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Conditions of transfer and quality of food

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Summary

Many factors contribute to the production of safe foods of animal origin. Initiatives for an integrated approach to food safety recognise the importance of optimising transportation conditions to ensure on-farm interventions are preserved. Physical, microbial, and environmental hazards during the transportation process may adversely affect the safety and quality of meat, poultry, and egg products. Additionally, the stress level in animals can be raised by transportation conditions, potentially causing increased pathogen shedding in carrier animals which exposes other animals to possible contamination. The physiological effects of stress on animals can reduce the quality of meat, poultry, and egg products produced by the animals, thus decreasing the economic value of the animal. Increased globalisation of markets provides an incentive for transportation standards of food animals within a country as well as transportation standards between countries.

Keywords

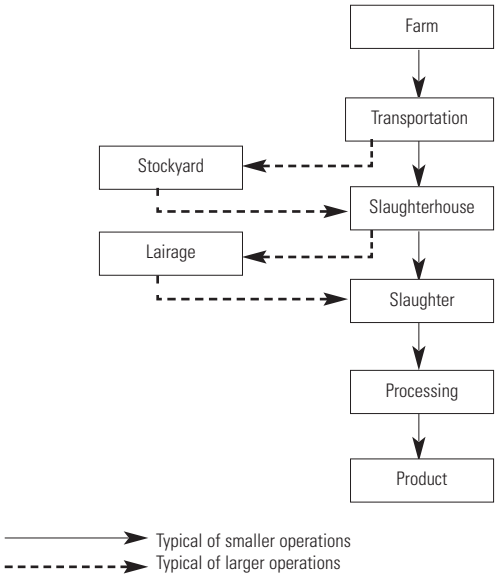
Animal welfare – Food-borne disease – Lairage – Meat quality – Meat safety – Pre-slaughter handling – Stress – Transportation.

Introduction

Incidence of food-borne illness in the United States of America (USA) has declined in recent years, in part due to preventative, risk-based measures implemented in meat and poultry establishments by regulators and the food industry (3). The development of risk-based animal production principles on the farm helps to reduce the risk of food-borne pathogens amongst food animals. While the health status of animals at the time they leave the farm is important, it is crucial to recognise the importance of optimising transportation conditions. Researchers are now looking at the process of transporting food animals from farm to slaughter to determine how the positive effects of on-farm interventions aimed at controlling the spread of pathogens in live animals can be preserved during transportation.

Transporting animals to slaughter is far more demanding than the transfer of animals from one location to another (Fig. 1). Numerous microbial, physical, and/or environmental hazards during transport have the potential to negatively affect not only the health and welfare of the animals, but also the safety and quality of the resulting meat, poultry, and egg products. In addition, studies have shown that animals experience a great deal of stress during pre-slaughter handling and transportation that may impair cellular immune responses and cause physiological changes, possibly affecting the safety and quality of the resulting food products (1, 12, 21). Time in transit, distance travelled, pre-transport conditioning, environmental conditions, and lairage at the slaughterhouse are all components of transportation that may negatively affect stress levels and diminish the economic value of the animals and the food products.

This paper focuses on the various hazards that food animals face during transport to slaughter and their impact on the safety and quality of food products from these animals. The paper will briefly address global and economic considerations and consequences associated with transporting food animals.



This diagram illustrates various phases of transportation. Microbial, environmental and/or physical hazards can occur at any one of these stages and directly or indirectly affect the safety and quality of meat, poultry and egg products

Fig. 1
Stages of transportation in the 'farm-to-table' continuum

Effects of stress on meat safety and quality

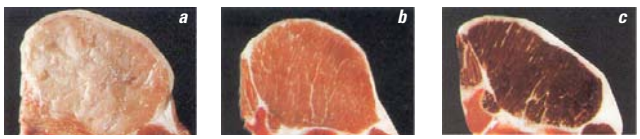
It is well known that mammals possess the capacity to feel pain and experience stress (4). In the case of food animals, much of this pain and stress takes place prior to slaughter, particularly involving the events associated with transportation. There are a number of factors that determine the effect that varying amounts of stress will have on a particular animal. Health status at time of transportation, state of nutrition, and the genetic makeup of certain species or breeds are just a few of the variables that can bring about dissimilar responses to various stressors (1, 21).

