have been caused by raw or under-pasteurized milk even though the raw milk cheeses constitute a minor part of the market (Institute of Food Science & Technology, 1998). Pasteurisation was specifically designed to destroy bacterial pathogens and it is the simplest means of ensuring safe milk and milk products. However, the bacteriological quality of the milk may vary tremendously between countries and herds as well as the hygiene during handling. Likewise, a number of studies have shown that the fate of the pathogenic bacteria may also vary according to manufacturing processes and from cheese to cheese (Johnson, 1990, Knøchel et al. 1995, Little & Knøchel, 1994, Back et al. 1993) and even specific microbial interactions may also be of importance (Larsen & Knøchel 1997, Ennahar et al.2000). It is understandable that the food safety authorities are reluctant to allow the production of raw milk cheeses in general but it is also recognised that the risks involved will depend on the individual operation. A case-by-case approach is now being adopted in Denmark but in order to be operational some demonstration tools are needed. The present project will allow us to generate, summarize, analyse, and interpret microbiological data develop a HACCP and a risk simulation model for a specific cheese production, where we shall be able to follow the production from the staple environment to the finished cheeses during different seasons and feeding practises.

We will therefore – based on the production of red-lead putty cheese made with raw and pasteurized organic milk, respectively, from a specific dairy – be able to explore the major claimed advantages and disadvantages of raw milk based cheeses; i.e. to compare the flavour and texture development by means of texture measurements, flavour analyses based on high vacuum distillation, peptide profiling and electronic nose measurements and to develop a generic HACCP model and a risk simulation model for the specific cheese which may serve as a tool for public safety managers.

4. State of the art

Cheese based on raw milk and produced at farm dairies has the reputation of being of the highest quality (Muir et al., 1997) and is often described as having a more intense flavour than cheese based on pasteurized milk (McSweeney et al., 1993; Roy et al., 1997; Shakeel-Ur-Rehman et al., 1999). The less intense flavour of cheese based on pasteurized milk can be explained by a reduction in the natural bacteria and a partial inactivation of the natural milk enzymes (Urbach, 1997; Grappin & Beuvier, 1997). The microbial flora of unpasteurised milk contributes to the development of flavour, e.g. by production of fatty acid ethyl esters by microbial lipolytic enzymes Dahl et al., 2000). The level of free amino acids has been found to be higher in unpasteurised ewe's milk cheese compared with pasteurised, which may affect the flavour of the ripened cheese (Mendia et al., 2000). A sensory test of 34 Cheddar cheeses produced from either unpasteurized milk or pasteurized milk showed a larger flavour variation among the unpasteurized cheeses, and the flavour was often described as rancid, bitter and unclean (Muir et al., 1997). Both the flavour and texture or body of the cheese contribute greatly to cheese quality, and texture profile analysis has been used to characterise the texture of semi-hard Italian cheese (Montasio) made from unpasteurised milk (Innocente et al., 2000). The characteristics and ripening conditions of the raw material seem to be important for the sensory quality of the resulting cheese, and decisive to whether it is possible to produce cheese of a quality that exceeds the quality of conventionally produced cheese.

Raw milk may contain a number of pathogens but relatively few have been associated with cheese outbreaks. If we look at the globally published outbreaks during the last 25 years most have been

caused by *Listeria monocytogenes, Salmonella spp.* and *verotoxin producing E.coli.*. The focus of the project will therefore be on these bacteria (Institute of Food Science & Technology, 1998). All of these bacteria have been associated with soft and semi-soft cheeses such as the Münster cheese. The project will benefit from a number of data through previous projects and surveys re the prevalence of these bacteria in selected Danish herds gathered by The Zoonosis center at the Danish Veterinary Laboratory. Other bacteria potentially relevant will be included on the basis of literature and available data from the Danish Veterinary Laboratory.

