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HACCP-based Quality Risk Management approach to Udder Health problems on Dairy Farms

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Abstract

Against the background of a long-lasting history of prevailing udder health problems on dairy farms and while notifying the relatively low success rate of recovery or prevention, this paper addresses a new type of approach to such udder health problems.
First, the current udder health control programmes are highlighted and their drawbacks indicated. Among these programmes are the 'five point scheme', sometimes expanded to eight or ten points, all focussing on contagious mastitis pathogens, and the programmes focussing on environmental pathogens like coliform bacteria.
Next, the concept and principles of hazard analysis critical control points, HACCP, are introduced. The eight core elements of this concept are dealt with by using an example dairy herd with a mastitis problem due to *S. aureus*. The different steps to be taken for developing a HACCP-based quality risk management programme are illustrated through the application of the different core elements.
Finally, it is shown that the HACCP key words structure, organisation, planning, communication and formalisation –which do not or hardly appear in conventional programmes like herd health & production management programmes or in the udder health control programmes- could largely contribute to a better success rate in udder health. The role of the veterinarian can be paramount and of added value, if he is willing to invest in new knowledge and skills, like in the HACCP quality control concept, farm economics, animal nutrition, and –most of all- in his role of persistently coaching the dairy farmer in his efforts to take intervention and prevention measures in the various areas related to udder health..

Introduction

Mastitis in dairy cows is a multifactorial disease with a long history. Next to the associated impairment of welfare due to the pain, it is the most costly endemic disease in dairy herds with an average yearly incidence of about 28%. Among the economic loss components are the loss of milk production, treatment costs, extra labour, premature culling of chronically infected cows (Huirne *et al*., 2002). Moreover, mastitis represents a stress factor for the farmer, reducing his labour joy.
Over decades, much research has been conducted in the area of udder health. Although different treatment and prevention protocols have been issued over the years, success rates have been variable and a true solution to the problem has not been found. Differences in mastitis prevalence rates between farms are large (Hogeveen and Osteras, 2005; Noordhuizen and Hogeveen, 2005).
Regarding the potential causes of failure to solve the problem, various indications are given. First, multifactorial diseases are not always easy to eliminate if not adequate attention is given

to contributing causal factors, or if the pathogen is ubiquitously present in the environment. Secondly, for a proper understanding of the mastitis problem sufficient information must be available, e.g. cow history, environmental conditions, production data, management data. Thirdly, hygiene is recognised as an important issue, but farmer should understand that hygiene goes far beyond the hygiene during milking alone. Hygiene at all levels should be addressed: housing, feeding, cows in the barn, milkers. Finally, when an udder health control programme, UHC, is designed and implemented, it warrants a persistent, consequent and protocol-based approach by both the farmer (and his co-workers) and a coaching veterinarian in all areas of udder health concerned in a balanced way (Hancock and Dargatz, 1995; Noordhuizen and Hogeveen, 2005).
This paper deals with a new kind of approach to udder health problems in which all fragments of other approaches are integrated, structured and formalised: the HACCP-like Quality Risk Management approach. The objectives are to show that this approach is feasible on the dairy farm, and that its intrinsic structure, organisation, planning and formalisation may yield better results than the conventional methods.

Udder Health Control, UHC

The complexity of mastitis and –hence- its control is presented in Fig.1 (after Noordhuizen and Hogeveen, 2005).
In addition to the herd dynamics with different interactions between cows, influenced by variations in housing, climate, feed quality and milking machine conditions, we have a great impact of management (e.g. milking method, drug application, feeding management, hygiene practice). This complex is further impacted by issues like the farmer's attitude, animal welfare and the use of analgetics, and farm economics. At the output side there are several options to measure the udder health state in the herd directly or indirectly (e.g. somatic cell counts; bacteria counts; bacteriological culturing of mastitis samples; incidence/prevalence figures) and we can conduct monitoring & surveillance activities in the areas related to udder health and its control.

