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Review

Animal welfare in multipurpose cattle production Systems and its implications on beef quality

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Animal welfare and its influence on beef production are major considerations in many developed countries. In the developing world, where food insecurity and poverty are prevalent, the welfare of animals receives low priority due to factors such as traditional customs and beliefs, lack of knowledge in animal handling and sub standard handling facilities. This is worsened by the fact that cattle are used for several purposes, such as meat production, milk production, draught power and traditional ceremonies. Research on animal welfare and how it relates to animal production have been done in the developed world. The objective of this study is to discuss indicators of animal welfare assessment, their impact on meat quality and applications to improve beef production in developing countries.

Key words: Behavioural assessments, flight zones, meat quality, ritual slaughter.

INTRODUCTION

Animal welfare refers to the physiological or biochemical state of an animal as it attempts to cope or respond to internal challenges or ante-mortem conditions at the time of observation (Gregory, 1998; Broom, 2000; Grandin, 2001). It represents the mental and physical health of an animal in relation to its environment (Smith and Pearson, 2005). Animal welfare also involves the application of sensible and sensitive animal husbandry practices to the livestock on the farm. Good animal welfare has a positive effect on production.

Good practices of animal welfare are underpinned by the framework provided in the five familiar freedoms that describe an animal's fundamental needs (Gregory, 1998; Bech et al., 2008; Vessier et al., 2008). Animal management practices should aim at keeping animals free from thirst, hunger and malnutrition, discomfort, pain, injury and disease, fear and distress, and should also be able to engage in normal pattern of animal behaviour (Bech et al., 2008). Non-fulfilment of these needs may expose the animal to stressors with detrimental effects on meat production. Prolonged exposure to stressors disrupts energy mobilization and reactions involved in stress response, thus affecting the normal body functions, for example, immunity, growth, reproduction and expression of normal behaviour (West et al., 2003).

Concerns for animal welfare and its influence on meat quality are major considerations in many developed countries (Veissier et al., 2008; Muchenje et al., 2009a; Strappini et al., 2009). In the developing world, where food insecurity and poverty are prevalent, the welfare of animals receives low priority due to lack of knowledge in animal handling, traditional customs and beliefs, sub-standard handling facilities and failure of government legislation (Veissier et al., 2008). Under communal production systems, for example, cattle tend to have high levels of parasites (Muchenje et al., 2008a) and face nutritional deficiencies due to deteriorating rangelands, particularly in winter (James and Hazel, 2007; Dube, 2008) and during the cropping season where animals are

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Abbreviations: AWOs, Animal Welfare Organizations; **DCB,** dry cutting beef; FS, flight speed; **FT,** flight time; **NEFA,** non-esterified fatty acid; **ACTH,** adrenocorticotropic hormone; **CK,** creatine kinase; **APP,** acute phase proteins; **Fb,** fibrinogen; **Hp,** bovine haptoglobin; **SAA,** serum amyloid-A.

used for draught power (Chimonyo et al., 2002). In addition, health management systems in developing countries are weak or non-existent and draft animals are being brutally mistreated and totally neglected (Ramaswamy, 1998).

In South Africa, ritual slaughtering during traditional ceremonies, especially in the Zulu culture and traditions, sparks a lot of controversy concerning animal rights and cultural practices (Mnguni, 2006). During marketing of cattle, animals are taken to abattoirs using various transport means. Animals are improperly loaded in trucks which are inappropriate, small, poorly ventilated, uncomfortable and even open to direct heat and rain. In addition, overcrowded trucks and on foot driving for long distances with untrained stockmen who use sticks and goads are common, where bruising is not uncommon. Indigenous African ethnic pastoral groups, such as the Maasai people of Kenya, bleed live cattle by opening a vein on the neck or flank with the point of an arrow and these practices impose pain, thus raising obvious animal welfare concerns (Alana et al., 2008). The reasons behind these practices need to be understood for effecttive intervention.

There is need to raise awareness of these animal welfare issues and enforce animal welfare assessment methodologies in developing countries (Broom, 2000). Identification of poor handling procedures, their control and preventative measures can be implemented effecttively to reduce losses for producers and livestock keepers and also to improve the quality of the meat produced. Assessment of animal welfare may contribute, not only to improved beef production but also promotes animal well-being. Ensuring the well-being of the animal is an ethical requirement for sustainability of biodiversity, especially when adapted animal breeds are selected and reared in production conditions of their ancestral origin.

A number of methods have been developed to assess animal welfare and authenticity of beef products in the developed world (Broom, 2000; Tarrant and Grandin, 2000; Campo et al., 2008). These methods evaluate the behaviors of animals, assess biochemical and physiological properties and make quantitative observations. Novak et al. (2004) used various complementary parameters, such as production indicators (performance and yields), physiological indicators (endocrine and cardiovascular responses), pathological indicators (morbidity, diseases and mortality) and ethological criteria, such as abnormal behavioural patterns. Besides their use in monitoring the welfare of animals on farm, physiological and biochemical measurements can also be used to monitor the health status of animals on the farm (Eckersall, 2000) or at slaughter (Campo et al., 2008; Muchenje et al., 2009a, b).

A number of reviews on the impact of animal welfare on meat quality in the developed world are available (Gregory, 1998; 2007; Broom, 2000; Ferguson and Warner, 2008; Strappini et al., 2009). This review discusses the methodologies that could be used to assess animal welfare practices, their impact and application to improve beef production in developing countries. The intention is to open a discussion among practitioners and researchers on improving handling procedures for beef animals because most of the available literature is on pig production, particularly in developed countries. In addition, the current situation on animal welfare in the developing countries and possible areas which need research are highlighted.

CATTLE MANAGEMENT ISSUES AFFECTING ANIMAL WELFARE IN THE SMALL HOLDER AREAS

Rearing of cattle is an integral part of agricultural production systems in semi-arid regions of most developing countries, such as Zimbabwe and South Africa (Chawatama et al., 2003; Mapiye et al., 2009b). There are however, little efforts towards raising of animal welfare issues in most developing countries and animals are reared under very extensive, range-management conditions, of which their interactions with people are infrequent and nearly always aversive (Ali et al., 2006; Dwyer, 2009). Under communal production systems that are common in most developing countries, high parasite loads, feed shortages, provision of draught power, poor housing conditions and cultural practices tend to impact heavily on the welfare of animals, particularly cattle (Ramaswamy, 1998; Chimonyo et al., 2002; Muchenje et al., 2008a). Cattle in communal production systems are used for several purposes. These include meat production, milk production, traditional ceremonies, draught power and production of manure that is used for crop fertilisation (Mapiye et al., 2009a).

High parasite loads

Cattle in communal areas have been reported to have high worm and tick loads (Muchenje et al., 2008a; Ndlovu et al., 2009a). The impact of these parasites depends on breed, with the indigenous genotypes showing signs of tolerance and even resistance to the parasites (Muchenje et al., 2008a). As such, imported breeds which have been bred under relatively benign environments, fail to cope and their mortalities are high. The high parasite loads are common among most of the communal farmers, who are largely resource-poor, failing to afford veterinary drugs and the high cost of hiring veterinarians.

Dipping is mostly infrequent and in some cases, wrong dosages of the acaricide are applied (Moyo and Masika, 2009). Dip tanks are located far away from where cattle are kept and in some cases the dip tanks are non-functional due to the non-availability of water pumps, water and acaricides (Moyo and Masika, 2009). As a result, animals have to be hove driven over long

Figure 1. Neck-gall due to yoke rub (Ramaswamy, 1998).

distances to and from dipping areas and during theses journeys animals are given water and allowed to rest. Non-dipping of cattle due to these limitations results in high tick loads that cause tick damages to parts, such as udders and scrotums and tick-borne diseases such as heart water and red water (Muchenje et al., 2008a). In such cases, it is advisable to use indigenous cattle breeds that are tolerant to ticks and less susceptible to tick-borne diseases.

