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A short review of chain controlling systems in livestock production technology

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There is a general agreement that the main reason for domestication was to provide a reliable source of food protein. Wild animals were hunted for thousands of years, killed for meat, wool, fur, and liquid by our predecessors. This one-way relationship between humans and animals was changed much later, during domestication and until know, the man took responsibility for animals and changed and developed different production system and ethical relationship with animals. After Second World War, the governments tried to change so called traditional agriculture to more intensive. Animals have been kept in high concentration and for the continuous production as a consequence, disease control became essential. European Union issued a paper on food safety (White Paper on Food Safety 2000) where the EU commission tried to push forward a framework of legislation for further improvement and to develop more transparent and improved quality standards throughout a food chain from farm to table. This paper reviews a number of recent developments, starting with an integrated quality control system that collecting important data from the animal birth, through to the animal rearing phase to the end (i. e. slaughter). The importance of Hazard Analysis Critical Control Point (HACCP) is discussed, together with their concepts to assure safe animal food production.

Key words: animals, chain controlling systems, food safety

Domestication of animals

In human history of being, food has always been in closely related with human culture and traditions. Therefore, food has had a very special place in human society for at least 10.000 years.

The material basis for food production is closely associated with plant and animal breeding. From the historical point of view, humans and animals have been lived together on the same part of Nature, with limited reserves. One of the consequences is continuous struggle for survival between animals and human. It is hard to prove, but we suspect, that probably between 12.000 and 7.000 years ago, humans made a first step to take a head role in Nature and they start with domestication of wild animals (Rohrs 1994).

There is a general agreement that the main reason for domestication was to provide a reliable source of food protein. Wild animals were hunted for thousands of years, killed for meat, wool, fur, and liquid by our predecessors. This special relationship between humans and animals was only in one way. Firstly, they used the wild animals as suppliers of goods such as fur and food proteins. Much later, during domestication and until know the man took responsibility for animals and changed and developed different production system and ethical relationship with animals. They did not use animals only as suppliers of food proteins, energy (fat), but also for transport and farm work. Many animals also played a role as companions, status symbols... With alteration of dependence on the animal, man has been changed from a hunter and a collector to a farmer. During this process, man changed the type of association with animal; from the time, when 90% of human population had everyday contact with animals to today, where more than 90% of our population has no contacts with domesticated animals (Stanzinger 1993). This example shows that only a small part of our society is still closely connected with domesticated animals and consequently the comprehension of farm animals has been altered. Different parts of our society have different opinions about use of animals in food production and man does not consider animals as resources of primary existential goods. The animal is not anymore only the resource of meat, eggs, milk, wool, fat, fur, honey, etc., it is also causing pollution. Man has to taken full responsibility for it.

After Second World War, the governments tried to change so called traditional agriculture to more intensive. The aim of this change market oriented production: to produce high quantities meat and milk and to keep production costs low. According to Pugh (2002), this food policy leads to intensification of animal production and increase of production efficiency, evident as an increase of the growth rate, food conversion efficiency and meatiness in carcass. Growth rate and body composition of farm animals can be changed

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and altered to meet consumers' needs for a leaner product and to improve the efficiency of meat-animal-production, using tolls of genetic selection and molecular biology (Wray-Cahen et al. 1998).

Together with changes in technology of animal production, animals have been kept in high concentration, and this means, that they have been reared in one place in large house groups. As a consequence, disease control became essential for the continuous production of pigs, beef, rabbits and poultry in intensive production systems (Pugh 2002).

At the beginning of 21st Century, in livestock production, the emphasis was put on the practical application of different techniques and methods associated with the manipulation of embryos (Houdebine 2002), mapping the genome, modification of productions traits (Pursel 1998), as well as genome engineering (Simonneaux 1998). The animal breeding is also oriented to produce therapeutic proteins (Garner and Coleman 1998) and xenograft organs using transgenic livestock (White and Langford 1998).

