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Food safety aspects of dairy cow housing and husbandry systems[1]

Scientific Opinion of the Panel on Biological Hazards

(Question No EFSA-Q-2008-296)

Adopted on 9 July 2009

Relating to Opinions of the Scientific Panel on Animal Health and Welfare:

Scientific opinion on welfare of dairy cows in relation to leg and locomotion problems based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection. EFSA-Q-2008-337. Adopted 5 June 2009[2].

Scientific opinion on welfare of dairy cows in relation to udder problems based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection. EFSA-Q-2008-338. Adopted 5 June 2009[3].

Scientific opinion on welfare of dairy cows in relation to metabolic and reproductive problems based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection. EFSA-Q-2008-339. Adopted 5 June 2009[4].

Scientific opinion on welfare of dairy cows in relation to behavior, fear and pain based on a risk assessment with special reference to the impact of housing, feeding, management and genetic selection. EFSA-Q-2008-340. Adopted 5 June 2009[5].

Scientific opinion on the overall effects of farming systems on dairy cow welfare and disease. EFSA-Q-2006-113. Adopted 5 June 2009[6].

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2 www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902629358.htm

3 www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902629243.htm

4 www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902629142.htm

5 www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902628688.htm

6 www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902630995.htm

SUMMARY

The European Food Safety Authority (EFSA) asked its Panel on Biological Hazards to deliver a scientific opinion on: Food Safety aspects of dairy cows housing and husbandry systems. The Animal Health and Welfare Panel (AHAW) has addressed animal welfare aspects of dairy cow husbandry systems in form of five separate scientific opinions. The BIOHAZ Panel has focused on the food safety relevance of dairy cow welfare factors, in a single opinion incorporating all aspects addressed by the AHAW Panel opinions.

When assessing whether and how compliance or non-compliance with the requirements of the well-being of dairy cows in current farming and husbandry systems can affect the safety of the resulting foods (milk and beef), universal principles of the relationship between animal welfare and food safety, as well as food-safety evaluation of specific risk factors affecting animal welfare on dairy farms, have to be used. With respect to specifics of the animal welfare-food safety relationship in dairy farming, evidence that the relationship is quantifiable and directly applicable to a given combination of dairy cows welfare-relevant factor (on-farm) and milk- or beef-safety hazard (at milking or at slaughter) is either limited or unavailable. Therefore, only brief descriptive considerations of any such relationships identified, based on general principles of milk/meat hygiene and safety, are presented in this opinion.

In principle, assuring on-farm welfare of dairy cows contributes to, and is beneficial for the food safety aspects of their products entering the food chain. Good farming/hygienic practices (GFP/GHP) including provision of optimal animal welfare enhance the animals' resistance to infections and reduces on-farm spread of food safety hazards. Dairy farming practices that are beneficial for both dairy cows' welfare and food (milk and beef) safety particularly include, but are not limited to: effective herd health management including responsible use of antimicrobials hygienic husbandry including appropriate farm design and effective biosecurity; microbiological quality of feeds (both pasture- and compound feed-based) and water; management for preventing animal stress; hygienic milking; hygienic preparation of animals for slaughter; and management of grazing land with respect to the spread of animal manure. Each of these practices further comprises a number of contributing factors involved. Presently available information is insufficient to quantify the individual contribution of these practices/factors for, or to rank them with respect to, resultant milk and/or meat safety. However, some dairy farming practices that are considered beneficial for dairy cows' welfare may also increase the risks of foodborne pathogens in the animals and/or their products entering the food chain. These factors particularly include, but are not limited to: holding of animals in groups that can increase direct (animal-to-animal) and indirect (animal-environment-animal) transmission of microbial hazards, the latter involving vectors such as floor/wall surfaces and jointly used feeders, water troughs and animal handling equipment; use of bedding that can serve as a vector for microbial cross-contamination; use of grooved/non-slippery floors that are difficult to clean-sanitise; and access of animals to outdoor spaces that can increase their exposure to some environment- and wildlife-associated hazards. Presently available information is insufficient to individually quantify the ultimate food safety outcome of the opposing (welfare beneficial but food safety undesirable) effects of these factors. Consequently, further, multidisciplinary research on the relationship (positive or negative interaction) between animal welfare- and food safety-related factors on dairy farms should be encouraged.

Key words: dairy cows, dairy farming, animal welfare, biological hazards, food safety

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY EUROPEAN COMMISSION

Council Directive 98/58/EC concerning the protection of animals kept for farming purposes lays down minimum standards for the protection of animals bred or kept for farming purposes, including cattle, although no specific rules are laid down at Community level for dairy cows. The recently adopted Community Action Plan on the Protection and Welfare of Animals[7] has as one of the main areas of action "*upgrading existing minimum standards for animal protection and welfare….as well as possibly elaborating specific minimum standards for species or issues that are not currently addressed in EU legislation*".

In response to a request from the Commission, EFSA has recently issued a scientific opinion and report on welfare aspects of intensive calf farming systems[8], updating a report on the welfare of calves[9] adopted by the Scientific Veterinary Committee Animal Welfare Section on 9 November 1995. A scientific opinion on the welfare of cattle kept for beef production[10] has also been issued by the Scientific Committee on Animal Health and Animal Welfare on 25 April 2001. However no scientific opinion has yet been issued concerning the welfare of dairy cows, except for that on Bovine Somatotrophin (SCAHAW, 1999)[11].

TERMS OF REFERENCE AS PROVIDED BY EUROPEAN COMMISSION

Against this background the Commission considers it opportune to request EFSA to issue a scientific opinion on the welfare of dairy cows. This opinion should consider whether current farming and husbandry systems comply with the requirements of the well-being of dairy cows from the pathological, zootechnical, physiological and behavioural points of view.

In particular the impact that genetic selection for higher productivity has had on animal welfare should be evaluated, considering inter alia the incidence of lameness, mastitis, metabolic disorders and fertility problems. Where relevant for animal welfare, animal health and food safety aspects should also be taken into account.

ACKNOWLEDGEMENTS

The European Food Safety Authority wishes to thank the members of the Working Group for the preparation of this opinion: independent experts Sava Buncic and Frans Smulders, and the EFSA BIOHAZ Unit Scientific Officer Ernesto Liebana.

[7] http://europa.eu.int/comm/food/animal/welfare/actionplan/actionplan_en.htm
[8] www.efsa.europa.eu/science/ahaw/ahaw_opinions/1516_en.html
[9] http://europa.eu.int/comm/food/fs/sc/oldcomm4/out35_en.pdf
[10] http://europa.eu.int/comm/food/fs/sc/scah/out54_en.pdf
[11] http://ec.europa.eu/food/fs/sc/scah/out21_en.pdf

ASSESSMENT

1. Introduction

1.1. General relationship between animal welfare and food safety

Existence of a link between animal welfare - particularly as affected by stress and nutrition - and susceptibility to microbial infection, has been recognised for a long time. The scientific basis of the link between poor animal welfare and increased susceptibility to infection is complex and relatively poorly understood, but stress appears to be a particularly relevant mediator in that link.