Shedding of pathogenic microorganisms

Many food-borne pathogens are ubiquitous in the livestock and poultry environment and may be carried by healthy, unstressed animals without shedding (22). The physiological changes associated with stress can cause continual shedding in these animals due to a disturbance in intestinal function and lowered immune resistance (15, 21). Although the mechanism of increased shedding of microorganisms during stressful situations in carrier animals is not completely understood, the stress of transportation alone cannot account for all of the increases seen in post-transportation isolation rates.

Individual animal responses to stress and meat quality

Transportation stress not only affects the safety of the meat and poultry products produced, but also the quality. The physiological effects of stress cause decreased product value. For example, some breeds of pigs are susceptible to developing what has been termed the 'porcine stress syndrome' (PSS) which has been linked to pale, soft, exudative (PSE) meat. Confusion over these two acronyms has led many to believe that they refer to the same thing, but this is not so. PSS refers to a syndrome that occurs in the live animal, while PSE is the quality of the meat commonly produced from pigs suffering from this syndrome. Other causes of PSE include rough handling, electrical prodding, and stressful environmental conditions, such as extreme heat. The resulting quality defect has been attributed to muscle glycogen and lactic acid levels which play an essential role in meat quality. After slaughter, glycogen in the muscle is converted to lactic acid and it is this lactic acid which is needed to produce tasteful, tender meat of good quality and colour (4). When an animal is stressed, the glycogen is used up and the level of lactic acid is reduced. In cases of PSS, lactic acid is produced in excess, but it is contained within the blood and not the muscle. PSE meat and meat from pigs suffering from PSS are very similar in quality because they both produce very pale, soft meat that appears exudative or 'wet' with pronounced acidity and poor flavour (4, 13) (Fig. 2). This type of meat is undesirable and may have to be discarded (4).



a) pale, soft, exudative (PSE)
b) normal
c) dark, firm and dry (DFD)

Fig. 2
Quality differences in pork meat

Source: Chambers and Grandin (2), courtesy of Gunter Heinz

Another meat quality problem resulting from depleted muscle glycogen and lactic acid levels is that of dark, firm and dry meat (DFD). The term DFD is generally reserved for pork meat, but when this defect is seen in beef, the term 'dark cutters' is applied (13). Previous studies have found that the incidence of dark-cutting meat is higher among cattle that became agitated and excited in the squeeze chute and during other handling and transportation associated stressors (i.e. fighting and mixing of strange animals) near the time of slaughter (9, 25). Not only is this meat darker, drier and firmer and, as a result, less desirable to the consumer, but it also has a shorter

shelf life (4) (Fig. 2). The level of lactic acid in meat has been shown to directly influence the shelf life of the meat product. Lactic acid in the muscle could be considered as 'nature's bacteriostatic', because it retards the growth of spoilage bacteria that may contaminate carcasses during processing (4). When muscle lactic acid levels are low and the storage environment supports bacterial growth, the meat quickly develops an unpleasant odour and colour, and rancidity (4, 13).

Pre-transport preparation

Feed withdrawal

One of the first steps in preparing food animals for transfer to slaughter is feed withdrawal. Feed withdrawal is commonly performed prior to transportation with the intent of minimising the gastrointestinal contents in order to reduce faecal contamination of carcasses at slaughter (29).

In theory, the practice of feed withdrawal makes sense; if the gastrointestinal tract is empty, there should not be any faeces to cross-contaminate live animals during transportation or the facilities and equipment at processing and slaughter. However, the exact biochemical and physiological changes which will occur as a result of this practice on an individual animal cannot be predicted. Research has suggested that the stress associated with feed withdrawal may actually increase the carriage and shedding of pathogenic organisms (12, 15, 29). In poultry, it is estimated that after about four hours of feed withdrawal, birds instinctively peck at faecal-contaminated litter resulting in crop and intestinal contamination at slaughter (29). In a study by Harvey *et al*. (12), it was hypothesised that reductions in volatile fatty acid concentrations, as a consequence of emptying the gut, leads to an increase in intestinal pH. Alkaline environments tend to support the growth of pathogenic microorganisms and concurrently reduce the growth of beneficial microbes.