Feed shortages

Grazing in most communal production systems are uncontrolled and continuous grazing systems are common (James and Hazel, 2007; Dube, 2008). Besides, most communities are overstocked, since ownership of grazing rangelands is communal; little sense of ownership of the grazing resources exists (Dube, 2008). The cattle, therefore, lose body condition, particularly in winter and spring (Mapiye et al., 2009b). The poor body condition also exacerbates the impact of the parasites on the welfare of the animals. There is need to investigate the welfare status of animals in these deteriorating rangelands so that appropriate stocking densities can be formulated.

Draught power

The small sizes of arable land and the lack of sophistication of agricultural operations in most smallholder farming areas make the use of animal draught power inevitable. Oxen, bulls, cows and heifers are used for pulling ploughs, carts, cultivators and sledges (Chimonyo et al., 2002). Although pain is exerted during these operations, it is crucial to have the users of these animals trained. During ploughing, for example, whips are used for the animals to move fast. At the end, draught animals are left with wounds and scars. In India and Southern Africa, the use of traditional yokes and harnessing, such as those illustrated in Figure 1, bruise the neck and cause pain to the animal (Ramaswamy, 1998). Other agricultural implements attached to draught cattle, such as ploughs and carts are of crude design and inefficient, which hurt draught animals.

The working and resting times for draught animals and its impact on beef production has not been extensively researched under local conditions. Draught animals are also kept in the herd for long periods of time (Mapiye et al., 2009b). Draught cattle need to be in appropriate body condition (above 3.0) to enhance efficiency, which calls for providing them with adequate feed resources particularly, before the rainy season begins.

Poor housing conditions

Kraals used for housing cattle do not have roofs, in many instances. During the rainy season, the animals are, therefore, exposed to excessive rain, especially at night and become susceptible to diseases, such as foot rot (Moyo and Masika, 2009). During the rainy season cow dung in the kraals create muddy conditions. This makes it uncomfortable for cattle to lie down, in addition to creating conducive conditions for diseases. Kraaling the cattle for long periods also results in limited time for grazing. Awareness to these threats to the welfare of cattle needs to be raised among the poor farmers.

PRE-SLAUGHTER WELFARE ISSUES IN SMALLHOLDER AREAS AND THEIR EFFECTS ON MEAT QUALITY

Pre-slaughter welfare issues are influenced by factors including tradition, social customs and beliefs, inefficient policy implementation and government interventions, ritual slaughter, lack of education on animal handling, mixing of animal social groups from different households, poor transport condition, inappropriate handling facilities and poor slaughterhouse conditions (Mnguni, 2006; Gregory, 2007; Muchenje et al*.,* 2009a,b). During the ante-mortem handling conditions from rearing to slaughter, cattle are subjected to various internal and external challenges, which they perceive through specific features or experience. They will subsequently respond or cope with physiological and biochemical changes and products that influence the process of transformation of muscle to meat (Broom, 2000; Muchenje et al. 2009a, b).

Tradition, social customs and beliefs

Failure to implement animal welfare issues can also be ascribed to the weaknesses of traditional customs and beliefs among some ethnics groups, such as the Zulu, Karanga, Fulani and the Maasai in Africa (Mnguni; 2006; Gregory, 2007; SAPA, 2009). During traditional ceremonies, human-animal interactions involve constant penetration of animal flight zones, use of sticks and goads in driving animals, restraint, feed deprivation, noise, agitation, ululating, shouting and passing angry vocals to the animals when moving them in the required direction or when expressing some traditional sentiments (Mnguni, 2006; Gregory, 2007). The Fulani culture in Africa encourages stockmen to pass threats or willful behaviors by hitting the animal and failure to do so from childhood is regarded as not being courageous (Lott and Hart, 1977). On the other hand, in Asia, cattle awaiting slaughter are baited by dogs in the streets to make the meat more tender (Gregory, 2005).

In Zimbabwe, the Vahera people during slaughter, tightly tie all the legs together just below the abdomen region, such that the knot exert pressure on the abdomen in order to facilitate the rapid release of blood following slitting without stunning. Alternatively, the Vahera people may tie three legs only and then the other leg is forced to hook at the back of the head whilst a group of strong men pull the three legs from the back of the animal. Then the beast is cut on the neck without stunning. In Matabeleland South Province of Zimbabwe, the beast is restrained, its neck or horns are tied on the tree, and then blood is let out by cutting on the neck in the halal way following stunning by hitting the cow on the back of the head with a sharp axe. Furthermore, the Maasai people bleed live cattle to obtain blood for traditional reasons without any anaesthesia (Fratkin, 2001). In general, the slaughter practices vary with region and culture. These practices require investigation and documentation, to lessen the pain animal suffer during the slaughter process.

Slaughtering without stunning is associated with stress of restraint, pain of the cut and undue distress whilst the animal is bleeding out (Gregory, 2005). Cutting the neck in the unanaethetised state is likely to involve physiological events which are characterized by undesirable sensations that are likely to be a sense of shock, comparable to an electric shock (Gregory, 2005). Bleeding live animals in the Maasai culture is likely to cause pain which is almost the same as in unanaethetised stunning (Gregory, 2005).

In some developing countries in Asia, there are beliefs that stress benefits some quality traits, such as tenderness resulting in cattle being baited with dogs, chased through streets by mounting stockman equipped with goads (Gregory, 2007). On the other hand, the South African Zulu slaughtering method, for example, involves stabbing of the animal on the stomach by using a spear and then forcing the animal to move some distance (Mnguni, 2006). Physical activity for hours before slaughter which is common in the Asia, reduces glycogen concentration and plasma glucose levels below critical values (Chambers et al., 2001) eventually leading to reduced lactic acid and increased meat pH above critical range of 5.5 to 6.0 (Tarrant and Grandin, 2000; Kannan et al., 2002; Muchenje et al., 2008b) and reduced energy value. Ultimately, pH influences most of the meat eating quality traits (Aklilu, 2002; Andersen et al., 2005; Muchenje et al., 2008a). On the other hand, Grandin (2000a) established that, when the muscle pH approaches the value of 6.0, the beef tenderness decreases and later start to increase as the pH increases from 6.2 to 6.6, as shown in Figure 2. Although at high pH (6.2-6.6), the cal pain enzyme system gains more activity and tenderises meat, the meat becomes dark (Silva et al., 1999) due to the smaller amount of light reflected whereas there is high absorption of light radiation.

Napolitano et al. (2002) revealed that, traditional rearing methods with high levels of animal welfare and

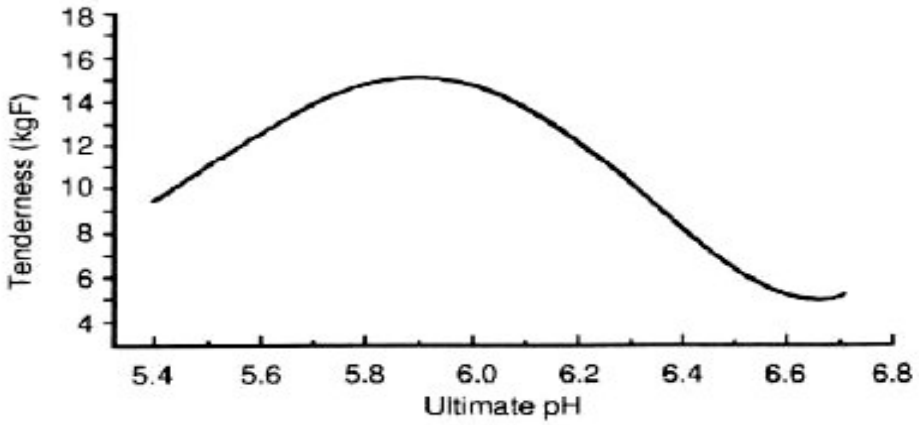

Figure 2. Relationship between meat tenderness and ultimate pH. The higher the kgF value, the less tender the meat (Adapted from Anon, undated).

product specificity may soon assume economic relevance. Therefore, there is need for research on these traditional practices in the developing countries under the local conditions and also including the resource users. In other words, there is need for marriage of stockman, scientists and policy, by incorporating ethnic groups in research and formulation of animal welfare policies, for this provides an opportunity to capture their perceptions and aspirations thereby developing shared policies and improving implementation. According to a report in The Citizen (2009), making a judgement between the rights of animals, people's cultural and religious rights impose a mammoth task to the judiciary, thus demands careful scrutiny.