Fundamental aspects of the relationship between animal welfare and food safety, as indicated in a previous BIOHAZ scientific opinions on food safety aspects of different pig housing and husbandry systems (EFSA, 2007b)[12], and on food safety aspects of veal calves farming (EFSA, 2006)[13], are universally applicable to farming of all farm animal species. It is generally considered that use of farming systems based on good/hygienic practices including provision of optimal animal welfare enhances the animals' resistance to infections and leads to a reduction of the food safety risks associated with the resulting foods of animal origin.

Today, it is generally accepted (de Passille, AM and Rushen, J, 2005) that animal welfare, overall, has the potential to reduce on-farm risks to food safety, principally through:

- reduced stress-induced immuno-suppression,
- reduced incidence of infectious disease on farms and reduced shedding of zoonotic pathogens by farm animals,
- reduced antimicrobial use and antimicrobial resistance.

1.2. Global regulatory context of food safety assurance on dairy farms

Proper management of dairy farm operations (good farming practices / good stockmanship) is not only essential in animal welfare terms (i.e. improving the resistance to animal disease) but also significantly reduces the likelihood of dairy cows transmitting zoonotic diseases to humans through foodborne (the milk and meat) and/or other routes. The latter has been clearly recognised in the 1999 EU's White Paper on Food Safety[14], which formed the basis of a number of recently issued items of European legislation. Council Directive 2002/99/EC[15] aims at assuring that only those products that originate from healthy animals are brought on the market. To this end general animal health requirements (and derogations thereof) applicable to all stages of production, processing and distribution of products of animal origin within the Community have been laid down. These measures are underpinned by veterinary certification and official veterinary controls by EU Member States and, in case of importation from third countries, by Community experts, who should document that animals and products thereof comply with Community rules. Further legislation [Regulation (EC) 852/2004[16] on the hygiene of foodstuffs regardless of their origin, and Regulation (EC) 853/2004[17] on specific hygiene rules of foods of animal origin] define the responsibilities of dairy farm operators. Finally,

[12] www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/biohaz_op_ej613_pig_welfare_rev1_en.pdf?ssbinary=true
[13] www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620773144.htm
[14] http://eur-lex.europa.eu/LexUriServ/site/en/com/1999/com1999_0719en01.pdf
[15] http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:018:0011:0020:EN:PDF
[16] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:139:0001:0054:EN:PDF
[17] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:139:0055:0205:EN:PDF

Regulation (EC) No 882/2004[18] includes the specific duties of the competent authorities for the verification of compliance with the General Food Law [Regulation (EC) No 178/2002[19] referring to both feed and food] and the animal health and welfare legislation. The ramifications of the said legislation for food business operators and controlling bodies have been reviewed by Smulders, FJM *et al.* (2005).

The European food safety strategies are based on a risk-based, longitudinally integrated approach. For the food processing area (not considered in the framework of this report) this implies a mandatory application of the principles of the Hazard Analysis Critical Control Point (HACCP) system. In view of the difficulties of its application on farms, the European legislature has not yet made HACCP mandatory for the primary production sector. However, Regulation (EC) 852/2004 states: "*Member States shall encourage the development of national guides to good practice for hygiene and that food hazards present at the level of primary production should be identified and adequately controlled*". This implies identifying all risk mitigating measures associated with strict adherence to Good Farming and Hygiene Practices (GFP, GHP). In the following sections these will be discussed both for raw milk and beef production, i.e. relating exclusively to the significance of good ante-mortem practices.

1.3. Scope of this opinion

The Animal Health and Welfare Panel (AHAW) has addressed animal welfare aspects of dairy cow husbandry systems in form of five separate scientific opinions[2,3,4,5,6]. The BIOHAZ Panel has focused on the food safety relevance of dairy cow welfare factors, in a single opinion incorporating all aspects addressed by the AHAW Panel opinions. When assessing whether and how compliance or non-compliance with the requirements of the well-being of dairy cows in current farming and husbandry systems can affect the safety of the resulting foods (milk and beef), both universal principles of the animal welfare-food safety relationship, and food-safety evaluation of specific risk factors affecting animal welfare on dairy farms have to be used. With respect to specifics of the animal welfare-food safety relationship in dairy farming, evidence that the relationship is quantifiable and directly applicable to a given combination of dairy cows welfare-relevant factor (on-farm) and milk- or beef-safety hazard (at milking or at slaughter) is either limited or unavailable. Therefore, only brief descriptive considerations of any such relationships identified, based on general principles of milk/meat hygiene and safety, are presented in this opinion.

In accordance with the remit, the main focus of this opinion is on the food safety aspects. Amongst food safety hazards (milk- and/or beef-associated), only biological hazards are considered here. Whilst recognising the public health/food safety relevance of chemical hazards associated with dairy farming, chemical residues will not be dealt with in this opinion as they are outside the mandate of the BIOHAZ panel.

2. Main biological food safety hazards associated with dairy cows farming

2.1. Relevance of dairy farming for the microbial safety of dairy cow-derived foods

2.1.1. Cattle on farms

In the EU in year 2007, reported percentages of cattle positive for the main microbial foodborne pathogens were: *Campylobacter* 0-34.4% (animals) and 0.2-70.5% (herds), *Salmonella* spp.

[18] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:165:0001:0141:EN:PDF
[19] http://eur-lex.europa.eu/pri/en/oj/dat/2002/l_031/l_03120020201en00010024.pdf

0.1-7.7% (animals) and 51.9% (herds) and verocytotoxigenic *Escherichia coli* 1.2-22.1% (animals) and 3.8-13.2% (herds/holdings) (EFSA, 2009a)[20]. The reported occurrences/prevalences data do not allow a clear distinction between dairy cows and other categories of cattle, also these figures are not directly comparable between Member States due to differences in reporting. The original sources of foodborne pathogens that presently cause most human foodborne bacterial diseases are farm animals that show no signs of illness but which faecally excrete the pathogens.

2.1.2. Milk

Raw milk. Because a number of microbial hazards transmissible to man exist in the bovine population and/or its environment (Table 1) and can contaminate raw milk (e.g. *M. bovis*, *B. abortus*, VTEC, *Salmonella*, *L. monocytogenes*, enterotoxigenic *Staphylococcus. aureus*), the consumption of raw milk, - expected to occur primarily in on-farm situations, - carries health risks. Presently, due to insufficient data, it is not possible to quantify the relative contribution of the raw milk consumption to overall occurrence of foodborne illnesses. Furthermore, raw milk-associated microbial hazards are also relevant for safety of dairy products produced from raw milk and which do not receive a bactericidal step during processing. However, considerations of the fate of biological hazards during production of dairy products having a very large number of different types, are beyond the scope of this document.

Pasteurized milk. Proper milk pasteurisation regimes eliminate vegetative forms of bacterial pathogens. Nevertheless, bacterial spores, some pasteurisation-resistant (non-pathogenic) bacteria and thermo-stable toxins can survive in the processed (drinking) milk. Generally, applying heat-treatment techniques to raw, liquid milk has made pasteurized milk probably one of the safest foods of animal origin from the biological hazards point of view. Therefore, assuming milk processing technologies were properly applied, the major cause of milk-borne disease in the general population is post-processing milk contamination. In the EU in 2006, dairy products were the vehicle for 3.2% of individually reported outbreaks of foodborne diseases (EFSA, 2007)[21]. The relative food safety relevance of milk/milk products within overall food safety is difficult to quantify, as it is highly variable both temporally and spatially. Nevertheless, some information suggests that milk/milk products were incriminated in up to 8% of all outbreaks of food-borne illnesses, at the time when meat/meat products and eggs/egg products were implicated in 16% and 24%, respectively (Small, A, 2006).