Animals transported from the farm to the stockyard, rather than directly to the slaughterhouse, potentially experience additional stresses from multiple episodes of transportation and handling, as well as repeated periods of feed withdrawal (19). Depending upon the number of destinations in the transportation process, food animals could be subjected to variable periods of feed and water deprivation. When planning for transportation, it is important to take into consideration feed withdrawal times in order to reduce the amount of carcass weight loss and dehydration. Carcass weight loss is most likely to occur between 9 h and 18 h after feed withdrawal has begun (8). Carcass weight loss initially results from fluid loss through the excretion of faeces and urine but longer feed withdrawal periods may contribute to a decrease in tissue substance and muscle glycogen levels (8).

Vehicle cleanliness and contamination

Proper sanitisation of trailers used for transport can contribute to a considerable reduction in the environmental levels of *Salmonella* and other pathogens (22). Non-carrier animals may be exposed to pathogenic organisms when transported in poorly cleaned vehicles or cages (22). The level of mud and faecal contamination on the hides/feathers of live animals presented to slaughter is directly associated with levels of visible contamination on dressed carcasses. It is intuitive that high levels of vehicle and cage contamination can contribute to the prevalence of pathogens on finished carcasses and processing equipment and pose a public health threat that may translate into incidences of food-borne illness (24).

Catching and loading

In preparation for transportation, catching and loading serve as immediate sources of stress for food animals. During this time, the animals are placed into unfamiliar situations that involve changes in their environment, social groups and handling. Research has shown an almost instantaneous increase in salivary cortisol (stress hormone) and heart rate during the initial stages of transportation (2, 8). Peak stress situations for pigs and animals unaccustomed to the noises and handling associated with transportation tend to occur during loading and unloading which is considered a critical stress and injury control point (8). It is especially imperative that animal handlers be proactive in the provision of humane handling and care during these stages. It is also important that these employees are properly trained on the appropriate use of behaviour modifying devices, such as electrical prods, when deemed necessary. Different methods of pre-transit preparation of livestock and poultry that may minimise stress have been examined by various sources. Table I is a summary of some of these recommendations.

Transport conditions

The concerns associated with transport conditions depend partly on the mode of transport, the type of animals being transported, and the age of the animals. Good management and well-designed equipment and facilities play vital roles in decreasing the amount of stress encountered during transportation. Poor transport conditions can have harmful effects on the welfare of the animal and can lead to considerable product loss, due to death and/or injury, and cross-contamination of pathogens among the animals.

Table I
Pre-transport preparation and handling recommendations for minimising stress in livestock and poultry

Pre-transport activities	Recommendations
Pre-transport health check	Ensure that animals are physically fit for transportation (7). Veterinary Services should be consulted before making any final decisions if the health of an animal is questionable
Feed withdrawal	Practise appropriate pre-slaughter feeding management by providing feed and water up to a pre-determined feed withdrawal start time. This helps to ensure that the animals are not subjected to longer than necessary feed withdrawal times
Catching	Poultry should be caught in the evening or use dim lights or dark curtains. A darker environment may provide a sense of calmness to the birds and reduce strain If bird-catching machines are available, they may help to make catching an easier process for the handlers and less stressful for the birds Catching animals during cooler parts of the day and/or keeping the transport vehicles shaded helps to provide some thermal relief from the exertion of catching and decrease the incidence of heat exhaustion in some animals (8)
Loading	Load quietly and minimise yelling, unnecessary noise, harassment or force Make sure that untrained assistants or spectators do not impede the loading process Painful procedures should not be used to move animals. Electric prods should only be used by trained handlers and only when deemed necessary and there is enough room for the livestock to move forward or react instinctively Restraint methods should be appropriate for the situation accounting for the age, size and type of animal Animals can best enter transportation vehicles when they do not have to overcome differences in height (6). The heart rate has been shown to increase linearly with that of the ramp's incline. The use of a hydraulic ramp with some animals, such as pigs, allows both the heart rate and body temperature to remain at a more stable level than when these animals have to climb over a slanted ramp (6) Ensure that the passageways livestock must travel to reach the transport vehicles are well lit and void of obstructions