Inefficient policy implementation and government interventions

Animal welfare issues are increasingly becoming the subjects of scientific study across the world, receiving major considerations in most developed countries and have led to government interventions and formation of non-profit Animal Welfare Organizations (AWOs) (Ramaswamy, 1998; Fitzpatrick et al., 2006; Vessier et al., 2008; Strappini et al., 2009). The impediments to proper welfare in developing countries can also be attributed to poverty, lack of knowledge on the importance of proper handling, lack of resources and inefficient government support for resource-poor farmers, for example, the budget by the Animal Welfare Board of India could not meet the need of establishing enough AWOs (Ramaswamy, 1998). Furthermore, some laws have been enacted in some developing countries, such as India and South Africa, but punishment is nominal and the laws are too cumbersome to implement and government interventions are lax or scarce (Ramaswamy, 1998; SAPA, 2009).

In the law enforcement process, animal rights need to be protected, at the same time, the people's cultures should be nursed. However, it is by logic that animal rights cannot be reversed but once people appreciate civilization in this era of globalization, cultures can be adjusted to accommodate welfare of animals. Record keeping and animal identification is however, still of low priority in developing countries but are important to allow traceability of animal products and conditions that are used to produce them in the meat industry.

To enhance traceability during welfare assessment, smallholder farmers are encouraged to introduce identification methods such as ear tags from the time of birth up to the time of slaughter (Smith and Pearson, 2005). The response of animals to handling procedures is multi-dimensional, thus to fully ascertain cattle welfare status, all aspects of condition of life, including health and disease, behaviour, husbandry and management should be traceable up to the time of consumption of beef (Fitzpatrick et al., 2006; Smith et al., 2008). Government and non-profit organizations are invited to formulate legislation and raise animal welfare awareness campaigns in developing countries.

It should also be noted that, most benchmarks on animal welfare conditions are based on research which has been done in developed countries under more advanced animal welfare conditions (Grandin, 2007; Gregory, 2007; Strappini et al., 2009). In developing countries, formulation and implementation of appropriate policies that can consider the local conditions and practices are of paramount importance to promote the well being of animals and proper use of resources.

Ritual slaughter and lack of knowledge in animal welfare

Information on ritual slaughters is limited because most issues to do with traditional ceremonies tend to be a closely guarded secret by the elders. According to Mnguni (2006), during ritual slaughtering in the Zulu

culture, such as at funerals (*Umngcwabo*), coming of age *(Umemulo)* and at weddings (*Umshado*), a group of people surrounds the animal (usually a bull) to be slaughtered in its visual field and cattle are slaughtered in the pens without stunning or appropriate handling. The beast is then stabbed using a spear and the animal is not expected to be killed instantly to encourage multiple stabbing (Mnguni, 2006), thus, raising animal welfare concerns due to pain caused by frequent stabbing and not rendering the animal unconscious before slaughtering. When the animal takes long to die, it would have as many stab wounds as possible and the bridegroom is expected to pay more to the in-laws. The bridegroom knows that he is to pay more when there are more stab wounds, this encourages less and less stab wounds which is desirable in terms of animal welfare.

The *Ukweshwama* ceremony of the Zulu culture of South Africa includes the slaughtering of a bull with bare hands, also without stunning (Mahlangu, 2009; SAPA, 2009; The Citizen, 2009). During this slaughtering process, the Zulu warriors strangle a bull to death to celebrate the first fruits of the harvest in the first week of December (Mahlangu, 2009). This practice led to some animal rights groups in South Africa taking the Zulu king to court because this was perceived as cruelty to animals (The Citizen, 2009). Those who practise the Zulu culture argue that, they love animals such that in all ceremonies that are performed animal welfare is seriously taken care of (The Citizen, 2009). Probably what is required in such cases is awareness to threats to animal welfare without necessarily demeaning one's culture.

These may not only impart mental well-being of cattle and cause pain to the animal, but may reduce consumer acceptability of beef produced from abused animals (Gregory, 2007; Bech et al., 2008). Severity welfare procedures, such as during ritual slaughter in the Zulu culture, may influence the ability of meat biochemical components to fall below or above the appropriate threshold levels, thereby compromising the beef quality traits of economic importance, such as colour, juiciness, tenderness, flavour and shelf life (Lawrie and Ledward, 2006). It is important for stockpersons to understand the behaviour of cattle so that stress can be reduced from rearing up to the time of slaughter (Grandin, 2006; Gregory, 2008).

Mixing of different social groups

Prior to transportation to the slaughterhouse or at the slaughterhouse, cattle from different social groups are gathered to a handling point, if there is any or are just driven to the slaughterhouse as groups from different pens or households (Grandin, 2000c; Lammens et al., 2007). During this period, different social groups from different pens are mixed thus influencing flight zones and individual distances or social distances between and within animal groups (Aschwanden et al., 2008).

If cattle are confined in spatially limited areas, such as crowded waiting pens at high stocking densities or in indoor loose-housing systems common in developing countries, animals may fail to respect individual distances (Calhim et al., 2006; Aschwanden et al., 2008) and subsequently results in animal to animal interactions, such as attacks, threats or avoidance behaviours. Fighting and bruising is further increased due to the fact that, most of the cattle slaughtered at small-scale abattoirs come from different herds and they are of different sizes. Bruising may also result due to lack of appropriate handling facilities and the use of whips and sticks in driving cattle on hooves. Dark, firm and dry meat and also pale coloured meat are associated with fighting and bruising of cattle depending on the time at which fight occurred prior to slaughter and these occurrences can cause a loss of edible beef parts and carcass devaluation (Grandin, 2000a).

Information on the differences in the individual distances of the Tuli, Nguni, Mashona cattle and their crosses is lacking but may be useful in assisting farmers to develop welfare standards, such as duration of resting in the lairage, stocking densities that conform to the local conditions and designing holding pens to reduce social conflicts between animals. Scoring of individual distances in conjunction with flight zones will also reduce isolation and crowding at smallholder slaughterhouse.

Poor transport condition

Although vehicle transport on tarred roads are replacing common methods such as driving on hooves and gravel road in developing countries, Maria et al. (2003) reported that, long transport journeys on tarred roads before slaughter increased the risk of dry cutting beef (DCB). Such defaults can be reduced by resting animals in the lairage for 36 h (Kuzmanvic and Elabjer, 2000). Most of the vehicles used for transporting animals are not roofed and they expose animals directly to the sun radiation.

However, there is no information on the response of animals or on possible alternatives to ensure animal welfare, for cattle transported by transhumance and gravel roads for these methods are still common for transporting cattle to the markets or abattoirs in developing countries, especially in the Sub-Saharan African region. Animals are inevitably transported for long distances from rural markets to urban smallholder abattoirs, lengthy journeys place enormous demands for energy metabolism on the animal and may be the reason of depleted muscle glycogen pre- and post-mortem thus, less lactic acid and consequently high beef pH post-mortem.