2.1.3. Beef

In the EU in 2007, reported percentages of fresh bovine meat samples positive for the main microbial food-borne pathogens were: *Campylobacter* 0-2.4 %, *Salmonella* 0-6.7 % and VTEC 0-2.8% (EFSA, 2009a)[22]. Data reported to EFSA in 2006 indicated that “unspecified” meat products were implicated in 6.7% of the salmonellosis outbreaks, with only 1 outbreak reported as due to bovine meat; “unspecified” meat products were implicated in 23% campylobacter outbreaks (no specific mention of outbreaks of beef-borne campylobacteriosis); and beef was implicated in 6.3% of VTEC outbreaks (EFSA, 2007). In addition, a number of other beef-associated outbreaks of *E. coli* O157 infections that have occurred worldwide. From beef safety perspective, it appears that of particular interest to dairy farming are salmonellae and verocytotoxigenic *Escherichia coli*.

[20] www.efsa.europa.eu/cs/BlobServer/Report/2007_Zoonoses_Community_Summary_Report,0.pdf?ssbinary=true
[21] www.efsa.europa.eu/cs/BlobServer/DocumentSet/Zoon_report_2006_en,0.pdf?ssbinary=true
[22] www.efsa.europa.eu/cs/BlobServer/Report/2007_Zoonoses_Community_Summary_Report,0.pdf?ssbinary=true

2.2. Relevance of dairy farming for antimicrobial resistance in microbial pathogens

The use of antimicrobials (antibiotics and chemo-therapeuticals) in dairy farming causes a suppression of sensitive microbial species resulting in a misbalanced microflora. This adversely interferes with the 'competitive exclusion' phenomenon. As animals with misbalanced natural microflora are rendered more susceptible to infection, especially with those bacterial species that have acquired antimicrobial resistance, antimicrobial therapy may thus cause an extended period of excretion of pathogens (Linton, AH and Hinton, MH, 1987). The selective pressure created by the use of antimicrobials can lead to an increased appearance of antimicrobial-resistant microorganisms such as *Salmonella* or *E. coli* spp. in human medicine (Hilbert, F and Smulders, FJM, 2004). Furthermore, emergence of meticillin resistant *Staphylococcus aureus* (MRSA) is a concern, the occurrence of which in dairy cows, particularly in cases of mastitis, also has been reported (EFSA, 2009b). The transfer of antimicrobial-resistant pathogens to man can occur via various routes, including via food (EFSA, 2008b)[23] . In treating dairy cows for disease it is paramount, therefore, to follow guidelines for the prudent use of antimicrobials (Bronzwaer, S *et al.*, 2004; FVE, 2007; WHO, 2001[24]). Further data on the occurrences of antimicrobial resistance in individual foodborne pathogens are available in the EU Zoonoses Report (EFSA, 2007).

2.3. Summary of biological food safety hazards associated with dairy farming

Zoonotic hazards associated with dairy farming can be transmitted to humans through various routes including ingestion of cow-derived foods (i.e. milk- and meat-borne diseases); direct contact (e.g. occupational infections) and as a consequence of contamination of wider environment due to spread of organic wastes/effluents from dairy farms. On the other hand, a number of non-zoonotic biological hazards causing infective diseases in dairy cows, as well as a variety of organic (i.e. non-infective) diseases in dairy cows, are also associated with dairy farming, but are omitted in this opinion. Main examples of biological hazards associated with dairy cows farming are presented in Table 1.

Table 1. Main examples of biological hazards associated with dairy cows farming

Sources: (Bohm, M *et al.*, 2007; Buncic, S *et al.*, 2009; Cavirani, S, 2008; Klinth-Jensen, W *et al.*, 2004; Roginski, H *et al.*, 2002).

Biological hazard	Main sources present on dairy farm	Main link(s) between dairy farm and human disease	Main principles of pre-harvest (on farm) control	Main principles of harvest- and post-harvest control (beyond farm)
		Bacteria		
Bacillus anthracis	Soil. Cows.	Contact infection (e.g. during skin handling/processing); rarely foodborne disease.	Grazing management. Management of animal wastes and effluents from dairy farms.	Spore-killing milk heating techniques, sterilization.
Bacillus cereus	Soil and vegetation. Cows.	Via milk and beef.	No effective control measures presently available.	Good manufacturing/good hygiene practices. Holding cooked foods at either >60^{o}C or <10^{o}C.
Brucella abortus,	Cows.	Contact infection (e.g. from handling infected animals/materials). Also via raw milk.	Herd health plans (vaccination, serological screening).	Milk pasteurization. Hygienic precautions for at-risk workers.

[23] www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902034881.htm
[24] www.who.int/emc/disease/zoo/who_glkobal_principles.html

Human pathogenic-verocytotoxic *Escherichia coli* (HP-VTEC)	Cows. Also environment, including water, effluents, organic fertilisers.	Mainly via meat and milk. Also via contact with cattle and associated environment.	Preventive measures based on hygienic husbandry and management of animal wastes and effluents from dairy farms.	Milk pasteurization. Good manufacturing/good hygiene practices. Meat cooking.
Campylobacter jejuni	Cows. Also environment, including water, effluents, organic fertilisers.	Mainly via milk, and also via beef.	Preventive measures based on hygienic husbandry and management of animal wastes and effluents from dairy farms.	Milk pasteurization. Good manufacturing/good hygiene practices. Meat cooking.
Clostridium perfringens	Soil. Cows (e.g. clostridial diseases).	Mainly via beef.	No effective control measures presently available.	Spore-killing milk heating techniques, sterilization. Holding cooked foods at either >60°C or <10°C.
Corynebacterium pseudotuberculosis	Cows.	Contact infection. Also from raw milk.	Heard health plans including udder treatments.	Meat inspection. Hygienic precautions for at-risk workers.
Erysipelothrix rhusiopathiae	Cows.	Mainly contact infection.	Hygienic husbandry. Herd health plans.	Meat inspection. Hygienic precautions for at-risk workers.
Leptospira	Cows. Rodents. Contaminated environment.	Contact infection, from infected animal's or rodent's urine or contaminated water.	Biosecurity (pest control, wet ground drainage), vertical infection controls, herd health plans.	Meat inspection. Hygienic precautions for at-risk workers.
Listeria monocytogenes	Soil, effluents, water, silage. Cows.	Mainly via milk and beef. Also contact infection from handling infected animals/ materials.	Hygienic husbandry, herd health management.	Milk pasteurization. Good manufacturing/good hygiene practices. Prevention of post-processing contamination.
Salmonella spp.	Cows. Also effluents, organic fertilisers, water.	Mainly via milk and beef.	Preventive measures based on biosecurity, hygienic husbandry and management of animal wastes and effluents from dairy farms.	Milk pasteurization. Good manufacturing/good hygiene practices. Meat cooking.
Staphylococcus aureus	Cows. Humans.	Mainly via milk and beef.	Milking hygiene. Mastitis control.	Milk pasteurization. Good manufacturing/good hygiene practices.
Streptococcus zooepidermicus *S. agalactiae*	Cows.	Mainly via milk.	Milking hygiene.	Milk pasteurization.
Mycobacterium bovis	Cows.	Primarily via milk, very rarely via beef.	Tuberculin testing and slaughter of positive reactors.	Milk pasteurization. Meat inspection.
Mycobacterium avium subsp. *paratuberculosis*	Cows.	Possibly via milk and, less likely, beef (debatable).	Herd health management.	Milk pasteurization (debate on potential survival of routine milk pasteurization).
Yersinia enterocolitica	Cows. Water.	Mainly via milk.	Impractical (wide range of animal hosts).	Milk pasteurization.
Coxiella burnetii	Cows. Also ticks.	Via aerosol and milk. Also possibly tick bites.	Tick control. Herd health plans.	Milk pasteurization. Hygienic precautions for at-risk workers.
Bacterial antimicrobial resistance				
All antimicrobial-resistant bacterial pathogens	Cows. Farm waste/effluents.	Mainly *via* milk and beef. Also via contact with cattle and associated environment.	Responsible use of antimicrobials. Withdrawal periods.	Milk pasteurization. Antimicrobials residue controls.
Fungi				
Trychophyton verrucosum	Cow.	Contact infection.	Herd health plans. Vaccination.	Meat inspection.
Mycotoxins* (e.g. aflatoxin produced by *Aspergillus flavus*)	Crops. Cows fed mycotoxin-contaminated feeds.	Via milk.	Feed hygiene and feed controls.	Milk and cheese testing (e.g. M1 aflatoxin metabolite). Meat inspection.