Vehicle cleanliness while in transit

As previously mentioned, the cleanliness of the crates and trailers impacts the transmission of disease and external contamination of the animals being transported. The importance of cleaning transportation equipment must be emphasised. Trailers and crates become contaminated with faecal matter during transportation which compounds pathogen levels and the associated risk. The specific transportation method directly influences susceptibility of animals to pathogens and the potential for external contamination, even if the trailers and crates are thoroughly cleaned and disinfected before loading. For instance, in the USA, most poultry are transported to processing plants in 'modules'. A typical module consists of individual cages that can hold as many as 25 birds. The cages are stacked upon each other and side-by-side to make up the module. One module may contain up to 300 birds (28). Due to the complex structure of these modules and the close proximity of the birds to one another, the potential for cross-contamination from faecal droppings or birds that die in transport is intensified. It is common for some animals to experience motion sickness and vomit when encountering unfavourable transport conditions thereby exposing the adjacent animals to bodily fluids that might transmit pathogens and result in carcass contamination during slaughter (8).

Crate density and space allowance

Crate density and space allowance can significantly affect stress levels during transport. Already stressed animals are further stressed when they are packed tightly and in uncomfortable positions. Heat stress can also occur when heavy crate densities do not allow for adequate ventilation in warmer temperatures. In addition to the physiological consequences of stress, the issue of space addresses physical consequences such as bruising, injury, and death due to fighting, trampling, or suffocation. An article by Chambers and Grandin (4) reported that fighting tends to occur most often when a vehicle stops suddenly and animals are inadvertently 'pushed' into each other. This would be a major concern to producers in the event that the animals gore, scratch, or bruise each other and carcass quality is affected. Sufficient space allows enough room for the animals to adjust their posture naturally, brace themselves against the movement of the vehicle, and get up in the event that they fall down (17).

The effect of physical hazards and handling on meat quality

Some pre-slaughter handling losses may be attributed to damage caused by physical hazards. Sharp objects on cages

and handling equipment and holes in the flooring and slippery conditions of vehicles and facilities at the slaughterhouse are sometimes overlooked hazards that can cause serious injury and loss (26). Transportation vehicles, containers, and holding facilities should be constructed to account for usage and a regular maintenance plan should be developed to ensure that these and other physical hazards are circumvented as much as possible.

It is the joint responsibility of all persons involved to make the appropriate handling of transported animals a number one priority. Meat quality is directly affected by the manner in which food animals are handled prior to slaughter. When dealing with unruly or stubborn animals, electric prods, and in some cases, sticks or other items may be used for control. At times, the use of these methods may be deemed necessary by trained handlers. However, problems arise when these methods are performed unnecessarily or incorrectly by improperly trained handlers. For example, significant bruising of sheep carcasses, particularly the neck and hind quarters, has been directly linked to wool-pulling and rough handling by human handlers (17). A physical blow or rough handling leading to bruising or other animal injury can result in parts of the carcass being condemned. Bruised meat is dark and bloody and must be removed for the carcass to pass federal inspection standards (4) (Fig. 3). This type of meat spoils rapidly and its appearance lacks consumer appeal.