Animal feed for Animal Production and White Paper on Food Safety 2000

On the beginning of 2000, European Union issued a paper on food safety (White Paper on Food Safety 2000). The aim of the EU document was to outline a range of actions in order to modernize the existing EU legislation of food safety. In this paper, the EU commission tried to push forward a framework of legislation for further improvement and to develop more transparent and improved quality standards throughout a food chain *from farm to table.*

In item No. 10 of new legislation framework, the EU commission proposed framework with various aspects of the food chains. One very important issue of this framework is also animal feed for animal production. It was defined as a use of specific feed materials and products; evaluation and authorization and labeling of feed; accreditation of feed production plants and control measures as well as establishment of rapid alert system (White paper on food safety 2000).

Only few months later the European Compound Feed Industry (ECFI) published a paper as a reflection on contents of the White Paper: Restoring consumers' confidence as regards food safety (The European Compound Feed Industry contribution to the reflection about the EU commission White Paper on food safety April 28, 2000).

It should be pointed out that feed manufactures in the EU produce approximately 120 millions tons of animal feed per year and it is representing about 35% of the total feed intake of farm animals in the EU. The rest represent roughage's and feeding stuffs produced by home-mixers. Therefore, it is obvious that farmers produce the major part of animal feed and therefore we need supervision, not only on this step, but also in the whole chain of animal production.

Because of the pursuit of a high level of protection of human and animal Health - which is one of the fundamental objectives of food chain surveillance (Smith DeWaal 2003) - the objective of the hygiene rules is to ensure a high level of consumer protection with regard to food and feed safety, taking particular account of the following principles:

1. primary responsibility for feed safety rests with the feed business operator;
2. feed safety ensured throughout the food chain, starting with – as mentioned in paragraph above - primary production of feed, up to the feeding of food-producing animals;
3. the general implementation of procedures based on the principles of hazard analysis and critical control points (HACCP) together with the application of good hygiene practice;
4. guides to good practice (GMP) are a valuable instrument to help feed business operators at all levels of the feed chain comply with feed hygiene rules and with the application of HACCP principles, and
5. the establishment of microbiological criteria for feed based on scientific risk criteria.

Feed hazards present at the level of primary production of feed should be identified and adequately controlled, to ensure that these objectives are met. Therefore, the principles should apply to farms, which manufacture feed solely for the requirements of their own production, as well as to farms that place feed on the market.

Chain Controlling System in Livestock Production Technology

In the future we can expect a rise of added costs for the EU livestock industry concerning a chain controlling system »from farm to table or fork« in relation to public health by:

(A) exclusion of antibiotics as a growth promoters and feed additives originated from animal feed, and reducing antibiotics as veterinary drugs (see the example of Nordic countries, Wierup 2001);

(B) occurrence of natural compounds of hormones or synthetically produced xenobiotics which have oestrogenic (oestradiol-17J3 and its esters; zeranol), androgenic (testosterone and esters; trenbolone acetate) or progestogenic (progester one; melengestrol acetate) activity (Karg and Meyer 1999; for review see Galbraith 2002);

(C) avoiding administration of natural or recombinant growth substance as a hormonal growth promoters which accelerates muscle growth and reduces fat deposition in most farm animals (bovine ST, porcine ST, ovine ST, growth hormone-releasing hormone (GHRH) and insulin like growth factor-I (IGF-I), ractopamine/pigs, salbutamol/pigs, clenbuterol/lambs, clenbuterol/cattle) (WrayCahen et al. 1998, for review see Bonneau and Laarveld 1999) or for improving milk production (for review see Stelwagen et al. 1992; Bauman 1992);

(D) controlling the presence of agrochemicals (nitrates, pesticides) (Centi and Perathoner 2003);

(E) exclusion of certain animal proteins as foodstuffs (Bovine Spongiform Encephalopathy (BSE), Creutzfeldt-Jakob Disease (CJD)) (Cowan 1998; for review see La Bonnardiere 2002);

(F) phasing out any material which is contaminated by dioxins, PCBs as a result of industrial pollution (0' Keeffe and Kennedy 1998);

(G) occurrence of heavy metals as a result of environmental pollution in animal feed (Hinton 2000;

Nicholson et al. 1999);

(H) contamination arising in domestic food preparation (Gorman et al. 2002);

(I) testing newly introduced proteins in GM crops and incorporation of them in animal feed as a potential allergens for animals and humans (Kleter and Kuiper 2002; Aumaitre et al. 2002).