Inappropriate handling facilities and poor slaughterhouse conditions

In most smallholder farming areas in the Sub-Saharan

region, animals in holding pens are stressed due to lengthy durations at market places, during auctioning or at the lairage, poor handling facilities and introduction into different social groups resulting in fights, bullying, bruises and mounting (Grandin, 2000a). Such situations influence cattle well-being (Muchenje et al., 2009a) and leads to decreases in glycogen levels below the critical threshold levels, thereby raising meat pH (Warris, 1990) and consequently imposes detrimental effects such as reduced beef keeping quality and dark cutting. In many communal areas in Southern Africa, cattle are slaughtered in the kraals and handling facilities are lacking (Mnguni, 2006). The situation is further exacerbated by underdeveloped passageways into the smallholder slaughter-house which allows vision of novelty situations or unfamiliar stockman and poor operational techniques. As a result, animals that are easily agitated, such as *Bos indicus,* have greater chances of producing meat with defaults (Voisinet et al., 1997a) which may reduce the monetary rewards for producers.

Despite recent reports in Nguni and Bonsmara cattle (Muchenje et al., 2009b), information on the biochemical changes that take place in relation to stress responsiveness and the depletion of glycogen and its effect on beef quality of most indigenous cattle breeds, such as Tuli and Mashona in the developing world, is lacking. Furthermore, there is little or no information on the animal welfare status during transportation and performance of cattle following climatic changes and gradual deteriorating rangelands of most developing countries. There is therefore, need to develop animal welfare assessment protocols that can be easily adopted in the developing world. Such animal welfare assessment protocols can be developed using relevant, convenient, accurate and/or affordable behavioral, quantitative, physiological and biochemical assessment methods that are already available.

ASSESSMENT OF ANIMAL WELFARE IN MULTIPURPOSE CATTLE

Due to the multipurpose nature of cattle production systems and limited resources in most developing countries, the development of animal assessment protocols can be complex. Despite the possible complications, assessment techniques that are developed for typical beef cattle production can be adopted to indicate animal welfare status by stockmen and ritual slaughter participants. Knowledge of these indicators will go a long way in raising awareness and minimising pain to cattle pre-slaughter, at slaughter and traditional ceremonies. Current animal welfare assessment methods in use can be categorised into behavioural, quantitative, physiological and biochemical classes.

Behavioural measurements of animal welfare

Changes in animal behaviors are the most obvious indicators that the animal is having challenges in coping with the welfare procedures and in most cases some aspect of the situation is aversive (Broom, 2000). During the pre-slaughter period, animals perceive specific features through previous experience and learning (Gregory, 2007) and will subsequently react through appropriate behavioral responses that influence meat eating quality (Muchenje et al., 2009a). Although evidence exist that man-animal relationships during handling can have major impact on both production and welfare of animals (Munksgaard et al., 2001), information on the behavior of cattle during gravel road transport is scarce, but it is important in indicating possible modifications to improve handling facilities (Tarrant and Grandin, 2000) and how animals acclimatize under extensive management conditions. The commonly used behavioral measurement methods include temperament, flight zones, visual fields and vocalizing scoring. Compilation of these measurements is easy and cheap such that resource-poor farmers, if trained properly, can produce accurate on farm welfare audits.

Temperament

Temperament refers to an animal's behavioral expression in response to challenging situations such as human handling or presence (Ferguson and Warner, 2008). Temperament and stress are strongly related to cattle behavior and can be used in various aspects to assess the previous experience of the animal and predicting optimum welfare techniques to reduce meat defects. Crush scores can be used to evaluate temperament using a 1 (calm) to 5 (combative) scales (Campo et al., 2008). Lower crush scores imply previous optimum welfare and consequently chances of obtaining quality meat which accommodates high consumer concerns.

Although, familiarization of animals to handling procedures makes them easy to handle during the pre-slaughter period (Grandin, 1993; Gregory, 2008), certain breeds, such as *Bos taurus* have calmer temperaments than the *B. indicus* cattle (Fordyce and Goddard, 1984). Studies on the Limousin, Red Bororo and Brahman cattle confirm that *B. indicus* animals are difficult to handle (Minka and Ayo, 2007) and their meat tends to be characterized by dark cuttings and toughness. Behrends et al. (2009) reported that, the response of cattle to novel experience early in life are best predictors of traits impacted by temperaments later in life such as beef tenderness. Docile cattle are associated with greater average daily gain (ADG) than those agitated during routine handling (Voisinet et al., 1997b) and this signifies that, rearing of docile cattle has positive economic implications. Muchenje et al. (2008b) reported that Nguni cattle raised on natural pastures had acceptable meat pH values which can be used to suggest that they had calmer temperaments or were properly handled during the pre-slaughter period.

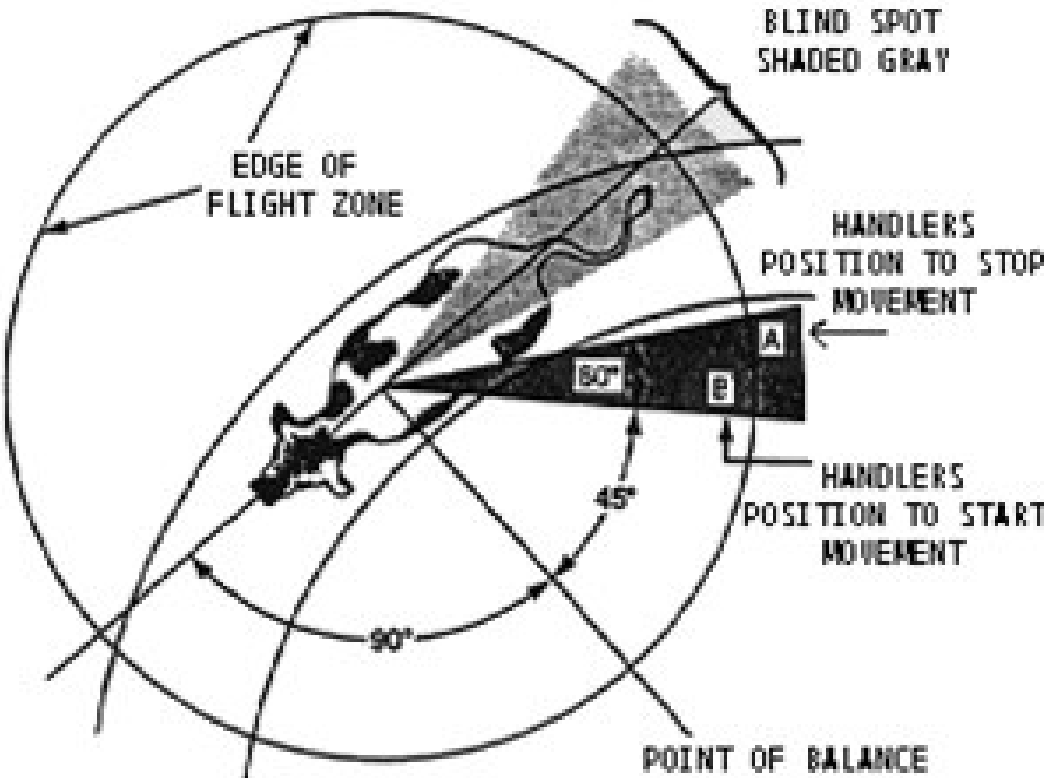

Figure 3. Diagram of flight zones illustrating the most appropriate positions for moving an animal forward (Grandin, 2000c).