Fig. 3
Bruising on a cattle carcass
Source: Chambers and Grandin (2) courtesy of P.G. Chambers

Length of time in transit and rest stops

Another concern about transport conditions is the length of time in transit and the distance travelled. Time in transit does not necessarily coincide with the distance travelled and it may be impossible to avoid or reduce lengthy transportation times due to the location of farms in relation to slaughter establishments (27). A study by Cole *et al*. (5) concluded that the majority of losses due to transport stress take place during the early portions of the journey and that longer periods of travel may not significantly add to the amount of stress experienced (5, 7). The report suggested that adaptive mechanisms became effective as the time increased and that was reflected in the maintenance or decrease of stress levels (7). However, animals never fully calm down during transport and longer times may increase the amount of time required for rest and recovery at the slaughterhouse (8). Transport conditions may affect stress levels more than the length of transportation itself even though common sense would lead most people to view length in transit as a significant stressor. Some studies have shown that a reduction in transportation time by as little as an hour has a positive effect on meat quality (8). This may be because although fluid losses are highest early, losses continue throughout, albeit at a slower rate, and other physiological changes occur which can affect meat quality. Effects on meat quality and safety cannot be attributed solely to transport stress and/or time en route (5). Nonetheless, both should be minimised as much as possible to ensure public health safety, product quality standards and animal welfare.

The debate over the advantages and disadvantages of rest stops while in transit is on-going. The stresses associated with loading and unloading during rest stops are thought to be additive. Depending upon the length of the journey and the animals being transported, rest stops may involve stopping the vehicle with or without unloading. The stopping of the vehicle is beneficial in one way because it allows the animals to be temporarily relieved from constantly trying to keep their balance and, in some cases, it also provides them with access to water and feed (8). However, depending on the environmental conditions, the heat in a stopped vehicle can rise quickly, thereby increasing stress (10). The benefits of rest and feeding should be weighed against the stresses of loading and unloading to decide whether or not to stop (10). The method of transport, distance travelled, species, and age of the animals must also be taken into consideration when determining the frequency of rest stops and whether unloading, feeding and/or watering should take place.

Weather conditions

Weather influences the level of stress experienced during transport and variances in weather conditions affect the overall ability of the animals to recover at lairage (8).

Severe increases or decreases in temperature can lead to livestock and poultry transportation losses. Insufficient vehicle ventilation and individual animal health status challenge the animal's ability to adequately adjust to varying temperatures. Some animals may experience heat exhaustion, sun burn (pigs) and dehydration when temperatures are elevated and hypothermia and frost bite when temperatures are low. These concerns are further heightened when travel involves long distances, such as in the event of international transportation. Adverse weather conditions cannot necessarily be predicted, but must be managed during the transportation process to limit the amount of added stress on the animal. In addition, caution must be taken to not introduce new hazards when attempts are made to protect the animals against the elements. An example of this would be how covering trailers in cold weather can trap truck fumes and cause carbon monoxide poisoning.

Lairage

Lairage, or holding prior to slaughter, allows animals to replenish muscle glycogen levels, rest, and recover from the effects of feed and water withdrawal and other transportation stressors (18, 20). Rest obtained in lairage also reduces the incidence of meat quality defects, though time in lairage has also been associated with an increase in the prevalence of pathogenic contamination (16, 20, 29).

The lairage environment and contamination

The lairage environment itself and the comingling of animals may inhibit the ability to recover from transportation and expose the animals to pathogens different from those from their farm of origin (18). Hurd *et al*. (16) reported increases in the number of pigs testing positive for *Salmonella* at slaughter versus those tested on the farm. This study also found a difference in the strains of *Salmonella* obtained at the slaughter establishment, suggesting that the pathogens originated from sources other than the farm (15, 16). These findings provide evidence that in addition to possible exposure during transportation, the holding pens for lairage are significant control points for reducing carcass contamination. External contamination may be compounded when the time in lairage is increased and the prevention of long lairage holding periods and overcrowding should help to reduce the amount of external contamination of animals at slaughter (21).

Time in lairage and meat quality

The time in lairage should be specific to the type of animals involved and the conditions of transport. Lairage times can be manipulated within certain limits and can vary from less than one hour to more than twenty (27). Most studies have shown that a lairage time of two to three hours is sufficient to ensure animal recovery and protection of the safety and quality of the resulting products (27). In pigs, the incidence of PSE is highest within the first two hours of lairage while the incidence of DFD meat increases with time in lairage (8). In cattle, especially males, increasing time in lairage has been linked to an increased incidence of dark-cutting beef and bruising on meat due to fighting (8). Table II provides a list of recommendations from various sources for optimising transportation and minimising stress in transit and at lairage.