An integrated quality control system

An integrated system requires permanent collection of different information from the animal birth, through to the animal rearing phase to the end (i. e. slaughter). Therefore, the basis for good functioning of an integrated control system is good documentation of all-important data. The information should be transferred backwards and forwards among different users and this would require accountability and transparency in all parts (Fig. 1). Such an integrated system could include all types of animal production systems such as organic farming, animal breeding in small farming systems as well as industrialized animal production systems.

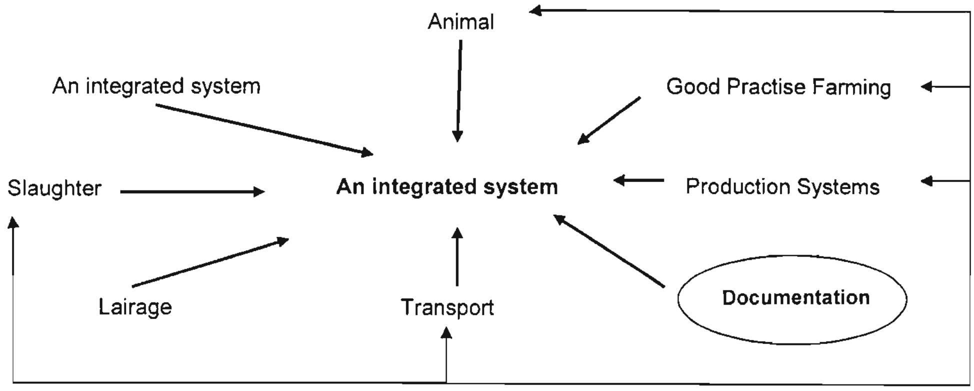

Fig. 1. The basis of an integrated system, considering each species/category separately (Opinion of the scientific committee on veterinary measures relating to public health on identification of species/categories of meat producing animals in integrated production systems where meat inspection may be revised (adopted on 20-21 June 2001).

According to the proposals of the EC for health and consumer protection (2001), several parts of an integrated system should be considered.

Animal

For each animal, it is required to know their identification, origin, category (prewean, weaned, production stage (eggs, milk, fattening), end of production and documentation.

Good Practice Farming (GPF)

GPF demands an identification and registration of farm, their building construction, climate conditions and farm facilities, data on separation of units within the farm as a part of specific animal production system, quarantine facilities, animal density, data on veterinarian medial records (disease, treatment, ...), specific performance monitoring, consumption of feed and water, cleaning and disinfect ion procedure and other types of control such as manipulation with waste (manure handling).

Production system

For each species, it is necessary to document category of animals and their production goal (egg, milk, fattening,..) and production system (organic, small farming, industrialized) related to a specific husbandry, housing system, feeding requirements and delivering service (restriction, ad libitum, ...), feed origin and feed processing (pasture, home made mixtures, manufacture animal feed), feed storage (bag, silo). The EU commission included in this part also the transport of farm animals and pre-slaughter technology, slaughter, inspection procedures and additional controls.

Documentation records

In each animal production system, it is required to keep in order animal and production documentation, specific indicators of animal production, animal movements within the farm and outside, the use of medicaments, etc...

Transport

Transportation of animals from the farm to the slaughter house or between farms necessitate a farm animal transport vehicles, taking into account appropriate loading density, transport time, climate, possible mixing of animals or groups of animals from different origins.

Lairage

After the time spent on transport, it is necessary that animals have enough time for rest. It is obvious that resting time is related to transport duration. Lairage facilities should have enough space for appropriate animal density and animals must have free access to water and feed. The reduction of stress situation results in decreased incidence of lower meat quality, well known as PSE (Pale Soft Exudative) and DFD (Dark Firm Dry) (Murray 1995).