Although Denmark and several other countries are known to have a high hygienic standard for milk production pathogens may still be found. A survey conducted in the late 80'es showed a *Listeria monocytogenes* prevalence of 4.2 % of the herds investigated (Jensen et al. 1996) but no quantitative data are available. Similarly, a survey in England and Wales in the early 90'es also found 5% bulk farm samples positive for *Listeria monocytogenes* and 0,36% for Salmonella spp. (O' Donnell, 1995). A recent, still unpublished fresh cheese outbreak in Sweden found up to $>10^6$ cfu *Listeria monocytogenes*/g cheese as well as different pathogenic *E.coli* and *Staphylococcus aureus*. One goat without any clinical signs had $>10^4$ Listeria/ml milk ! (Danielsson-Tham, M-L. personal communication). These findings illustrate that prevalence may vary within regions, herds and individual animals. It also illustrates that the bacteria may sometimes grow to very high numbers in the cheeses. The relative importance of actions directed towards minimisation of contamination at various points or inhibition of growth may be estimated by use of a risk simulation model based on probabilistic distributions and predictive microbiology.

6. Objectives and expected achievements

The overall aim is to improve the prospects of producing high quality organic cheese with acceptable microbial safety and of high sensory quality from unpasteurised milk.

In this context the principal objectives are

- to investigate the effect of raw material on the ripening process through the determination of sensory quality and textural parameters
- to investigate the level of contamination with specific cheese-associated foodborne pathogens from the staple to the finished cheeses in a farm dairy
- To evaluate the potential for growth or survival of these pathogens in the cheeses
- To elaborate a HACCP and a risk simulation model
- to compare the sensory quality of cheese prepared from unpasteurised milk with the analogous pasteurised cheese

The expected achievements of the project are

- to establish critical reference points of significance for the microbial safety in an organic production of cheese based on unpasteurised milk
- to establish the raw material and ripening parameters of significance for the sensory quality of the products
- to achieve better knowledge on whether cheese based on unpasteurised milk has a more complex sensory quality compared to the analogous cheese based on pasteurised milk
- that the obtained results can form the basis of guidelines for dairies, who wish to establish a production of cheese based on unpasteurised milk and also be part of the risk assesments performed by the authorities

7. Description of workpackages including methods

Table 1: Workpackage list

WP	WP title	Responsible	Budget	Start	End	Deliv-

No		participant				erable, No
1	Flavour and texture development in cheeses made from raw or pasteurized milk	JacobH. Nielsen	1,036,800	02/2002	12/2003	
2	Elaboration of a HACCP and a risk simulation model for a specific raw milk cheese production	Susanne Knøchel	1.273.200	02/2002	12/2003	
Total			2.310.000			

5. Description of workpackages including methods

Table 2: Description of workpackages

WP1:
Flavour and texture development in cheeses made from raw and pasteurised milk

Workpackage number: 1
Start date or starting event:
Responsible person: **Jacob Holm Nielsen**
Contributing persons: **Lotte Bach Larsen**
Person-months:

Objectives:
To study whether cheese based on unpasteurised milk has a more complex sensory quality compared with the analogous cheese based on pasteurised milk

Description of work:

Task 1 Cheese production

From well characterised unpasteurised milk are produced a cheese (Münster-type) with a relatively high water content and a short maturation period. The milk used for the cheese production is obtained from a single herd of 130 Holstein cows. The production at Hinge Osteri is repeated four times during one season to give variations in feeding and milk quality. As a control the same cheese type is produced from pasteurised milk.

The cheeses will be produced according to the following schedule:

Mid-May 2002
Mid-September 2002
Mid-January 2002
Mid-May 2003

Two batches of cheese are prepared at each time point, one from pasteurised milk and one from unpasteurised. The freshly produced cheeses will be stored at relatively high temperature and humidity for one week and then be in retail for 4 – 5 weeks. Extracts from separate cheeses will be

analysed once a week during maturation period as well as the period where the cheeses are normally in retail, giving 5 to 6 samples from each cheese of varying maturation. Salt and pH of each sample will be analysed.