Viruses				
Tick-borne Encephalitis Virus (TBEV; from family *Flaviridae*)	Rodents. Ticks. Infected cows.	Tick bites. Also via milk.	Hygienic husbandry. Pest/tick control.	Milk pasteurisation.
Norovirus genogroup III** (from family *Caliciviridae*)	Cows.	Unclear. Occupational exposure e.g. seropositive veterinarians.	Hygienic husbandry, herd health management.	?
Parasites				
Taenia saginata cysticercus	Cows.	Via beef.	Sewage management. Grazing management.	Meat inspection. Meat cooking and freezing.
Cryptosporidium parvum	Mainly calves. Also water and environment.	Mainly via water, also via contaminated milk and direct contact.	Hygienic husbandry. Management of animal wastes and effluents from dairy farms.	Milk pasteurization. Effective water treatments.
Toxoplasma gondii	Cats. Cows.	Via contact (partition). Via beef.	Hygienic husbandry, biosecurity.	Cooking of meat. Meat inspection.
Sarcocystis hominis	Dogs, cats. Cows.	Via beef.	Hygienic husbandry, biosecurity.	Cooking of meat. Meat inspection.
Prions				
BSE agent	Cows. Contaminated feed.	a meat if containing SRM.	Feed (mammalian proteins) controls.	Removal of Specified Risk Materials (SRM) at slaughter. Effective animal by-product treatments.

* Not within the remit of the BIOHAZ Panel; ** Emerging pathogen in cattle (diarrhoea), bovine strains infectious for humans

Among biological hazards indicated in Table 1, from the perspective of their overall effects on public health, *Campylobacter jejuni* and *Salmonella* spp. are particularly relevant as the leading causes of foodborne morbidity and mortality (Buncic, S *et al.*, 2009; EFSA, 2009a; Oliver, SP *et al.*, 2009). Reported human infections caused by some other bacterial hazards (e.g. *Yersinia* spp., verocytotoxic *E. coli* and *L. monocytogenes*) have comparably lower incidences, but they are also very relevant because they may cause severe diseases with relatively high case/fatality rates (at least in at-risk sub-populations) e.g. VTEC in children or *L. monocytogenes* in immunocompromised individuals (Nørrung, B and Buncic, S, 2008).

3. Consideration of the relevance of on-farm factors affecting welfare of dairy cows for milk and beef safety

3.1. General aspects

The dairy cow potentially constitutes a major source [“site of contamination” (ICMSF, 1988)] of microbial contamination of associated foods, as the intestinal contents, the mucosal membranes of the digestive-respiratory-urinary tracts, hooves and hides carry marked levels of microflora. In particular, microbial loads in faeces and on hides are as high as 6-10 log cfu per g or cm^2. At least part of this population varies with husbandry practices (Grau, FH, 1987; Warnick, LD *et al.*, 2001). Contaminated feedstuffs (Hinton, MH, 2000; Notermans, S and Beumer, H, 2002) and contaminated water supply (Linton, AH and Hinton, MH, 1987; Sofos, JN, 2002) are important sources of microbial colonisation/infection of cows. Pathogenic microorganisms on pastures (e.g. spread by manure and contaminated effluents) or excreted in stables may be ingested by cows and hence colonisation of the gut may occur, particularly in young immature animals. As the rumen develops, both the composition and the content of the gut microflora undergo drastic changes. For instance, generic *E. coli* are often present in calf intestines at levels as high as 10 log cfu/g faeces, but is more rarely found in such a high numbers in the rectal contents of adult cows (Howe, K and Linton, AH, 1976). The excreted pathogens are spread further in the farm environment and among the animals leading to the on-farm "recycling" of pathogens. A wide range of environmental, on-farm, transport and lairage-related factors can influence the occurrence and distribution of microbial pathogens in cattle at herd, lot and individual animal levels. These factors can be summarised (McEvoy, JM *et al.*, 2002) as follows:

- farm location,
- specific husbandry practices,
- herd size,
- herd/lot mingling at the farm,
- proportion of mature and immature animals within a herd,
- drinking water systems,
- details of feeding regime,
- intensive management procedures,
- contact with vermin, wild or other farm animals,
- concurrent viral, parasitic or other infections,
- transport conditions and duration,
- lairage practices, and
- herd/lot mingling at the abattoir.

On the other hand, currently feasible options for on-farm (including dairy farms) control of foodborne pathogens can be summarised (Buncic, S, 2006) as follows:

- effective cleaning and disinfection of stables,
- avoiding mixing animals (new or by age group),
- using a reliable pathogen-free source of livestock,
- disinfection of vehicles for transportation,
- training of staff to disinfect boots and equipment and keep work clothes on site,
- operating an effective programme for control of vermin,
- regular cleaning and disinfection of water troughs,
- avoiding grazing animals on land newly applied with slurry or manure (i.e. storage of these wastes for 3 months prior to application onto land),
- restricting of access of visitors to units,
- managing feed (e.g. reliable sourcing, using quality silage) properly,
- monitoring pathogens in animals, and
- developing appropriate vaccination programmes.