Animals with aggressive temperament also result in economic losses to the meat production enterprise due to malicious damaging of the handling facilities, injuries to the beast or handler, and poor quality meat (Gregory, 2008; Muchenje et al., 2009b). Temperament also correlates well with physiological measures of stress such as cortisol concentration and catecholamines (Muchenje et al., 2009a). Animals that are easily stressed are difficult to handle. Genetic variations in temperament among and within breeds are evident. Heritability estimates as high as 61% have been reported (Gauly et al., 2001) such that, selection pressure can be exerted in breeding programmes to improve temperament by selection. There is need to identify and evaluate traits which are correlated with temperament, such as facial hair whorl position in beef animals to aid genetic characterization and improvement (Lanier et al., 2001). Temperament indicators can be easily adopted by resource-limited farmers.

Flight zones and visual fields

The flight zone is the area inside the distance which when a person or any source of danger enters, the animal will maintain it or move away (Albright, 2000; Grandin, 2007). The visual field is the area of the external environment that is visible to the animal at any given position without moving the eyes or turning the head. The flight zone and visual fields define the animal's personal space such that when a person or any source of danger enters it, the animals will move away, but its size will slowly diminish with avoidance of the visual fields by stockman, tameness of the animal or when animal previously received frequent and gentle handling (Grandin, 2000b; Campo et al., 2008).

Knowledge of flight zones and their association with visual fields of cattle are more useful in preventing stress than tameness and animal experience especially during the pre-slaughter period. Figure 3 illustrates the concept of visual field and flight zones during slaughter of animals (Grandin, 2000c). When driving cattle in their visual field, the stockman should stand in the shaded area marked A and B (Figure 3) and approach the animals at the edge of the flight zones while staying out of the blind spot because, deep penetration of flight zone may cause the animal to panic (Grandin, 2000c) and induce undesirable physiological and biochemical changes which may compromise with beef meat quality traits. Application of cattle flight zones and visual fields is more useful in replacing traditional methods employed in developing countries, such as using goads, sticks, dogs and making aggressive threats or willful behaviors to move the animals in a desired direction as well as ululating to the animals during traditional ceremonies (Mnguni, 2006;

Gregory, 2007).

The reaction of the cattle to the presence of a stressor can be explained by the fact that, the animals will be trying to maintain space between them and the external force which they perceive to be dangerous. In other words, deep penetration of flight zones requires total avoidance of visual fields or correct positioning in the field of vision (Grandin, 2000c). The manner in which animals flee can be used to detect the aversiveness of the procedure, temperament of the animals and easiness of subsequent handling as well as the welfare through assessment of flight speed (FS) and flight time (FT) (Campo et al., 2008). Flight speed is the rate of change of distance covered per unit time by an animal as it maintains its flight zone. It can be generalized through ranking scale such as: 1, Walked; 2, trotted; 3, ran (Campo et al., 2008). Petherick et al. (2002) reported that, animals with faster and slower FS have “poorer” temperament and “good” temperament, respectively. Furthermore, high FS indicates cruelty of the welfare method used in handling the animal. Flight time refers to the time period it takes an animal to cover a fixed distance (5 m) after release from a restraining device (Campo et al., 2009); or when maintaining flight distance, prolonged durations indicate aggressiveness of welfare procedure.

Flight speed is positively correlated to weight gain (Fordyce and Goddard, 1984). For example, *B. indicus* cattle with faster FS had lower ADG and feed conversion efficiencies than those with slower FS (Petherick et al., 2002). Since temperament determines ultimate pH, tenderness and color (Muchenje et al., 2009a), it can be postulated therefore, that animals with slow FS are likely to produce meat which is uniformly colored, tender and having low pH. Information on flight zones and visual fields of the Tuli, Nguni and Mashona cattle and their associations with meat quality, is lacking. Such information is important in improving or designing preslaughter handling facilities because cattle’s visual pers-pective should be a primary consideration such that the animal’s view of the handler should be blocked by opaque sides to calm them. Conditions in small scale abattoirs in the developing world are harsh mostly due to inadequate space, shortage of skilled personnel and inappropriate handling designs which do not fulfill recommended welfare standards such as blocking the visual fields and manipulation of the visual fields. Some animals which perceive danger by sight may stand still or indicate discomfort through vocalizing.

Vocalization scoring

Warris et al. (1994) reported that, vocalizations are noticeably correlated with physiological measures of stress in pigs. In cattle, vocalization scorings of mooing and bellowing are one of the most obvious if not potential welfare indicators of animals facing difficulties in coping with welfare procedures (Grandin, 1998; 2001). However, unlike some other social species which collaborate when caught or hurt, cattle can relatively be undemonstrative through vocalizations when hurt or severely disturbed (Broom, 2000). Thus, any vocal scoring during cattle handling is an obvious indicator of harshness of handling procedures used. The critical limit of vocalization scoring ranges from 3 to 5% for most well run slaughter plants and is compiled on a yes/no scoring on a per animal basis (Grandin, 1998, 2007; Gregory, 2007).

Responses due to vocalizations provide more information about an animal's experience and a more convenient and less expensive way to determine than other physiological or biochemical measures, such as heart rate and cortisol levels, that are commonly employed as indicators of pain or distress. Furthermore, such measures are less effective than vocal scorings because they fluctuate when animals are excited but with vocalizations pitch, one can distinguish between pain and pleasure. Grandin (2006) reported that, percentage vocalization scoring during handling and stunning in the year 1996, 1999 and 2003 decreased from 8, 2.4 and 2, respectively. Such welfare audits can be used to assess the improvement of handling in smallholder farms, ceremonies or abattoirs for they are cheap and easy to compile. In certain traditions, if an animal vocalizes, you are not supposed to slaughter it. This in a way, encourages handling animals with minimal stress.

Quantitative observations as indicators of animal welfare

Quantitative observations and analysis of production aspects, such as average daily gain, bruises, broken limbs, loading densities, stocking densities, feed conversion efficiency, carcass and meat quality attributes, mortalities and body condition scoring provide a way of assessing welfare (Ortiz-Pelaez et al., 2007; Gregory, 2007). Most of these quantitative measurements are influenced by on-farm management practices, such as feeding, health and breeding management. Therefore, in assessment of animal welfare, it is important to combine all biological components including the health aspect, implying that, proper nutrition on its own does fully optimize animal well being. However where resources are limited, assessing indicators such as daily gain and feed conversion efficiency is difficult. Indicators such as broken limbs, stocking densities and condition scores can be used.

Mortality rates

Mortality rates are useful tools in assessing poor welfare associated with disease and lack of care in farm animals

Table 1. Mortality rates that might be tolerated in industrialized nations before concerns are raised about the welfare of the animals or profitability of the enterprise.

Class of stock or situation	Mortality rate (%)
Calves raised of milk replacer	10
Feedlot cattle	4
Fat cattle transported for slaughter	0.005
Breeding cattle-ranching system	4

(Gregory, 2007).

(Gregory, 2007), especially during transportation and in calves during their first 6 months of life (Ortiz-Pelaez et al., 2007). In most cases, mortalities during handling and transport are usually preceded by a period of poor welfare due to failure of the physiological activities to cope or withstand external or internal challenges. Poor and prolonged cattle transportation using vehicles on gravel roads or on hoof, especially when it is hot, could cause high mortalities before slaughter in most under-developed countries. In the case of vehicle transportation, mortalities can be caused by the accretion of exhausts fumes and road dust in respiratory tract with subsequent poisoning. This poisoning combined with inadequate escape of gaseous exchange, especially on stationary vehicles, can then be large enough to cause the animal to faint or even die from suffocation before even getting to the slaughterhouse (Berg, 2001).