DJF is responsible for distribution of samples and chemical characterisation

Task 2 Enzyme activities and composition of milk and cheese

The raw milk used at each time point (four) of cheese production and extracts prepared (in duplicate, giving a total of 96) from the manufactured cheeses will be characterised by the following parameters:

Protein pct.
Fat pct.
Cell count (only in milk)
Fatty acid composition
Proteolytic enzymes (plasmin/plasminogen)
Casein degradation (γ-casein)
Lipase activity
Xanthine oxidase activity

These parameters describe the gross composition of the milk used as raw material and of the cheeses as well as the level of milk enzyme activities of significance for the development of sensory quality during ripening.

Task 3 Analytical evaluation of sensory attributes

To evaluate and compare the sensory attributes of cheeses made from pasteurised or unpasteurised milk the cheeses will be characterised by the following analytical methods:

Texture analysis
Aroma analyses
HPLC profiling of peptides

The analytical methods are selected to cover development in both texture and aroma. The texture analysis is expected to be carried out as a penetration measurement by texture analyser instrument as a parameter to describe the softening of the cheese. The texture analyses will be carried out on duplicate cheeses (96 samples) 5 to 6 times during storage and retail. Flavour analysis of cheeses are performed by solvent assisted flavour extraction (SAFE) followed by an enrichment on vigreux columns. The enriched extracts are subsequent analysed by GC/MS. The use of the SAFE system makes it possible to quantify semi-volatiles as well as volatiles. The flavour analysis will be carried out on dublicate cheeses (48 samples) 6 times during storage. Aroma analysis will furthermore be carried out on electronic nose in order to classify the cheeses from the aroma profile (6 cheeses of each type will be analysed from each sampling date). The HPLC profiling is carried out to compare the ripening process in terms of protein degradation in pasteurised and unpasteurised cheeses. The method involves preparation of extracts from both types of cheeses and the comparison of obtained peptide profile after HPLC separation. The production of peptides from milk proteins is the result of proteolytic enzyme activity in the cheeses, and may affect both the texture and flavour attributes through the softening of the protein network and the generation of flavour peptides, respectively. The HPLC profiling is relatively time-consuming and expected to be carried out on du-

plicate cheeses at 2 to 3 times during storage and retail period (48 samples).

Deliverables:
D1-D4 Production and distribution of Münster cheeses incl. measurements of salt and pH
D5 International papers
D6 End report
D10 Discussion meeting with stakeholders

Milestones:
M1 Method for analysis of peptides in cheeses has been established
M2 Method for analysis of volatiles and semi-volatiles from cheese has been established
M3 Analysis of cheeses has been performed

WP2: Elaboration of a HACCP and a risk simulation model for a specific raw milk cheese production

Workpackage number:	**2**
Start date or starting event:	**02/02**
Responsible person:	Associate professor Susanne Knöchel. Dept. Dairy and Food Science Royal Veterinary and Agricultural University (KVL)
	Associate research professor Tina Beck Hansen. Dept. Dairy and Food Science Royal Veterinary and Agricultural University (KVL)
Contributing persons:	Laboratory technician NN
	Head of section Flemming Bager Zoonosis Center The Danish Veterinary Laboratory (DVL)
Person-months:	**19 scientific staff + 6 technical staff**

Objectives: To evaluate the risks associated with production of raw milk cheese at a farm majeri

Description of work:

Task 4. Litterature survey on contamination of raw milk and raw milk cheeses from industrialised countries.

International and national data on the prevalence and concentration of *Listeria monocytogenes, Salmonella spp. and E.coli O157*and other pathogenic agents in herds, raw milk and raw milk cheeses will be reviewed incl. recent data from a survey conducted by The Danish Veterinary Laboratory.