3.2. Factors contributing to stress in dairy cow husbandry

Stress-mediated suppression of immune function caused by trauma and/or malnutrition and production of neuroendocrine hormones (host- and/or pathogen-related) stimulate pathogen's responses including enhanced growth and/or virulence. It is known that a large number of farming-related factors e.g. those associated with management practices and housing conditions may impose stress on animals. These include inappropriate handling by humans (e.g. poor stockmanship), inadequate feeding/watering, inappropriate levels of temperature and noise, higher concentrations of ammonia, hydrogen sulfide or carbon dioxide in confined spaces, disruption of social relationships and mixing with unfamiliar individuals. Dairy farming-related stress factors may lead to increased occurrence of pathogenic microorganisms in cows e.g. *Salmonella* and clostridial spores in lymph nodes and intestines (Schüppel, H *et al.*, 1995). In addition, the stress-mediated increased peristaltic movements of contents along the bowel result in a higher rate of excretion of pathogenic organisms in faeces, resulting in increased spread of microbial infections and/or cross-contamination amongst the animals.

3.3. Housing factors

3.3.1. Floor design

Cattle including dairy cows often carry foodborne pathogens such as *Escherichia coli* O157, *Salmonella* and *Campylobacter* on their coats and in their intestines (Reid, CA *et al.*, 2002). After introducing animals, the housing facilities including floors quickly become contaminated (Heard, TW *et al.*, 1972); animals held in contaminated pens are also rapidly cross-contaminated (Grau, FH and Smith, MG, 1974; Hurd, HS *et al.*, 2001; Larsen, ST *et al.*, 2004). An adult bovine can void up to 25 kg of faeces each day (McGrath, JF and Patterson, JT, 1969), containing 6-7 log10 cfu microorganisms per g. Pathogenic bacteria remain viable on the floor surfaces at least for days and sometimes for weeks depending on their species and the environmental conditions; the survival is better under dirty-wet-colder conditions (Gibson, EA, 1961; Small, A *et al.*, 2003). However, even survival of almost 6 years was reported for *Salmonella* Dublin on fecally contaminated non-woven polyester, rubber and concrete (Plym-Forshell, L and Ekesbo, I, 1996). Routine cleaning procedures are often insufficient to remove the most relevant pathogens from the surfaces including floors within animal environment (Oosterom, J and Notermans, S, 1983; Schmidt, PL *et al.*, 2004; Swanenburg, M *et al.*, 2001). Furthermore, pathogen removal by cleaning is less efficient from non-smooth/grooved flooring than from smooth flooring. However, although the latter is preferred from the hygiene perspective, the former is non-slippery and so is preferred from the animal welfare aspect. In addition, some cleaning techniques e.g. pressure washing of floors on farms to produce aerosolised *Salmonella* which contributes to the spread of infection in the housing (Hinton, MH *et al.*, 1983). When disinfectants or sanitisers are used during cleaning, their efficacy is much reduced in the presence of organic material (Sprenger, RA, 1997), or by usage with water at temperatures below 25C^{o}, hard water or unclean water (Gelinas, P and Goulet, J, 1983). Therefore, flooring systems enabling regular and thorough removal of faecal matter and effective sanitation are preferred.

3.3.2. Use of bedding

Provision of bedding may be beneficial from dairy cows welfare perspective, as it can help to maintain good foot condition and encourage animals to lie down. Animals prefer straw as a lying substrate over, for example, slats (Gordon, GDH and Cockram, MS, 1995). However, bedding could also be considered as having some undesirable effects with regard to hygiene and consequently food safety. Firstly, bedding may serve as a vector for transfer of microbial contamination on the coats of animals (Jarvis, AM, Harrington, DWJ *et al.*, 1996; Jarvis, AM, Messer, CDA *et al.*, 1996; McClain, J *et al.*, 1997). Secondly, increased lying down could mediate increased contamination of the coat and the udder in dairy cows. Thirdly, foodborne pathogens e.g. *E. coli* O157, *Salmonella* and *Campylobacter* have significantly higher survival rates on straw compared with concrete or metal surfaces (Small, A *et al.*, 2003). On the other hand, it is probable that these risks may be reduced, to an unknown extent, when the bedding is sufficiently deep, clean and dry.

3.3.3. Facilities for segregation of sick animals

Sick animals including chronically ill are potentially a source of further spread of microbial pathogens within the farm to other animals, and ultimately further in the food chain. This spread can relate to biological agents that actually caused their current illness and/or to other pathogenic organisms which sick animals can excrete to an increased extent due to their immuno-compromised status. Therefore, provision and use of facilities for sick animals allowing segregation by adhering to biosecurity principles, is essential from both animal health/welfare and food safety perspective.

3.3.4. Facilities for handling and restraining

Information on the possible role of animal handling/restraining facilities in the ecology/epidemiology of foodborne pathogens on dairy farms is lacking. Nevertheless, it could be presumed that any facility physically contacted by a number of different animals may serve as a vector for transfer of microorganisms, i.e. cross-contamination between those animals. For example, in the pre-slaughter area of cattle abattoirs, around 11% of swabs from surfaces of the crush, and around 22-27% of swabs from surfaces of the stun box, were found to contain one or more of foodborne pathogens (*Escherichia coli* O157, *Salmonella* spp., *Campylobacter*) (Small, A *et al.*, 2002). As such contaminated surfaces can come in intimate contact with every animal entering the facility, from a microbiological perspective, ‘‘mixing’’ of different animal groups may occur via some animal handling/restraining facilities even if different groups are normally kept physically separate.

3.3.5. Feeding practices and facilities

Where feeding practices are so inadequate/inappropriate that some cows in a group are unable to feed properly, this can lead to induction of stress in some or all cows which, in turn, have negative food safety implications. Furthermore, the issue as to whether every cow has its own feeder or different cows have access to the same feeders can be relevant for microbial hazards' spread. In the case of the latter, feeders (similarly to water troughs) could serve as a vector for transmission of the hazards between animals.

3.3.6. Temperature and humidity

Inadequate temperature and humidity in housing can have negative effects on health/welfare of dairy cows and are also of food safety relevance. For example, extremes of temperature or humidity can cause stress in animals resulting in higher occurrence and/or excretion of microbial pathogens (see 3.2). Also, temperature and humidity are relevant for the survival of microbial pathogens (e.g. *Escherichia coli* O157, *Salmonella* spp., *Campylobacter*) in the animal-related environment: generally, on common substrates (bedding, concrete and metal), these bacteria survive better at lower temperatures and higher humidity (Small, A *et al.*, 2003).

3.3.7. Indoor/outdoor facilities

Access to the outdoors has a number of implications for both farm animals' (including cows') health/welfare and food safety aspects. For example, spread and transmission of microbial hazards is increased when grouped animals are kept in confined space. On the other hand, access to outdoors can be beneficial for cows' health/welfare which, in turn, has beneficial effects on safety of foods from those animals. However, access to the outdoors can also increase animals' exposure to the surroundings and wildlife-associated hazards (Bohm, M *et al.*, 2007). For example, *Mycobacterium bovis* infection endemically exists in some wildlife e.g. in possums (in Australia and New Zealand) and Euroasian badger (in UK). Although the infection may have spread from cattle to these wild species originally, epidemiological studies in these countries have clearly shown that the infection readily passes to domestic animals including cattle in contact with those wild animals (Roginski H, *et al.* 2002). Also, access to outdoors increases exposure of domestic pig to *Trichinella* infection (EFSA, 2005)[25]. Food safety implications of indoor/outdoor facilities are a multi-factorial and complex issue that depends on interference of various factors in a given farm situation. Therefore, and also because currently available related information is insufficient, it is not possible to make a universal judgement on the superiority/inferiority of either indoor or outdoor farming practices from the overall food safety perspective.