Mortalities impose negative implications on the economy of the farm because they result in delayed breeding, reduction in number of offspring, losses when carcasses are disposed at arrival at the abattoir (Broom and Fraser, 1997) and they also reduce selection intensities. Analysis of mortality records are not important in investigating the severity of the welfare methods only but if combined in different regions, they can provide useful information for national mortality statistics, economic impact and disease surveillance and control (Ortiz-Pelaez et al., 2007). Unfortunately, records or estimates of livestock mortality rates in developing countries are lacking but a study of traditional cattle herds in Ethiopia reported mortality rates from diseases of 24 months of age to be 19% (Donaldson, 1996). Calf mortalities in communal production systems, though not well documented and quantified, are unacceptably high mainly due to the inevitable competition between the household and the calf for milk and colostrums (Roderick et al., 1999; Gregory, 2007). The situation is exacerbated in small herds which are characteristic of most smallholder farmers than in large herds especially when cows are also used for draught work during the ploughing season (Chimonyo et al., 2002).

Farmers in developing countries are encouraged to keep records of deaths during handling procedures or in cases of disease outbreaks. Record keeping, eventually opens a way for diagnosis and correction of where the welfare of animals is suboptimal. Gregory (2007) proposed mortality rates which when exceeded, will be cause for concern amongst stock owners (Table 1). When incidences of deaths increase beyond the acceptable levels, their causes which are likely to indicate poor welfare to the animals should be investigated.

Bruises or body damages

Occurrence of bruises, broken limbs or footpad lesions are sources of pain and have negative impact on animal welfare as well as on the quality of beef (Gregory, 2007; Strappini et al., 2009). The thickness of bovine skin makes it difficult for bruises to be seen during the ante-mortem period but their presence, position and age can be detected successfully in the carcasses (Strappini et al., 2009). Whilst the presence of bruises indicates aversiveness of the welfare procedure, age and position of the bruises provide information on when and where the welfare is suboptimal.

Bruising and foot pad lesions common in cattle in communal production systems results in lameness, wounds, reluctance to eat and drink, thereby increasing the risk of acquiring infectious diseases (Gregory, 2007) and subsequently reducing the available meat due to high mortality rates and trimming off of affected meat portions. In cattle, bruises result due to lack handling facilities, use of whips and sticks as well as poor restraining of draught animals or during routine husbandry (Ramaswamy, 1998; Gregory, 2007). In addition, bruising reduces the economic value of the meat (Grandin, 2000b). Reducing bruising improves animal welfare, so livestock handlers need to use and understand principles of cattle handling, such as visual fields, flight zones and their point of balance, flock instincts and loading densities. Most bruises can be prevented by careful, quiet handling, dehorning of calves, fixing broken equipment and shunning traditional customs of handling animals, such as animal abuse (aggression, assertion and intimidation) (Lott and Hart, 1977), inappropriate restraint and confinement and routine husbandry procedures (Mnguni, 2006; Gregory, 2007).

Loading densities

Among other regulations for beef cattle transportation, the amount of space provided for animals is one of the most important aspects influencing animal welfare (Broom and Fraser, 2007). High or low loading densities, such as 600 and 200 kg/m^2, increases the bruising scores (Tarrant et al., 1988). In communal production systems in the developing world, high loading densities are likely to result, due to shortage of vehicles. Carcass bruise score are elevated above basal levels with increase in loading densities, as illustrated in Table 2. Animals with reduced capacity to withstand the rigors of

Table 2. The effect of stocking density during 24 h road journeys on plasma constituents and carcass bruises in Friesian steers.

Plasma constituents	Stocking density		
	Low	Medium	High
Plasma cortisol (ng ml^{-1})	0.1	0.5	1.1
Plasma glucose (mmol l^{-1})	0.81	0.93	1.12
Plasma creatinine kinase (units l^{-1})	132	234	367
Carcass bruise score	3.7	5.0	8.5

Values for plasma cortisol, glucose and CK are the difference between the pre- and post-transport values (Tarrant et al., 1992).

Table 3. Consumable feed production and sustainable stocking rates in different agro-ecological zones of Africa.

Zone	Consumable feed (t dry matter per ha)	Estimated sustainable stocking rates (TLU per km^2)
Arid	0.19	8
Semi-arid	0.51	22
Sub humid	0.72	31
Highland	0.76	33

(Gregory, 2007)

transport, such as aggressive breeds extensively reared and horned animals should be provided with segregated space sufficient for the animal to lie down in a normal position.

Stocking density

Stocking density refers to the number of animals per unit area of land over a given point in time. Most small-scale farmers in developing countries raise their livestock under natural grazing in rangelands which are poorly managed (Muchenje et al., 2008b; Mapiye et al., 2009a). Although circumstantial, there is strong evidence that overstocking is the main cause of desertification and land degradation in the developing world, resulting in reduced carrying capacity due to deterioration of rangelands (Dean and Macdonald, 1994; Gregory, 2007; Mapiye et al., 2009a). The risk of erosion is intensified by landlessness (de Harn, 1995), loss of rangeland diversity and reduction in vegetation cover, eventually leading to increased risks of animal welfare due to poor feeding and this depends on the grazing management employed especially stocking density (Gregory, 2007). To counter for proper welfare of cattle, the sustainable stocking rate should not exceed the observed stocking rate. Table 3 illustrates the estimated carrying capacities for different agro-ecological zones in Africa.

In Africa, such animal welfare hazards can be reduced by limiting the number of animals grazing in communal areas (Ezanno et al., 2003; Gregory, 2007), selection of breeds with sound walking ability, small-body framed animals with competing meat quality such as the Nguni cattle breeds (Muchenje et al., 2008a, b, c; 2009c), Mashona, Tuli and Maasai, raising awareness programmes through extension officers and implementing long term grazing management schemes. The Nguni, Mashona and the Tuli in Southern Africa and their crosses graze during hot day periods, whilst some of the large-framed breeds would spend some of their grazing time in shades. Maasai zebu cattle in Kenya walk for up to 16 km per day during grazing under semi-arid conditions (Homewood et al., 1987). Large body-framed breeds will not withstand such grazing distance and the welfare problems can be worsened further in large herds (>100) (Ezanno et al., 2003), especially those which are kraaled at night.

Physiological evaluation of animal welfare

Though cheap, quantitative and behavioral measurements are inadequate to ascertain the welfare of animals in most cases and physiological or biochemical methods should be used to validate overall response (Broom and Fraser, 2007). For example, Campo et al. (2008) suggested that, steers subjected to a high energy composition diet performed better than those on low energy diets, but showed highest levels of acute phase proteins and accurate indicators of stress. Physiological parameters demonstrate aversiveness of welfare because impulse results in the activation of the hypothalamo-adenohypophyseal-adrenocortical axis due to stimulation of the parasympathetic or sympathetic nervous system, which leads to changes in heart rate, respiratory rate, temperature, blood metabolites, electrolytes and hormonal levels and subsequently the quality of the meat. Physiological indicators of stress which are commonly used as stress indicators are shown in Table 4.

Heart rate

Heart rate, in particular tachycardia, and heart rate varia-

Table 4. Commonly used physiological indicators of stress during transport.