Task 5. Microbiological investigations at Hinge's dairy farm

Both young animals, milking cows (pooled feces samples) and raw milk will be tested

for *Listeria monocytogenes, Salmonella spp. and E.coli O157* 3-4 times covering different seasons and feeding patterns before the start of the production batches. The herd investigation will be done in collaboration with The Danish Veterinary Laboratory using standard methodology. If a sample is positive, individual sampling of the raw milk will be done to obtain a variation in concentration using standard techniques as well as quantitative PCR and samples will also be taken at different stages of production.. All cheeses wil be examined at their last day of consumption. A number of samples from the production enviroment post-cleaning will also be examined to validate the prerequisite programme of the dairy farm.

Task 6. HACCP

A production flowsheet from feed to finished cheese will be elaborated together with the dairy. All data on the developments in temperature, salt and pH gradients of the cheeses during production will be collected and estmations of the variations will be performed. Predictions of growth and survival will be done using predicton modelling tools such as Food Micro Model and results from previous projects. The latter shows that FoodMicroModel tends to overestimate growth rate but also lag phase. A growth simulation study during starter culture acidification will be performed with both pasteurised and raw milk. All the information will be analysed and used to elaborate a generic HACCP programme.

Task 7. Risk simulation model

All the information from the three former tasks will be used in a risk simulation model. I terms of risk assessment this simulation model will focus on the exposure-assesment. The model will describe pathways and processes leading up to the exposure and divide these into discrete models. Different approaches will be evaluated in developing an overall model. Estimates of exposure will be made using a probabilistic approach where uncertainty and variability are taken into account by representing parameters as probabilistic distributions. Monte Carlo simulations will then be performed using appropriate software. A sensitivity analysis will be made estimating the effect of changes in the various parameters in order to identify the most efficient ways of inhibiting high level exposure of pathogens. The newly formed risk assessment group at The Danish Veterinary Lab will participate in the discussions.

Deliverables:
WP 2, D7: Review on pathogenic bacteria in raw milk and raw milk cheeses
WP 2, D8: Suggestion for a generic HACCP programme
WP 2, D9: Elaboration of a risk simulation model
WP 2, D10: Discussion meeting with stakeholders
WP 2, D11: Final manuscript

Milestones:
WP 2, milestone 4: Review produced
WP 2, milestone 5: Microbiological analyses performed
WP 2, milestone 6: Generic HACCP programme produced
WP 2, milestone 7: risk simulation model generated

6. Implementation and time schedule

Table 3: Deliverables list

Deliver-able, No	Deliverable title	Delivery date	Meeting	Nature
WP1, D1	Production and distribution of Münster cheeses incl. measurements of salt and pH	5/2002		Cheese pr.
WP1, D2	Production and distribution of Münster cheeses incl. measurements of salt and pH	9/2002		Cheese pr.
WP1, D3	Production and distribution of Münster cheeses incl. measurements of salt and pH	1/2003		Cheese pr.
WP1, D4	Production and distribution of Münster cheeses incl. measurements of salt and pH	5/2003		Cheese pr.
WP1, D5	International papers	12/2003		Intern. pa-per
WP1, D6	End report	12/2003		Written report
WP1, D10	Discussion meeting with stakeholders		x	
WP2, D7	Review on pathogenic bacteria in raw milk and raw milk cheeses	12/2002		Written report
WP2, D8	Suggestion for a generic HACCP programme	3/2003		Written report
WP2, D9	Elaboration of a risk simulation model	10/2003		Written report
WP2, D10	Discussion meeting with stakeholders	11/2003	x	
WP2, D11	Final manuscript	12/2003		Written report

Table 4: Timetable

TI-TLE		**2002***				**2003***			
Tasks	**Co-ordination Quarter**	1	2	3	4	1	2	3	4
1	**WP1:**		5	9		1	5		
2			7	11		3	7		
3			7	11		3	7		
M1									
M2									
	WP2:								
4			x	x	x				
5			x	x	x	x	x		
6				x	x	x	x		
7					x	x	x	x	x

* If convenient, indicate the actual month (can be dome by numbers: January is 1 etc.)

7. Collaborative partners

The Danish Zoonosis Center at The Danish Veterinary Laboratory will participate in the collection and analysis of herd samples as well as the risk simulation modelling.