<<Fig.1>>

Among udder health control programmes there is the Five Points Scheme issued in the 60's and predominantly focussing on contagious mastitis by e.g. *Streptococcus agalactiae.* This scheme has proven to be rather successful (Kingwill *et al*., 1970; Bramley and Dodd, 1984;). The five points regard the clinical and subclinical mastitis, drying off therapy, the culling of chronically infected cows, the proper milking machine function, and an appropriate milking method including teat dipping. Main goals are to prevent new infections from occurring and reducing the number of existing infections. Since the 60's this five points scheme has been expanded to eight or ten points, including areas like feeding, farm hygiene and adequate housing and climate, but the principles remained the same. Total farm hygiene means that in addition to hygiene around milking (machine, milkers, waiting area, teats and teat dip), attention must be given to overall hygiene of cows in the barn, hygiene of cubicles, exercise areas, equipment and feed bunk. All these activities together are not easy to persistently conduct on a farm.
After applying an UHC the pathogen profile of dairy herds usually change. Coliform bacteria have emerged in low cell count herds where streptococci have been reduced, indicating udder infections due to environmental bacteria challenging the immune responsiveness of high yielding cows (Schukken *et al*., 2005). Impaired immune-responsiveness is at the same time coupled with an increased milk yield, provoking more or less severe negative energy balance

(NEB) after calving and ketosis. The latter is known for its detrimental effect on the immune system (Suryasathaporn *et al*., 2000). Control measures are usually focussed on improving the immune-responsiveness of cows by e.g. reducing the NEB and ketosis, and optimising cow comfort issues (Noordhuizen and Lievaart, 2005). *Staphylococcus aureus* as a third major udder pathogen group plays an intermediate role between contagious and environmental bacteria. This pathogen has various subtypes, each with its own epidemiological herd dynamics (Zadoks *et al*., 2002).
The reliability of information about the udder health situation on a dairy farm is –at least- variable. This variability can occur due to a higher or lower availability of such information, but also due to bias in e.g. the farmer's or veterinarian's observational skills. Moreover, laboratory testing results may show bias, due to variation in sensitivity and or specificity of diagnostic tests; there is quite a difference in results when comparing bacteriological culturing and DNA-fingerprinting results. Any bias may lead to misclassification and misinterpretation, either negative or positive, which on their turn lead to improper UHC measures.
Last but not least there is the matter of persistency in taking full measures in the indicated areas and the way that any advice is provided and adopted. This is about communication and coaching. Especially in the domain of udder health problems with all their complexity it is paramount that the farmer understands the different risk factors and their impact, that he knows that the veterinarian is member of the problem solving team and that he does not stand alone with his own responsibilities. Effects of advice are for only 25% accounted for by its technical content, while 75% is contributed to communication qualities (empathy, emotion, perception, attitude, voice and tone of speaking). It seems that too often the farmer does not quite understand the relevance of risk factors and of measures to be taken, while at the other hand the veterinarian too often leaves the farmer alone with his problem, without playing his role of a coach.

Hazard analysis critical control points, HACCP: concept and application

HACCP addresses product quality through the control of the production process. It was originally developed for the NASA space programme to safeguard astronauts from chemical, physical and micro-biological hazards through food. For a history and review see Pierson (1995) and Hulebak and Schlusser (2002).
The HACCP concept and principles have been adopted by the EU for safeguarding consumers from food safety hazards through the food producing industries. Moreover, in 2004 the EU has suggested that farmers implement a HACCP-like programme on their farm to control hazards and risks in the areas of food safety and public health, and animal health and welfare, as part of the new Hygiene directive EC 852/853/854-2004 (Noordhuizen *et al*., 2007).
The 8 key components in the HACCP concept and principles, and –hence- in the handbook of HACCP-like Quality Risk Management programmes are: analysis of main hazards and associated risks on a farm (e.g.mastitis); production process diagrams (e.g. a more detailed elaboration of Fig.1); definition of critical control points, CCP, with their standards and tolerance limits, and points of particular attention, POPA with their targets; the monitoring of these CCP's and POPA's; the availability of corrective measures; working instructions and guidelines; records; verification (Cullor, 1995;Noordhuizen and Welpelo, 1996).
In the next section the example of a herd mastitis problem due to *Staphylococcus aureus* is addressed by following several of the forenamed 8 key components.