Slaughter

Slaughter of animal is encompassed by systematic analysis of potential hazards, appropriate control mechanism should be implemented, and animals must be identified as well as their carcass halves and parts of meat. It is very important, that appropriate sampling of animal tissues is taken for control and relevant information is transferred forward to a convenient authority. Essential for any integrated control system is to develop strategy for product recall.

Processing/chilling

After slaughter, the carcasses are moved to a chilling room. It is necessary to have an appropriate cooling capacity on the basis of a daily production of the slaughterhouse. For differentiation of carcass halves of different species, Procedure has to be divided into separate units with appropriate chilling systems. In all other facilities, hygiene, cleaning and disinfection is required.

The above-presented list is resolved to be only a basis for further consideration associated with an integrated control system.

Computer-aided chain-health and information network in animal production

»Stable to table« has become a phrase of this strategy. Petersen et al. (2002) suggested a computerized food safety monitoring (CFSM) in animal production. The aim of CFSM is in the first step to develop an integrated control system through the whole food chain on the basis of modern information technology. The model of CFSM includes the whole food production chain from the health and welfare of animals to the slaughter. The CFSM model is formed according to the data recording, processing, and exchange of information between farms, slaughterhouse and consulting service. The integrated control system, which was described and presented above with elementary points, must be completed with consulting service and for such an integrated system it is required accomplish and exchange information between different parties in information network.

In case of pig production, suppliers' chain is composed of piglet production, fattening and slaughter. Each category of suppliers' chain was grouped into five parts: management, hygiene, stall, climate, health status of the animals, performance and it was further divided into several subclasses. Using scoring system evaluation (1-5), on the basis of summarized scores; pig producers could be ranked into categories A, B and C (Petersen et al. 2002). In the next step, data flow and communication between the farm and abattoir is demanded.

Ranking of livestock producers could be very important information in advance for abattoir as well as pre-information for the next part of supplier chain (Fig.2). Consulting service could give a backward advice to a producer any time on the basis of information collected in databank.

Hazard Analysis Critical Control Point (HACCP) System

In food production HACCP is internationally recognized system and its scope is to help to assure safe food production. The aim of the HACCP not only to identify critical points along food chain, but also to determinate and to evaluate all possible risk factors, to avoid any potential hazards, which may occur, and then strictly manage and monitor these points, to make sure that the process is under control.

The HACCP system based on three parts (Blaha 1999):

1. The identification of hazards and risk.
2. The determination of critical control points required to control hazard.
3. Establishment and implementation of monitoring procedures.

The application of HACCP principles to primary production of feed is the medium-term objective of European hygiene legislation. The guides to good practice should already be encouraging the use of appropriate hygiene requirements.

The HACCP has seven following principles:

1. Conduct a hazard analysis
2. Identify critical control points in the control of hazards.
3. Establish critical limits
4. Define critical control points (monitoring requirements).
5. Constitute corrective actions.
6. Establish an effective record-keeping system that documents the HACCP system.
7. Install procedures to verify corrective working of HACCP system.

The central role plays two factors: the risk and hazard. The first means a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard; and the second represent a biological, chemical or