Stressor	Physiological variable
Measured in blood	
Food deprivation	↑NEFA, ↑β-OHB, ↓glucose, ↑urea
Dehydration	↑Osmolarity, ↑ total protein, ↑albumin,↑PCV
Physical exertion	↑CK, ↑ lactate
Fear/arosal	↑Cortisol, ↑PCV
Motion sickness	↑ Vasopressin
Other measures	
Fear/arosal and physical exertion	↑ Heart rate, ↑ respiration rate
Hypothemia/hyperthemia	Body temperature, skin temperature

NEFA. Non-esterified free fatty acids; β-OHB, β-hydroybutrate; PCV, packed-cell volume; CK, creatine kinase (Knowles and Warriss, 2000).

bility are associated with the activation of sympathetic-adrenomedullary system (Tarrant and Grandin, 2000) and are other forms of autonomic response that are initiated by acute stressors such as human contact or disturbing situations that need rapid response in farm animals (Broom, 2000). The normal heart rate for resting animals is 76.5 beats per minute. Elridge et al. (1988) showed that, the heart rates of cattle during transportation were 15% above those recorded, while the animals were grazing at pastures. Confinement of animals into the vehicle therefore, had direct effects on the physiological status of the cattle, so there is need for resting the animals after transportation so that they return to their basal levels during the pre-slaughter period. In cattle, heart rate can be used for the assessment of progress or well being of animals especially during situations like intra-specific grooming of young cattle with constant invasion of its flight zones or during transportation. They can also be used to assess animal welfare in animals that are used for draught power (Dube et al., 2000).

Temperature and respiratory rate

Temperature and respiratory rate can be recorded during handling or transportation directly through measurements of rectal temperature and by direct observation, respectively. Martinez et al. (2006) introduced ingestible pills, which can be used to monitor the welfare and health status of cattle under research through records of core temperature. Meat quality is associated with the rate of glycolysis and temperature both in the ante and post mortem conditions. For example, Mounier et al. (2006) revealed that, body temperature above normal for bulls on arrival of the truck at the slaughterhouse was associated with greater pH of the longissimus muscle. Since climatic conditions of most developing countries are characterized by hot sub-tropics, temperature of the animals has to be monitored as a welfare measure, roofed vehicles should be used and transhumance during hot weathers should be avoided at all costs.

Biochemical measurements of animal welfare

Biochemical properties have normal basal levels which fluctuate with differences in the severity of the welfare procedure such that any deviations from normal basal levels indicate that some aspect of the situation is aversive. To optimize the welfare of animals, it is necessary to determine the physiological response in relation to the biochemical changes and products that affect the meat eating quality especially with extensively kept animals (Muchenje et al., 2009a; Ndlovu et al., 2009b). Measurement of metabolites, such as acute phase proteins, hormonal concentrations, blood glucose levels, non-esterified fatty acids (NEFA), urea, meat pH and glycogen concentrations can be used to monitor beef cattle health and welfare status both on the farm and at slaughter (Eckersall, 2000; Chimonyo et al., 2002; Campo et al., 2008). Although, biochemical assessments are more expensive and difficult to apply in resource-limited conditions, they are more accurate indicators of animal welfare than behavioral assessments.

Hormonal levels

Hormones such as cortisol, adrenaline, creatine kinase, dehydrogenase, prolactin, beta-endorphin and glucocorticoid are good indicators of acute stress experienced by animals. These hormones increase substantially when cattle are exposed to various welfare procedures, such as being handled, castrated, feeding, regrouped, transported and receiving veterinary attention (Corkum et al., 1994; Boe and Faerevik, 2003; Muchenje et al., 2009b). Fluctuations of hormonal levels are important indicators of the activity of the parasympathetic and sympathetic nervous systems, because they result from neuronal washout of tissues as the animal tries to cope or respond

Table 5. Urinary catecholamine concentrations of Nguni, Bonsmara and Angus steers as biochemical indicators of steers exposed to pre-slaughter handling, transportation and confinement at an abattoir in South Africa.

Catecholamine	Breed		
	Nguni	Bonsmara	Angus
Nor-epinephrine (nmol/mmol)	4.3	9.7	6.5
Epinephrine (nmol/mmol)	5.1	10.8	6.7
Dopamine (nmol/mmol)	4.0	14.8	7.2

(Muchenje et al., 2009b).

to welfare procedures. Relationships between changes in hormonal concentrations and meat quality traits are quite noticeable (Muchenje et al., 2009b) and these can be used to predict optimum welfare methods suitable for attainment of particular levels that are associated with beef quality which meet consumer demands.

The release of adrenaline and nor-adrenaline due to pre-slaughter stress results in depletion of muscle glycolgen causing increased meat pH, dark meat (Muchenje et al., 2008; 2009b) and mobilization of energy which is further amplified with the increase in glucocorticoids secretions. On the other hand, evidence exist that, dopamine regulates the cortisol secretion (Ahmadzadeh et al., 2006) and glycogen metabolism thereby causing quantifiable effects on tenderness, ageing potential, color and water-holding capacity (Gregory, 2007). Increased heart rates may arise from increased movement and exercise but rough journeys are more stressful than smooth ones, as demonstrated by elevated plasma cortisol (Ruiz-de-la-Torre et al., 2001).

Elevation is the concentrations of catecholamines in urine (Muchenje et al., 2009b, Table 5), saliva and blood (Grandin, 2000b), that can be used as physiological indicators of welfare or stress. Secretion of cortisol is time-dependent taking approximately 15 to 20 min for it to reach peak value (Lay et al., 1998) and 1 h to return to its baseline level (Veissier and Le Neindre, 1988), during this time, dopaminergic mechanisms results in the release of β-endorphin hormone above basal levels (5 ng/ml) (Ladewig and Smidt, 1989). Records on measurements of blood β-endorphin levels are useful as a backup for adrenocorticotropic hormone (ACTH) or cortisol measurement in assessing welfare. A rise in ACTH is often accompanied with a rise in β-endorphin. Moreover, β-endorphin is involved in the regulation of various reproductive hormones. Gregory (2007) suggested that, records of β-endorphin are vital tools to explain the reduction in reproductive performance during poor welfare conditions. Increase in the number of injuries, such as bone breakage, can contribute to metabolic exhaustion and consequently stimulates the release of creatine kinase (CK) (Elrom, 2001) into the blood system. The CK will catalyse the conversion of creatine to phosphocreatine for energy reservoir in tissues as a response to physical stress. This process causes diminished post-mortem lactic acid concentration in the blood system. The glycogen depletion process may start from the first few minutes of confinement, especially to cattle from unsophisticated management such as those of small-scale farmers with different social status and continues during handling and transportation thus causing high post-mortem beef pH (Kannan et al., 2002).

Glycogen and glucose levels

Blood or muscle glycogen concentrations in cattle ranges between 75 and 120 mmol/kg but fluctuate with changes in psychological and physical response (Immonen et al., 2000; Ndlovu et al., 2009b). Muscle glycogen concentrations are the most important factors affecting beef quality at slaughter (Immonen et al., 2000). For example, animals with muscle concentrations that are not within the critical threshold of 45 to 57 mmol/kg will not attain the desired ultimate pH (pHu) of 5.5 to 5.6 in meat (Tarrant et al., 1988; Mounier et al., 2006). It can be suggested that, animals within the normal threshold levels should be slaughtered if desirable meat pH is the target of the producer and this can be achieved by optimization of welfare procedures.

Glycogen concentrations and metabolizable energy intake are correlated. It is therefore suggested that, improvement of nutrition through supplementing with concentrates for 17 days before slaughter as a welfare measure can help prevent depletion of glycogen levels and reduce the effects of stress in raising pH (Immonen et al., 2000; Gregory, 2008) and eventually, preventing dark cutting and poor keeping quality. Glycogen concentrations influence post-mortem glycolytic rate in ovine muscle (Ferguson and Warner, 2008) and possibilities of the same effects are expected in bovine muscles.