Hazard identification.
This step resulted in the main hazard "*Staphylococcus aureus*" . Based on a herd inventory and history, a herd treatment advisory plan is designed, comprising several categories of disease sign groups (e.g. mild; severe; very severe mastitis), and the actions or interventions (including drug choice, dosage, route of administration and withdrawal period). Problem cows are identified based on a set of criteria (e.g. mastitis history, repeat cases, cure rate, cell count levels). Next step is the identification of *risk factors* for *Staphylococcus aureus*, applicable to this particular farm. These risk factors are listed in Table 1.

<<Table 1>>

Regarding the CCP's and POPA's it can be stated that formal HACCP programmes comprise CCP's which have to meet different formal criteria; if those criteria are not met, one can decide to retain that point as point of particular attention (POPA). The criteria most frequently not met are: a full restoration of process control after corrective measures are taken; and: the presence of formal standards and tolerance limits. In physical processes (e.g. industry) most if not all control points are CCP; in live animals with their biological variation we will most often deal with POPA's.
Regarding the definition of *CCP's and POPA's*, the following action was taken.
The risk factors from Table 1 were weighted and ranked in order of estimated relevance (see the figures between brackets in Table 1). Weighing can be done quantitatively using odds ratios, semi-quantitatively using the procedure of adaptive conjoint analysis (Angus *et al.*, 2005), or qualitatively by making a best possible estimate (Noordhuizen *et al.*, 2007). Then, each of them were screened for CCP or POPA, provided with a standard/tolerance limits or a target respectively and positioned in the *monitoring scheme*. The latter includes: CCP or POPA, method of monitoring, frequency of monitoring, person responsible of monitoring, result of monitoring (see also Table 2).

<<Table 2>>

Targets are for example: the envisaged yearly incidence rate of clinical mastitis cases (< 25%); the somatic cell counts at cow level (< 150.000/ml); the level of new udder infections per time unit (< 10%).

Each of the items listed under "Risk area" in Table 2 should be further detailed to be as specific as possible. This specification is needed to associate the respective monitoring actions with. For example, the farmer considers daily which cows should be defined as problem cows; he considers once a week which problem cows should be culled when or treated. Zadoks (1999) has shown the decision dilemma about treating or culling. An older cow with subclinical mastitis in hind quarters due to *Staphylococcus aureus*, an average somatic cell count level of 2 million/ml, 150 days in lactation should better be culled than treated because expected cure rate is around 1%, while –for example- a young cow with a mastitis in one front quarter and a somatic cell count in milk of 500.000/ml and 220 days in lactation would have an expected cure rate of around 60%. Various economic assessments about treating mastitis or not have been published too (Swinkels *et al*., 2005).
Results of each monitoring action are recorded on a monitoring log with date and findings; when deviations have been noticed, the intervention conducted is recorded too.

An *intervention plan* for this example farm could comprise the following elements, as listed in Table 3

<<Table 3>>.

The proposed interventions (*corrective measures*) are described on a separate sheet and updated when needed e.g. after a follow-up evaluation.
The *working instructions* (WI) as indicated in Table 3 (herd treatment advisory plan; instruction on milking method and hygiene; criteria for culling) can be considered as technical management tools. They are meant to avoid flaws in attention and lack of compliance. It has been proven that such working instructions are highly beneficial to and economically justified for the dairy farmer (Animal Health Service, 2006). Working instructions are detailed elaborations of (parts of) *good dairy farming codes of practice*, which are general guidelines to improve attitude and mentality of people working on the farm (OIE, 2006). Examples are: good milking hygiene, good medicine application. For further reading about these issues we refer to Noordhuizen *et al*. (2007) and to the website www.vacqa-international.com.