3.4. Feeding and nutrition factors

3.4.1. Microbiological quality of feed and water

Farm animals including dairy cows can be exposed to microbial pathogens through grazing or harvested feed that has previously been contaminated by spreading untreated abattoir- and/or farm wastes (manure, slurry) containing faecally shed pathogens [e.g. *Salmonella*, *Escherichia coli* O157, *Listeria monocytogenes*, *Campylobacter* and protozoan parasites (*Crytosporidium*, *Giardia*)] as fertilizers on agricultural land (Hutchison, ML *et al.*, 2004; Pepperell, R *et al.*, 2003). In addition, contaminated drinking water can be another source of pathogens ingested by animals, with water troughs used by different animals serving as an additional vector for transmission of pathogens between the animals. Therefore, inappropriate land management can mediate infections and/or re-infections of animals with enteric pathogens.

Food safety aspects of microbiological quality of compound feedingstuffs in farm animals, where *Salmonella* has by far the highest overall relevance, have been considered in a previous BIOHAZ opinion on Microbiological risk assessment in feedingstuffs for food-producing animals (EFSA, 2008a).

Briefly, the opinion stressed that transmission of *Salmonella* from animal feed to animals consuming the feed, and to food products derived from the animals, has been shown to occur. The relative importance of different sources of *Salmonella* infections in animals varies. In regions with low prevalence status, where endemic infection is well controlled or absent, *Salmonella* contaminated feed is the major source for introducing *Salmonella* into the animal food production. In other regions with high prevalence, although it is difficult to quantify, the relative importance of contaminated feed as compared to other sources of *Salmonella* may be lower.

Furthermore, the opinion indicates that some other feed-associated pathogenic bacteria also have certain relevance for animal and human health. *Listeria monocytogenes* seem to be primarily associated with silage of poor quality. *Escherichia coli* O157:H7 has been detected in

[25] http://www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/biohaz-ej200-summary-trichinella-en1.pdf?ssbinary=true

cattle feed and feed has been suggested to be a potential source of infection in cattle. *Clostridium botulinum* present in poor quality silage may cause serious intoxications in bovines and *Cl. perfringens* is commonly isolated from several animal feed ingredients of animal or plant origin.

3.4.2. Roughage in diet

Overall, the actual relevance of particular diet for faecal shedding of foodborne pathogens is still unclear. For example, some studies on whether shedding of *E. coli* O157 is higher in grain-fed (low roughage) or hay-fed (high roughage) ruminants resulted in opposing conclusions (Hovde, CJ *et al.*, 1999; Mather, AE *et al.*, 2007; Kudva, IT *et al.*, 1995). It seems that direct comparison of results from different studies on given diet-pathogen shedding relationship is difficult due to interference of other animal- and/or farm-related variable factors acting simultaneously. A recent comprehensive review of literature data on the effects of diet on *E. coli* O157 shedding in cattle (Callaway, TR *et al*., 2009) concluded that abruptly switching cattle from a high grain ration to a high-quality hay-based diet has been shown to reduce generic *E. coli* and *E. coli* O157:H7 populations; however, switching all cattle from grain-based diets to hay prior to slaughter is not practical. The conclusions also stress the need for further research to elucidate the mechanism (e.g. competitive exclusion, physical removal, forage quality, tannins, lignin, other phenolics) by which forage-feeding impacts the microbial ecology of the bovine intestinal tract, including the ecology of *E. coli* and *E. coli* O157:H7 populations.

On the other hand, it could be expected that some feeds (e.g. silage) increasing physical spreadability of the faecal excreta in the environment also could enhance spread of microbial hazards both on-farm and during transport-lairaging. In contrast, feeding roughage increases the consistency (“firmness”) of the faeces, which could reduce further environmental spreadability of faeces and pathogens. Feeding hay to cattle during lairaging appeared to have a protective effect on hide contamination with *E. coli* O157 (Mather AE, *et al*., 2007). Presently, the overall outcome of the relationship faeces volume versus faecal spreadability in the context of epidemiology of foodborne pathogens in dairy cattle is unclear.

3.5. Farm management factors

3.5.1. Herd health management

Provided a dairy cow is healthy, in principle, contamination of the udder interior is a minor source of raw milk contamination. Therefore, maintaining the dairy cow’s general health status including prevention of subclinical illness (Noordhuizen, J and Collins, JD, 2002) is very important for safety of raw milk. From a food safety perspective, particularly relevant aspects of dairy herd health management are:

- adhering to effective diagnostic and control scheme for brucellosis and tuberculosis,
- establishing of, and adhering to, effective mastitis prevention programmes, including through maintenance of animal cleanliness (particularly hide and tail),
- keeping lactating cows from coming into contact with other animal species (e.g. pigs and poultry) potential carriers of pathogens such as *Salmonella* and *Campylobacter*,
- separation of cows with mastitis, enteritis and metritis from healthy cows and discarding their milk during and after related treatments,
- assuring the feed ration contains enough roughage which reduces faecal contamination of animals/environment and the occurrence of environment-mediated mastitis; in contrast,

deficient roughage rations in combination with high (>18%) crude protein content are known to reduce faeces consistency ("firmness") making it more spreadable.

3.5.2. Antimicrobial treatments

All antimicrobials used in the EU have been registered for their current uses on the basis that they are effective and safe to both man and animals. They reduce the suffering and distress associated with disease, and speed recovery. Their medicinal use on cattle farms is under the supervision of the veterinary surgeon and, as is the case for all medicines and including in-feed medication, it is a legal requirement for farmers to keep a record of their administration. Antimicrobials, even those not valuable in the treatment or prevention of disease, may not be used as feed additives and have been banned as of the 1st of January 2006 (Regulation EC No. 1831/2003)[26].

Antimicrobials are used therapeutically (i.e. treatment of a single animal), methaphylactically (additional treatment of non-diseased animals in the group), or prophylactically (use on herd level). The latter mode of usage is widely practised in dairy farming, e.g. at the end of lactation to prevent mastitis in dairy cows (Erskine, RJ, 2000). It is currently under discussion as this mode of antimicrobial administration is considered to be responsible for an increase in antimicrobial resistance (IFT, 2006; McEwen, SM and Fedorka-Cray, PJ, 2002).

The problem of antimicrobial resistance as associated with usage of antimicrobials has been the subject of a number of recent trans-national studies (Hendriksen, RS *et al.*, 2008). The latter authors conclude that in general, isolates from Denmark, England (and Wales), The Netherlands, Norway, Sweden and Switzerland showed low frequencies of resistance, whereas a higher proportion of isolates from Belgium, France Italy, Latvia and Spain were resistant to most antimicrobials tested.