8. Budget

Institution 1	**2001**	**2002**	**2003**	**2004**	**2005**
Months (scientific)		4	7		
Months (technical)		11	5		
Salary (scientific)		144	252		
Salary (technical)		253	115		
Operation – equipment					
Operation - other		60	40		
Overhead		91.4	81.4		
Total		548.4	488.4		

Institution 2	**2001**	**2002**	**2003**	**2004**	**2005**
Months (scientific)		8	11		
Months (technical)		5	1		
Salary (scientific)		320	451		
Salary (technical)		116	24		
Operation – equipment					
Operation - other		80	70		
Overhead					
Total		619.2	654		

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Appendix:

The Danish Institute of Agricultural Sciences is a part of the Danish Ministry of Food, Agriculture and Fisheries and has approximately 1100 employes. The institute coveres research from gene to

fork and has fascilities for production of specific types af feed and our own production herd making it possible to study effects of feeding on milk quality.

Department of Animal Product Quality has app. 50 employes and conducts research in the areas of oxidation and flavour, protein characterization, muscle biology and physical changes in animal products and foods. The department has its own pilot plant with a pasteurization line and pumping equipment as well as advanced analytical equipment including GC/MS, ESR, DSC and chromatographic equipment for analysis of oxidation products, flavour components and antioxidants. The scientific staff working with oxidation and flavour in animal products and foods includes five senior researchers, two researchers, two PhD-students and one master student.

Jacob Holm Nielsen, Oxidation and Flavour group leader, has conducted research in relation to oxidative changes in foods and has during the last five years coordinated several research projects concerning milk quality.

DEN KGL. VETERINÆR- OG LANDBOHØJSKOLE

Mejeri- og Levnedsmiddelinstituttet

14. juni 2002

Appendix: Rawmicheese

The research group at KVL

The Royal Veterinary and Agricultural University (KVL) is the agricultural university of Denmark where research and education encompass the areas of veterinary medicine, horticulture, forestry, agriculture, food science and nutrition. There are approximately 1,600 employees and 3,500 students, 400 of whom are Ph.d. students. Within KVL the Department of Dairy and Food Science is in charge of research and education in the area of food science. The activities at the department are under the auspices of the Centre for Advanced Food Studies (LMC) which coordinates research and education between KVL and Technical University of Denmark (DTU). LMC has recently been appointed a “Major Research Infrastructure” in the field of food science by the EU.
Within the department the Food Microbiology section currently comprises approximately 45 persons and is responsible for a number of courses for food science students incl. advanced courses in food preservation and safety assurance. The section is very well equipped for microbiological work using classical and molecular techniques as well as rapid methods and there is access to classified laboratories. The food preservation group is headed by lecturer Susanne Knøchel. The project will form part of this group which currently comprises one lecturer, three post-docs, two ph.d. students + one guest ph.d. student, three lab.technicians and students. The group is mainly focusing on safety aspects of foodborne pathogenic bacteria in processed foods and water.
Our aim is to:
Understand how we can inhibit or inactivate pathogenic bacteria in food

- at the molecular level
- at the cell and cell population level
- at the food production level

To predict how changes in processing or formulation will affect safety and shelf life

- for use in HACCP
- for use in risk assesment

Associate professor S. Knøchel currently coordinate or co-coordinate the following projects:
1)*Stress induced cross-protection in Listeria monocytogenes 2) Targeted biopreservation: resistance development 3) CO_2-induced changes in Listeria monocytogenes 4) Hygienic aspects of water re-use in the food industry 5) Microbiological stability and safety of pre-peeled vacuum-packed potatoes. 6) Development of an image analysis method for measuring hand hygiene*

The group has extensive experience in working with cheese. We have been actively involved in a FØTEK project on growth and survival of pathogenic bacteria in cheese (1992-1995) and a company financed project on the suppression of pathogenic bacteria in yellow cheese by bacteriocin-producing starter culture. We also have experience in generating and applying data for quantitative aspects of HACCP and risk assesment. Associate professor S. Knøchel teaches food science students in food preservation microbiology, microbiological safety management as well as in pathogenic bacteria in dairy products.