As far as the *records* are concerned in a HACCP-like Quality Risk Management programme, some examples have been given above. Records must be functional to e.g. operational farm management to keep up motivation of the farmer. But they must also be relevant with regard to HACCP demands. In the latter case such records must allow the internal validation of the proper functioning of the HACCP-like Quality Risk Management programme, as well as meet the demands of HACCP with regard to demonstrating the herd status on and measures taken for improvement of animal health and welfare, public health and food safety. Summing up the following records are core components: general farm information sheet; hazards & risks sheet (including risk weighting, true risk identification, CCP & POPA determination); monitoring scheme (including the CCP's and POPA's, their standards+tolerance limits, or target values respectively, the method, frequency and person responsible for monitoring); the moitoring results sheet (including CCP's and POPA's monitored with date and findings, and –in case of deviations- the corrective measures taken); the GDF guidelines and working instructions; a list of monthly, 6- or 12-monthly herd performance figures; checklists for internal validation; reports of external verification audits. Further detailing of the forenamed records can be found in Noordhuizen *et al*. (2007).

Discussion and conclusions

Looking through the various paragraphs related to sections of a formal HACCP-based Quality Risk Management programme handbook, there are several remarks to be made.
First, this type of QRM represents a highly structured and organised approach. Planning and prevention are fully protocol-based. Aspects as such are quite often lacking in conducting veterinary UHC or herd health & production management programmes (Brand *et al*., 1996; De Kruif *et al*., 2007). Secondly, there are quite some elements in this QRM approach which may look familiar because they also appear in herd health & production management programmes. Examples are risk assessment, monitoring, record keeping, performance figures, interventions. But again, herd health & production management programmes are often too much "freestyle". The large differences between the two approaches are structure, planning, organisation, formalisation present in QRM, absent in HHPM. Given for the similarities between the two, it is very well possible to integrate the two approaches into one advisory programme for the dairy farmer. In that way, the operational management issues and the more tactical quality risk control can be addressed simultaneously.

With a focus on UHC problems, the HACCP-like approach will –thanks to the earlier named intrinsic features- avoid a loss of farmer's attention for relevant areas and tendencies to neglect issues. In QRM all areas (see paragraph UHC) must be addressed at the same time, and preferably to a large extent. Guidance is provided by a coaching veterinarian and through the prescribed records of the handbook. These records provide the means to consequently focus on the relevant areas. In fact, it is what farmers state once they have experienced the implementation of HACCP principles: they are much more focussed, they are motivated because guided and willing to solve a herd problem because the whole picture is more clear (Valeeva *et al*., 2007). Moreover, the HACCP-like QRM provides the veterinarian with means to act as a coach of the farmer, once the veterinarian has acquired the necessary knowledge and skills, of which adequate communication is one of the most important (Noordhuizen and Metz, 2005; Cannas *et al*., 2006). Other domains of new knowledge are e.g. farm economics, animal nutrition, marketing & business administration. As has been stated elsewhere, the technical content of an advice accounts for 25% of the effect of that advice. The other 75% are accounted for by elements of communication (e.g. empathy, emotion, perception, body language, tone of voice, dominance of attitude). It can be expected that in the complex udder health problem situations a strict coaching and execution of actions is warranted, something that is easily slackened in conventional approaches or herd (udder) health approaches.
HACCP is one among other quality control concepts. Other concepts are e.g. good manufacturing practice and international standardisation organisation concepts (e.g. ISO 9000, ISO 14000 and ISO 22000). It has been determined earlier that the HACCP approach is best applicable to (dairy) farms because it is highly farm-specific, with relatively low labour and costs input, fit for integration in food chain quality assurance programmes and for certification. Moreover, the herd status with regard to animal health and welfare, and public health and food safety can be demonstrated as well as improvement measures taken (Cullor, 1995; Noordhuizen and Welpelo, 1996). The concept and 7 principles are integrated into a 12-steps scheme for developing a HACCP-like Quality Risk Management programme on dairy farms (see Annex 1, adapted after Culler, 1995). Further information, examples and detailed elaborations of this QRM can be found at www.vacqa-international.com and in Noordhuizen *et al.* (2007).
Veterinarians who want to enter this new field of approach will -after acquiring the proper knowledge, skills and experience- prove their added value to dairy farmers and the dairy sector, and –hence- will fulfil their role of intermediate between the dairy (farming) sector and the society (consumers).