Guidelines for proper ('responsible') use of antimicrobials by farmers have recently been summarized by the RUMA Alliance in the UK (RUMA, 2005)[27]. Major ones include the following:

- In accordance with the supervising veterinarian's instructions, use the correct antimicrobial in the right season
- Use antimicrobials in support (not in lieu) of herd health plans including preventative treatments (e.g. routine foot care, mastitis, vaccination and worming)
- Use an antimicrobial that is subject to veterinary prescription exclusively with formal veterinary approval
- Administer the full course of treatment with the correct dosage
- Ensure that the required withdrawal time prior to slaughter or the sale of milk is strictly adhered to
- Keep an animal medicine record book and relevant regulations and Codes of Practice on the farm
- Record the identity of treated animals, the batch number, amount and expiry date of the medicines used, plus the required withdrawal period and time and date the medication was completed for any specific animal.
- Store medicines according to the manufacturer's instructions

[26] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:268:0029:0043:EN:PDF
[27] www.ruma.org.uk/guidelines/antimicrobials/long/cattle%20antimicrobials%20long.pdf

- Report suspected adverse reactions of either animal undergoing treatment or staff treating them

3.5.3. Stockmanship

Good stockmanship (adhering to Good Farming Practices) serves to lay the basis for disease control and preventing the possible transfer of zoonotic pathogens through the food chain. The following elements need to be particularly addressed to ensure a proper risk management on the farm:

- Purchase new cattle from known sources only,
- Ensure proper transportation in cleansed and disinfected trucks,
- Avoid mixing of cattle with different health status,
- Ensure that dirty and clean paths on the farm do not cross,
- Do not allow professional visitors not adhering to hygiene protocols,
- Caution with manure spread,
- Prevent contacts with wildlife, pet animals, and rodents.

This can be achieved by a number of measures which have been summarized by Noordhuizen, JP and Jorritsma, R (2005)[28] as follows:

- Make the farm more closed (canals; fences; ditches; natural vegetation
- Design a people entrance protocol (hygiene barrier; boots; clothes)
- Design an animal entry/exit protocol (health status certificates; vaccinations; trucks)
- Assign on-farm units and sections and design protocols for each unit/section
- Set protocols for health care, for feeding management; hygiene and disinfection
- Design an on-farm monitoring protocol
- Instruct farm workers; assign responsibilities; evaluate performances
- Define a farm-specific training programme for the farm workers in the different units
- Evaluate the critical risk conditions in all units on fixed time points
- Have regular team assessments for possible adjustments of the biosecurity plan

3.5.4. Biosecurity

Each dairy farm should have a plan in place for controlling risk from viruses, bacteria, parasites and other contaminants. These controls must be considered from the standpoint of: 1. their introduction to the farm; 2. their exposure and spread within the herd; 3. general and specific measures for immunization; and, 4. minimizing the risk of export to other farms (Bureau of Animal Health, Massachusetts Department of Agricultural Resources)[29].

The main objective of biosecurity plans is to reduce the effects of risk conditions or control these risks so that probability of disease will be as low as reasonably feasible on that particular

[28] www.isah-soc.org/documents/2005/keynotespeakers/mon/nordhuisen%20.doc
[29] www.mass.gov/agr/animalhealth/dairy_facility_biosecurity.htm

dairy farm. Animal hygiene issues (see GFP above) are essential elements in a biosecurity plan. Biosecurity is focused on both disease prevention and disease risk control. These plans are only functional when the proper hygiene practices prevail on a dairy farm, and when all who work on or around the farm have adopted the rules set out (Noordhuizen, JP and Jorritsma, R, 2005).

The use of manure as fertiliser and its role in zoonotic agents transfer

The fecal waste from thousands of animals reared under intensive conditions often is spread as fertilizer or spread on pasturelands, sometimes after composting. Groundwater, streams, and other waterways contaminated with these wastes also may facilitate the spread of bacteria carrying antimicrobial resistance traits (McEwen, SM and Fedorka-Cray, PJ, 2002).

Farm yard manure (FYM) and other animal wastes are widely used in both organic- and non organic agriculture systems. This use of FYM as fertilisers gives rise to concerns about possible contamination of agricultural products with pathogens (especially *Salmonella* and verotoxinogenic *E. coli*) and possible contamination of ground and surface water (Jones, PW, 1980; Kouba, M, 2003). A recent English report concludes that there is insufficient information available to categorically state if the risk of pathogen transfer from organic farms differs significantly from the risk associated with conventional farming practice (Nicholson, FA *et al.*, 2000).

Survival of pathogens in manure used as fertiliser

With respect to livestock wastes, *E. coli* O157, *Salmonella*, *Campylobacter* and *Listeria* can survive for up to 3 months in slurries and dirty water, whereas in solid manure kept in dung heaps, in which the temperature reach >55^{o}C, these pathogens do not survive for more than one month (Nicholson, FA *et al.*, 2005). In manure spread on land (both on sandy arable and clay loam grassland soils) the former three pathogens can survive for up to 1 month, whilst *Listeria* even longer. Furthermore, *E. coli* O157:H7 can produce verotoxins in manure for up to 10 weeks (Wang, G *et al.*, 1996).

The role of wildlife

The contact of dairy cattle with wildlife and the role of the latter in the transfer of zoonotic pathogens has become a point of concern in more recent years. In Sweden, *Salmonella*, is not uncommon in small passerine birds and may cause clinical, sometimes fatal, infections, mainly during winter and early spring, probably under the influence of feeding stations (Hurvell, B and Jevring, J, 1974; Mörner, T, 1991). In that country, among all wildlife, the red fox is the animal most commonly found to be infected with *Salmonella* (Mörner, AP and Mörner, T, 1994). *Salmonella* infections have also been observed in gulls. Therefore, wild animals living in the proximity of human refuse may be expected to be more exposed to *Salmonella* (Wahlström, H *et al.*, 2003).

Several published studies indicated that firm evidence has yet to be obtained that wildlife is a reservoir for verotoxinogenic *E. coli* O157 and other serotypes (Asakura, H *et al.*, 1998; Rice, DH *et al.*, 1995; SVC, 1997[30]; Wallace, JS *et al.*, 1997), . Nevertheless, there are reports of *E. coli* O157 being present in wild rabbits (Bailey JR, *et al.*, 2002).

Campylobacter species were detected in Swedish wildlife, and the prevalence in birds was higher than in the mammals investigated, in agreement with earlier investigations in which *Campylobacter* was a common finding in wild birds, e.g. 62% in Germany and 50% in the USA (Fallcara, DM and Monahan, CM, 2001; Glünder, G *et al.*, 1991). Overall, *Campylobacter*

30 http://ec.europa.eu/food/fs/sc/oldcomm4/out15_en.html

jejuni was the most frequently isolated species, and it is also the one most commonly isolated from cattle in Sweden (Asakura, H *et al.*, 1998; Rice, DH *et al.*, 1995; SVC, 1997; Wallace, JS *et al.*, 1997).

Furthermore, as indicated in section 3.3.7, possums (in Australia and New Zealand) and Euroasian badger (in UK) are reservoirs of *M. bovis*, and wild carnivores and wild boars are reservoirs for *Trichinella* (EFSA, 2009a).

3.5.5. Milking hygiene

Farm design significantly affects the way dairy farm operations and practices are carried out. This ultimately influences the overall hygienic status of the farm including cleanliness of premises, animals, equipment and personnel which, in turn, determine the level of the risk of contamination of raw milk. Dairy farm design-related effective measures to prevent or reduce environmental contamination of the raw milk (Small, A, 2006; Smulders, FJM, 2007) can be summarised as follows:

- enabling implementation of effective biosecurity,
- keeping stables strictly separated from the milk parlour, and assuring that the connecting driveways are easy to clean and disinfect,
- providing isolation facilities for diseased animals,
- assuring that feed storage areas are well separated from the milk production and storage area and taking preventive pest control measures, utilising the milk parlour exclusively for this purpose, and providing appropriate infrastructure allowing optimal cleaning and disinfection of milking equipment and pipelines.