CURRICULUM VITAE

Jacob Holm Nielsen (born in 1958) Head of research unit, MSc, PhD
Tel. +458999 1163, Fax +458999 1564, jacobh.nielsen@agrsci.dk

Education:
M. Sc. in biologi (1992)
Ph. D. in food chemistry (1995) "Cholesterol oxidation in dairy products"

Employments:

May 1992-June 1995	**Ph.D-student, Centre for Food Research**
June 1995-June 1996	Research Assistent professor, Mejeri og Levnedsmiddel Instituttet, KVL
June 1996-December 1998	Senior scientist, Department of Animal Product Quality, DIAS
December 1998-	Head of research unit, Department of Animal Product Quality, DIAS

Other activities:
Censor at KVL in food chemistry
Project mangement:
Flavour and taste of organic milk
Organic milk quality-Improvement through gentle storage
Improvement of shelf life and quality of dried egg powder
Drip loss as influenced by calcium in pork
Milk quality as influenced by somatic cells in milk
Sensory and technological quality of milk as affected by automatic milkin

Flavour in milk as influenced by feeding, mechanical stress and storage of the raw milk

Early events for oxidation of milk – significance for oxidative stability of organic milk and dairy products (Only for DIAS)

Recent references

H. Østdal, H. J. Andersen, & J. H. Nielsen (2000) Antioxidative activety of urate in bovine milk. *Journal of Agricultural and Food Chemistry.* **48**, 5588-5592.
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L. WIKING, M.B. FRØST, L.B LARSEN, J.H. NIELSEN (2001) Effects of storage conditions on lipolysis, proteolysis and sensory attributes in high quality raw milk. *Milch Wissenschaft* (accepted)
I. H. Lambert, J. H. Nielsen & N. Ørtenblad (2001) Cellular model for introduction of drip loss in meat. *Journal of Agricultural and Food Chemistry* **49** *4876-4883*

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EDUCATION: Ph.D., Water and Food Microbiology, The Royal Veterinary and Agricultural University, Denmark, 1989. M.Sc., Food Science, The Royal Veterinary and Agricultural University, 1981. International Post-Graduate University Course in Microbiology, The Department of Fermentation Technology, Osaka University, Japan, 1983

PROFESSIONAL CAREER:

1991	Associate professor (Food Preservation Microbiology) at the Department of Dairy and Food Science, Royal Veterinary and Agricultural University, Denmark
1989-91	Senior researcher. Water Quality Institute. In charge of microbiological water hygiene
1984-89	Senior researcher. Technological Laboratory, Ministry of Fisheries (Lyngby, Denmark)
1982-84	Visiting scholar in Japan (Awarded Monbusho Scholarship).
1981-82	Research Associate .Technological Laboratory, Ministry of Fishery,

Main areas of interest:
Food- and waterborne bacteria detrimental to human health or food quality. Microbial ecology of foods. Factors affecting the growth, stress response and survival of pathogenic bacteria. Cross-resistance phenomena in food-borne pathogenic bacteria and the implications for food preservation. Interactions between starter cultures and foodborne pathogens. Application of predictive microbiology in HACCP and risk analysis.
Working experience:
More than 30 peer reviewed papers and book chapters in food microbiology. Extensive experience in research project management from the application phase to publications or implementation of the results in industry. Extensive teaching experience in the area of food microbiology and hygiene as well as experience in supervision of bachelor-, master course and Ph.D. students.
Current research group:
The group currently comprises three post-docs, two ph.d. students + one guest ph.d. student, three lab.technicians + students. The group is mainly focusing on safety aspects of foodborne pathogenic bacteria in processed foods and water.

Referee

Member of the Editorial Board (Microbiology) J. Fd Sci.
Ad hoc referee for Int. J. Food Microbiol., Food Microbiol., Trends in Food Science and Technology, Water Science

SELECTED RELEVANT PAPERS

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