Global considerations

Increased globalisation of trade markets has made it useful to establish domestic food standards for transportation that take into account the expectations of trading partners. The recommendations and material addressed in this paper are more easily applied to larger-scale food animal production systems, such as those in industrialised nations. The manner in which animals are transported and the distances travelled varies tremendously across the globe. Animals may be transported in large, tiered, vehicles across a country or continent or they may be gathered in groups and transported across a city on the back of a bicycle. Either case presents possible animal welfare concerns and provides opportunities for live animal and carcass contamination that need to be addressed from a global standpoint to ensure international public health safety.

Unfortunately, many small-scale producers often lack the resources to carry out the most humane transportation methods that limit stress and hazard exposure. In fact, these producers are unlikely to be exposed to information about the effects transportation can have on product safety and quality. Increased international production and trade of poultry and livestock has changed the scope of the associated public health safety risks (11). Therefore, it is critical that stakeholders continue to support the establishment of scientifically based methods and education concerning the movement of food animals that do not preclude small-scale disadvantaged producers from full access to local and international markets (11).

Economic considerations

Change in the global view of animal transport and welfare is directly affected by economics. There is growing competition in the international market for livestock and poultry and increased stocking densities may be in response to the economic factors required to maintain

Table II
Recommendations for minimising stress while in transit and at lairage

Transport and lairage conditions	Recommendations
Facilities for in-transit monitoring	Drivers should check the effectiveness of transportation by being able to observe and tend to animals that may die in transport or be injured
Driving conditions	Drivers should try to account for varying weather and road conditions as much as possible to prevent unnecessary delays in arrival to the slaughterhouse The frequency, length and whether feeding, watering and unloading will take place during rest stops should be predetermined as much as possible Transportation should take place during the cooler/warmer parts of the day to minimise the effects of heat/cold stress in extreme conditions (8)
Vehicle conditions	The loading densities and the number of animals and their allocation to different compartments should be determined before loading takes place Space allowance should be calculated to avoid having groups which are too large and do not allow for comfortable transportation. There should be enough space for all animals to lie down at the same time and the stocking density should account for the season and climate (i.e. reduced density during warmer weather) Vehicles should be designed in a way that prevents faeces or urine from animals on the upper levels from contaminating the animals and their feed and water on lower levels Suitable bedding should be added to vehicle floors to assist absorption of urine, faeces and vomit and minimise slipping Vehicle design should adequately protect the animals from variations in climate so that the thermoregulatory needs of the animals in transit are met. Sufficient ventilation is enough to combat exhaust fumes and odours from the vehicle and the animals themselves
Lairage	Make sure the lairage environment has been adequately cleaned and disinfected prior to the arrival of the animals to lairage (14) Unload animals in a calm, unhurried manner Attempt to keep groups of animals from the same farm and/or transportation vehicle together to minimise the social stresses associated with the mixing of new animals and encourage rapid recovery Isolate sick or injured animals. Ensure that methods are in place for dealing with the humane handling of sick and injured animals Provide animals with clean drinking water upon arrival. Provide feed if slaughter will not take place within an acceptable amount of time (i.e. within 12 h) Make sure that the holding pens are secure to prevent animals from escaping and are free of physical hazards which may promote injury

commercial viability (6). 'Shrink', a term used to describe live weight loss occurring as a result of dehydration and feed deprivation, bruising, injury, and mortality during transportation are not only animal welfare and product quality concerns, but economic issues to all parties involved. It is a direct concern of producers when on-farm investments made to comply with regulations aimed at the protection of their product and public health, are essentially 'lost' in the process of transportation (23). In the US pork industry alone, transportation-associated losses have been estimated to be as much as US$ 8 million annually (23).