Milk is a good growth medium for many microorganisms because of its near neutral pH, complex biochemical composition and high water content. Although it is secreted free from microorganisms, it is subjected to microbial contamination from many sources (air, faeces, bedding material, soil, feed, water, animal hides, man). Some so-called udder ‘commensals’ (mostly lactic acid bacteria) can move up the teat canal and cause aseptically drawn milk to be contaminated. However, the animal’s immune system and its components secreted into the milk normally keep these bacteria at low numbers. Besides low levels of commensals, high quality raw milk is first and foremost characterised by the absence of pathogenic bacteria. The main hygienic measures to minimise microbial contamination of raw milk during milking (Small, A, 2006; Smulders, FJM, 2007) include:

- effective cleaning and disinfection of corridors and driveways to the milking parlour, as well as the milk parlour itself (walls, floor);
- applying appropriate milking techniques;
- thoroughly cleaning of udders before milking (may be preceded by hair clipping), as well as effective cleaning-disinfecting teats followed by subsequent drying, both pre- and post-milking;
- proper maintenance and cleaning-disinfection of milking equipment between milking cycles by a combination of mechanical, thermal (38-55°C water rinses) and chemical (alkaline, and periodically acid, rinses) techniques;
- thorough cleaning-disinfecting, generally achieved by spraying, of bulk tanks;
- pre-milking inspection of milk and subsequently discarding the foremilk;
- avoiding milking of an empty udder to prevent mastitis;

- storing raw milk at <6°C to minimise microbial growth;
- regular visual inspection of surfaces of milking equipment and bulk tanks for biofilm formation and periodic bacteriological testing is necessary.

3.6. Preparation of cows for slaughter

As opposed to raw milk pasteurisation that is regularly applied in dairy industry, decontamination of raw beef (i.e. dressed bovine carcasses) is not routinely used in slaughterhouses in the EU. Although carcass decontamination is permissible in principle, if applied as an additional measure within a HACCP-based process hygiene system and subject to regulatory approval (EU food hygiene packages 1-4), it is not yet widely used in the EU. This makes strict adherence to hygienic practices (i.e. to GFP, GMP and GHP principles) before slaughter of cattle including dairy cows even more critical in order to reduce the introduction of pathogenic organisms into the beef processing line.

3.6.1. Feed withdrawal

Traditionally, feed is preferably withheld from ruminants immediately before and during periods of transporting to, and lairaging at, abattoir. However, water is offered to animals throughout the pre-slaughter period. The reasons for feed withdrawal include difficulties which overfilled guts would cause during dressing (evisceration) of slaughtered animals, as well as economic aspects (Gracey, JF *et al.*, 1999). Generally, the two main foodborne pathogens associated with beef, *Salmonella* and verocytotoxic *E. coli*, do not proliferate in the rumen environment, except under conditions of extended starvation, which leads to a reduction of the volatile fatty acids concentration (Mattila, T *et al.*, 1988; Rasmussen, MA *et al.*, 1993). In a situation where 24-hour starvation already yielded 4% of the rumen *Salmonella* positive, this percentage increased to as high as 30% after 72-hour of starvation (Grau, FH *et al.*, 1968). The higher occurrence or levels of pathogens in rumen can increase their occurrence or levels in faeces, which increases microbial beef safety risks associated with those animals. Some studies demonstrated that fasting of cattle can result in increased shedding of total *E. coli* (Brownlie, LE and Grau, FH, 1967) or inoculated marker *E. coli* (Reid, CA *et al.*, 2002), as well as shedding of *E. coli* O157 (Brown, CA *et al.*, 1997; Cray, WC, Jr. *et al.*, 1998).

3.6.2. Animal cleanliness

Microorganisms including foodborne pathogens present in cattle faeces are frequently transferred, via direct or indirect routes, to the hide, which is now recognised as the major source of microbial contamination with these organisms. Total viable counts of bacteria (Newton, KG *et al.*, 1978), occurrences of inoculated marker *E. coli* (Collis, VJ *et al.*, 2004), and prevalences of *E. coli* O157 (Elder, RO *et al.*, 2000) on beef carcasses, all can be significantly affected by, and even correlated with, those present on respective hides. Also, it has been demonstrated that degree of visual coat soiling has a significant effect on the contamination level of the finished carcass (Byrne, CM *et al.*, 2000; Hadley, PJ *et al.*, 1997). Hygienic status of cattle hides significantly depends on maintenance of good hygiene in stables, and is also influenced by type of their diet. However, it is not entirely clear if the most significant contamination takes place at the farm or post-farm-gate i.e. during transport and lairaging (McEvoy, JM *et al.*, 2002). Nevertheless, it has been widely accepted that animal cleanliness is crucial to avoid the introduction of potentially pathogenic microorganisms in the beef processing line, so it is necessary to assure that only clean cows are presented for slaughter (Bolton, DJ *et al.*, 1998).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. In principle, ensuring on-farm welfare of dairy cows contributes to, and is beneficial for the food safety aspects of their products entering the food chain. Good farming/hygienic practices (GFP/GHP) including provision of optimal animal welfare enhance the animals' resistance to infections and reduces on-farm spread of food safety hazards.

2. Dairy farming practices that are beneficial for both dairy cows' welfare and food (milk and beef) safety particularly include, but are not limited to, the following:
   - effective herd health management including responsible use of antimicrobials;
   - hygienic husbandry including appropriate farm design and effective biosecurity;
   - microbiological quality of feeds (both pasture- and compound feed-based) and water;
   - management for preventing animal stress;
   - hygienic milking;
   - hygienic preparation of animals for slaughter;
   - management of grazing land with respect to the spread of animal manure

Each of these practices further comprises a number of contributing factors involved. Presently available information is insufficient to quantify the individual contribution of these practices/factors for, or to rank them with respect to, resultant milk and/or meat safety.

3. However, some dairy farming practices that are considered beneficial for dairy cows' welfare may also increase the risks of foodborne pathogens in the animals and/or their products entering the food chain. These factors particularly include, but are not limited to, the following:
   - holding of animals in groups that can increase direct (animal-to-animal) and indirect (animal-environment-animal) transmission of microbial hazards, the latter involving vectors such as floor/wall surfaces and jointly used feeders, water troughs and animal handling equipment;
   - use of bedding that can serve as a vector for microbial cross-contamination;
   - use of grooved/non-slippery floors that are difficult to clean-sanitise;
   - access of animals to outdoor spaces that can increase their exposure to some environment- and wildlife-associated hazards.

4. Presently available information is not sufficient to individually quantify the ultimate food safety outcome of the opposing (welfare-beneficial but food safety-undesirable) effects of these factors.

RECOMMENDATIONS

Further multidisciplinary research on the relationship (positive or negative interaction) between animal welfare- and food safety-related factors on dairy farms should be encouraged.

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