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ANNEX 1

The 12-steps scheme for developing a HACCP-based Quality Risk Management programme (adapted after Cullor, 1995)

Step 1	Assemble an on-farm QRM-team; describe the general farm geography
Step 2	Identify the most significant hazards in public health & food safety, and in animal health & animal welfare
Step 3	Determine the risk factors associated with the defined main hazards, and explore which are applicable on the particular dairy farm
Step 4	Draw farm process flow diagrams (general and detailed for a hazard) and check these on site
Step 5	Define critical control points (CCP), and points of particular attention (POPA)
Step 6	Determine the respective standards + tolerance limits (CCP) and target values (POPA)
Step 7	Weigh the different risk factors for their probability of occurrence and their impact
Step 8	Design a formal monitoring scheme, including CCP/POPA, method of monitoring, frequency of monitoring, person responsible, measures to be taken at deviations
Step 9	Determine sets of corrective measures for deviations occurring at CCP's and or POPA's
Step 10	Develop good dairy farming guidelines and technical working instructions for areas needing particular attention
Step 11	Introduce the necessary documents Install specific training programmes of short duration for farm workers
Step 12	Install internal validation procedures, and external auditing procedures

Table 1. Risk factors contributing to *S. aureus* mastitis on the example farm.

Old age of cows	(7)
Previous udder infections with *S. aureus* or *Strep. uberis* (4)	
High teat end callosity scores in the herd	(2)
Poor culling policy regarding problem cows	(6)
Deficiencies in the milking machine function	(1)
Poor milking method and hygiene	(5)
Contaminated hands of milkers, bedding material, flies	(3)

Table 2. Hazards & Risks listing (with CCP and POPA, standards or targets, monitoring)

Hazard defined: *S. aureus* mastitis

Risk areas:	CCP or POPA	Target	Monitoring
1. milking machine function (e.g. vacuum level)	POPA	Optimal.	Daily + 1x/wk+2x/yr
2. teat liner condition	POPA	Optimal.	1x/wk
3. overall hygiene on the farm (e.g. barn)	POPA	Optimal.	1x/wk
4. udder health state (pathogen profile)	POPA	Optimal.	Daily + 1x/wk
5. milking method and hygiene (+ milker)	POPA	Optimal.	Daily
6. culling rate of problem cows	POPA	Optimal.	Daily + 1x/wk

Note that "Optimal" means according to prescriptions of the manufacturer or at best possible practice (e.g. Bray & Shearer, 1994).

Table 3. Intervention & Advice Plan for the example farm.

Activities to be undertaken	WI	Responsible
• for the short term:		
1. keep milking machine in good function at all times (frequent check-ups; maintenance; machine evaluation)	WI	Farmer
2. adjust milking method and improve milking hygiene	WI	Farmer(V)
3. follow the herd treatment advisory plan for diagnosis And treatment of mastitic cows		
4. cull chronically infected cows according to criteria	WI	Farmer (V)
5. monitor healthy and infected cows and the environment		Farmer, Vet
• for the longer term:		
1. implement separate housing for mastitis cows		Farmer
2. improve cow comfort elements (feeding, housing, climate)		Farmer (V)
3. improve overall farm hygiene		Farmer (V)

WI refers to a certain technical working instruction for this topic; (V) means that the veterinarian provides technical support to the farmer on that topic, e.g. through the design of a working instruction or through herd inspection tours.

Legends to Fig.1.
A schematic view on the complexity of mastitis problems in dairy herds and elements of control