Any government regulations disallowing the use of injured or downer animals for human consumption could have a direct effect on the economics of the livestock industry. A downer animal is any animal that is unable to maintain normal mobility due to disease or injury. Transportation is an important control point to prevent a healthy animal from becoming injured due to poor conditions such that they would become labelled as a downer animal upon arrival to slaughter. In many developing countries, these types of losses are high because the marketing system does not always provide an economic incentive to reduce them (4). The practice of selling animals on a per head basis to the slaughter establishment is an example of a system in which the producer or transporter is not held liable for losses resulting from injuries or weight loss during transportation. As an alternative, some establishments pay for on-the-rail passed carcass weight, which means that the producer is paid for the weight of the animals after transportation rather than by head, or in other words, the number received at the establishment for slaughter. Under this alternative, the producer and transporters have an economic incentive to preserve the quality, and hence the value of the animal.

Conclusion

Understanding the linkage between on-farm food safety operations and processing will contribute a great deal to enhancing food safety and increasing consumer confidence in meat, poultry, and egg products. Many of the hazards associated with transportation can be minimised; therefore, it is imperative that all persons involved at the different stages of transportation be educated and committed to understanding the effects that their actions can have on the safety and quality of meat, poultry, and egg products. Public perception of food safety and quality is changing and the proper support of industry and regulatory agencies is necessary to ensure that producers are able to maintain and exceed expectations both locally and globally.

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Les conditions de transport et la qualité des denrées alimentaires

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Résumé

De nombreux facteurs contribuent à l'innocuité des produits alimentaires d'origine animale. Les initiatives en faveur d'une approche intégrée de la sécurité sanitaire des aliments mettent l'accent sur la nécessité d'assurer des conditions de transport optimales afin de préserver la qualité sanitaire obtenue au niveau de la ferme. Les dangers physiques, microbiens et environnementaux inhérents au transport peuvent menacer la sécurité sanitaire et la qualité des produits de viandes, volailles et œufs. En outre, les conditions de transport sont potentiellement génératrices de stress, ce qui accroît la quantité de microorganismes pathogènes excrétés par les animaux porteurs, exposant les autres animaux au risque d'infection. Les effets physiologiques du stress ont un impact négatif sur la qualité des viandes, des volailles, des œufs et de leurs produits, ce qui diminue d'autant leur valeur économique. La mondialisation accrue des marchés constitue un incitatif pour l'application de normes pour le transport des animaux destinés à la consommation, et ce tant au niveau national qu'international.

Mots-clés

Bien-être animal – Manipulation des animaux avant l'abattage – Qualité de la viande – Sécurité sanitaire de la viande – Stabulation – Stress – Toxi-infection alimentaire – Transport.

Condiciones de traslado y calidad de los alimentos

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Resumen

Muchos son los factores que intervienen en la producción de alimentos de origen animal inocuos. Las iniciativas que promueven planteamientos integrados en la materia otorgan la debida importancia a la optimización de las condiciones de transporte con el fin de garantizar que las intervenciones practicadas en la

explotación queden preservadas. Los peligros físicos, microbianos o ambientales que concurren durante el proceso de traslado pueden influir negativamente en la inocuidad y calidad de los productos elaborados con carne, aves de corral o huevos. Además, determinadas condiciones de transporte pueden elevar el nivel de estrés de los animales, cosa que a su vez puede incrementar la excreción de patógenos en ejemplares portadores y facilitar con ello la contaminación de animales sanos. Los efectos fisiológicos del estrés en los animales pueden mermar la calidad de los productos obtenidos a partir de la carne o los huevos de esos animales, reduciendo así su valor económico. La creciente mundialización de los mercados constituye un incentivo para aplicar, tanto dentro de un país como entre distintos países, reglas de transporte de animales destinados a la producción alimentaria.

Palabras clave
Bienestar de los animales – Calidad de la carne – Enfermedad transmitida por vía alimentaria – Estabulación – Estrés – Inocuidad de la carne – Manipulación previa al sacrificio – Transporte.

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