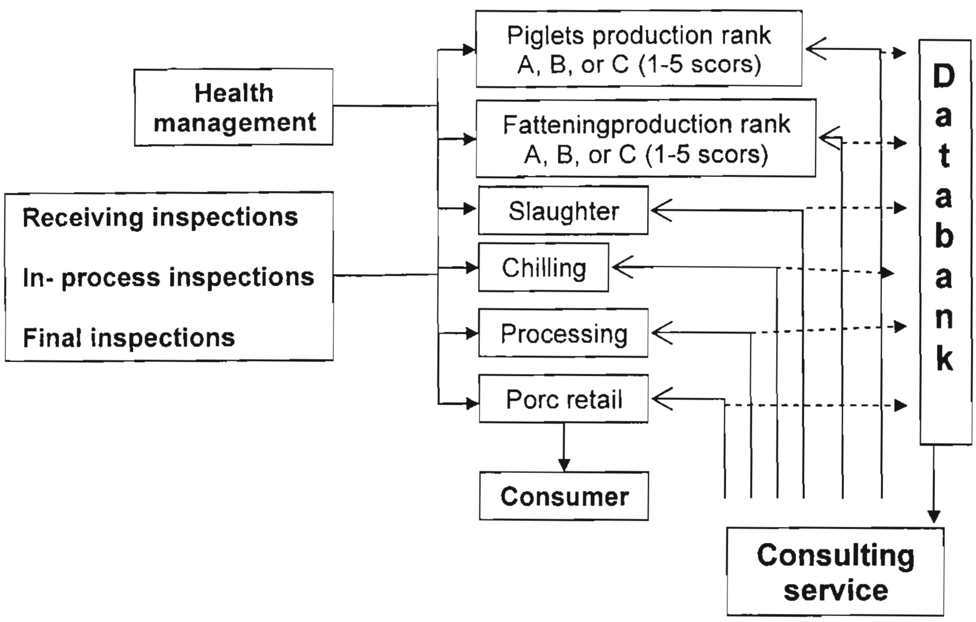

Fig. 2. Example of pork as a computer-aided monitoring of food safety (according to Blaha 1999 and Petersen et al. 2002).

physical agent in feed with the potential to cause an adverse health effect.

The hazard analysis is a process of three interconnected components: risk assessment, risk management and risk communication. Risk assessment means a scientifically based process consisting of four following steps: hazard identification, hazard characterization, exposure assessment and risk characterization.

To achieve the final principal points 6 and 7 the feed operators or an agricultural holding performs the risk management as the process of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors, and, if need be, selecting appropriate prevention and control options.

To summarize, the applied HACCP principles in the case of feed surveillance chain are following:

(I) identify any hazards that must be prevented, eliminated or reduced to acceptable levels;
(II) identify the critical control points at the step or steps at which control is essential to prevent or eliminate a hazard or reduce it to acceptable levels;
(III) establish critical limits at critical control points which separate acceptability from unacceptability, for the prevention, elimination or reduction of identified hazards;
(IV) establish and implement effective monitoring procedures at critical control points;
(V) establish corrective action when monitoring indicates that a critical control point is not under control;
(VI) establish procedures to verify that the measures outlined in points (I) to (V) are complete and working effectively. Verification procedures shall be carried out regularly, and
(VII) establish documents and records commensurate with the nature and size of the feed businesses to demonstrate the effective application of the measures set out in points (I) to (VI).

HACCP principles in feed production should take into account also the principles contained in the Codex Alimentarius (FAO) but should allow sufficient flexibility in all situations in the field. In certain feed business, it is not possible to identify critical control points and, in these cases, good practices can replace the monitoring of critical control points. Similarly, the requirement to establish »critical limits«, as set out in the Codex Alimentarius, does not require a numerical limit to-be fixed in every case.

In conclusion, the free movement of safe and wholesome food is an essential aspect of the internal market and contributes significantly to the health and well-being of citizens, and to their social and economic interests.

Failure Mode Effect and Criticality Analysis (FMECA)

The "Failure Mode Effect and Criticality Analysis" (FMECA) technique is effective tool to identify and asses how potential failures can affect the performance of a process or a product. The analysis of the failure modes provides important information on (Bertolini et al. 2006):

(I) the subsystems and final items of the system in a hierarchical arrangement (functional analysis of the production plant);
(II) any "failure" or generic "malfunctioning", with a list and description of all potential failure modes for the process/product being analyzed;
(III) the probability, severity and detect ability of each failure mode's occurrence;
(IV) the Critically Analysis (CA), which ranks all failure modes in order of importance.

FMECA is characterized by a bottom-up approach and it breaks down any system into basic components to detect all potential failure modes and their effects (Bertolini et al. 2006).

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