Acute phase proteins

Acute phase proteins (APP), is a group of proteins that change in concentration in animals subjected to external and internal challenges, such as infection, trauma, inflammation or stress (Campo et al., 2008), they act as inhibitors or mediators of inflammatory processes. Their

concentrations can be used to assess and monitor the livestock welfare and health status (Eckersall, 2000). For example, measurement of plasma APP has been used as stress indicators during weaning and transportation of calves (Arthington et al., 2005), physically stressed cattle (Alsemgeest et al., 1993) and in nutritional trials (Campo et al., 2008). Once the APP have been assayed, plasma concentrations of acute phase proteins such as ceruloplasmin, fibrinogen (Fb), bovine haptoglobin (Hp) and serum amyloid-A (SAA) in beef animals fluctuate with various welfare procedures such that their identifications are important during meat inspection.

The proposed respective acceptable values of bovine haptoglobin, serum amyloid A and fibrinogen in monitorring the calf health status are Hp: 0.13 g/l, SAA: 25.6 mg/l and Fb: 6.45 g/l (Ganhaim et al., 2003). Although, there is evidence that APP concentrations act as non-specific biosensors of any source of internal or external challenge (Gregory, 2007), there is need to link APP concentration to predict future performance of calves so that unprecedented levels may be monitored through handling and welfare of animals. According to Campo et al. (2008), animals with high APP values also have high pH values (48), indicating that stress plays an important role in the transformation of muscle to meat.

CONCLUSIONS

Animal welfare procedures have aversive result in poor meat quality that may impose negative economic implications on the beef industry due to failure to meet consumer expectations. Creating an environment which minimizes livestock discomfort and enhance their productivity is important. Furthermore, effective animal welfare assessment techniques will help in developing animal husbandry practices that will promote quality animal products from ethically acceptable production systems. Research activities that promote best practices from behavioral, biochemical and physiological assessment techniques are therefore encouraged in the developing world. There is need for research that focuses on addressing issues surrounding animal welfare during production of multipurpose cattle, including ritual slaughter. For successful implementation of the animal welfare awareness programmes, governments in developing countries have to implement schemes to promote well-being during management of livestock.

REFERENCES

Ahmadzadeh A, Barnes MA, Gwazdauskas FC, Akers RM (2006). Dopamine antagonist alters serum cortisol and prolactin secretion in lactating Holstein cows. J. Dairy Sci. 89: 2051-2055.

Aklilu Y (2002). An audit of the livestock marketing status in Kenya, Ethiopia and Sudan. Vol. 1. Nairobi, Kenya: Community-Based Animal Health and Participatory Epidemiology Unit, Pan African Programme for the Control of Epizootics and the Organization of Africa Union/Inter-Africa Bureau for Animal Resources. Available online: http://www.unsudanig.org/darfurjam/trackII/data/cluster/development/An%20Audit. Accessed on 6 July 2009.

Alana A, Corrie G, Laura L, Natalie S, Taunya V (2008). Maasai. Available on: www.nipissingu.ca/faculty/arohap/aphome/NURS3036/Resources/MaasaiPresentation.ppt
Accessed on the 3rd December 2009.

Albright JL (2000). Dairy cattle. In: Grandin T (Ed). Livestock Handling and Transport Livestock, Second edition. CABI Publishing, New York, USA.

Ali BH, Al-Qarawi AA, Mousa HM (2006). Stress associated with road transportation in desert sheep and goats, and the effect of pretreatment with xylazine or sodium betaine. Res. Vet. Sci. 80: 343-348.

Alsemgeest SP, Taverne MA, Boosman R, Van Der Weyden BC, Gruys E (1993). Peripartum acute-phase protein serum amyloid-A concentration in plasma of cows and fetuses. Am. J. Vet. Res. 54: 164-167.

Andersen H, Oksbjerg N, Young J, Therkildsen M (2005). Feeding and meat quality-A future approach. Meat Sci. 70: 543-554.

Arthington JD, Spears JW, Miller DC (2005). The effect of early weaning on feedlot performance and measures of stress in beef calves. J. Anim. Sci. 83: 933-939.

Aschwanden J, Gygax L, Wechsler B, Keil NM (2008). Social distances of goats at the feeding rack: Influence of the quality of social bonds, rank differences, grouping age and presence of horns. Appl. Anim. Behav. Sci. 114: 116-131.

Bech JM, Bennett A, Bouchard R, Condron R, Dabirian S, Dornom H, Erlacher-Vindel E, Jorn H, Laura K, Brian L, Cheryl M, Nitya NP, Jorg S, Girish KS, Girish KMS, Leopold SJ, Gwyneth V (2008). Guide to good animal welfare in dairy production. International Dairy Federation, Brussels, Belgium.

Behrends SM, Miller RK, Rouquette Jr. FM, Randel RD, Warrington BG, Forbes TDA, Welsh TH, Lippke H, Behrends JM, Carstens GE Holloway JW (2009). Relationship of temperaments, growth, carcass characteristics and tenderness in beef steers. Meat Sci. 81: 433-438.

Berg EP (2001). Running Head: Effect of stress on meat yield and quality. Influence of stress on composition and quality of meat, poultry, and meat products. Available online: http://www.fass.org/fass01/pdfs/Berg.pdf. Columbia: Animal Science Research Centre. Accessed June 21, 2008.

Boe KE, Faerevik G (2003). Grouping and social preferences in calves, heifers and cows. Appl. Anim. Behav. Sci. 80: p. 175.

Broom DM (2000). Welfare assessment and welfare problem areas during handling and transport. In: Grandin T (Ed). Livestock Handling and Transport Livestock, Second edition. CABI Publishing, New York, pp. 43-61.

Broom DM, Fraser AF (2007). Domestic Animal Behaviour and Welfare, CAB International, Wallingford, pp. 180-207.

Calhim S, Shi J, Dunbar RIM (2006). Sexual aggression among feral goats: testing between alternative hypotheses. Anim. Behav. 72: 31-41.

Campo M, Soares de Lima JM, Brito G, Manteca X, Hernandez P, Sanudo C, Montossi F (2008). Effect of different feeding strategies on animal welfare and meat quality in Uruguayan steers. In: Proceedings of the 54th International Congress of Meat Science and Technology held at Cape Town, South Africa.

Chambers PG, Grandin T, Heinz G, Srisuvan T (2001). Guidelines for human handling, transport and slaughter of livestock. Food and Agriculture Organisation (FAO) Publishers, Thailand.

Chawatama S, Ndlovu LR, Richardson FD, Mhlanga F, Dzama KA (2003). A simulation model of draught animal power in smallholder farming systems. Part I: Context and structural overview. Agric. Syst. 76: 415-440.

Chimonyo M, Kusina NT, Hamudikuwanda H, Ncube I (2002). Changes in stress-related plasma metabolite concentrations in working Mashona cows on dietary supplementation. Livest. Prod. Sci. 73: 165-173.

Corkum MJ, Bate LA, Tennessen T, Lirette A (1994). Consequences of reduction of number of individual feeders on feeding behaviour and

stress level of feedlot steers. Appl. Anim. Behav. Sci. 41: 27-35.
Dean WRJ, Macdonald IAW (1994). Historical changes in stocking rates of domestic livestock as a measure of semi-arid and arid rangeland degradation in the Cape Province, South Africa. J. Arid Environ. 26: 281-298.
De Harn C (1995). Development support and livestock services. In Wilson RT, Ehui S and Mack S (eds) Livestock development strategies for low income countries.FAO, Rome, Italy, pp. 23-27.
Donaldson KN (1986). Pastoralism and drought. A case study of the Borana of southern Ethiopia. MPhil thesis, University of reading, UK.
Dube S (2008). Communal rangelands of Eastern Cape Province: Is there interaction between resource users, science and policy? A case study in South Africa. In: Emergent practice of Adaptive collaborative Management in natural resources management in Southern Africa: Eight case studies. Wageningen International, Wageningen University and Research Centre, Netherlands.
Dube Z, Ndlovu LR, Muchenje V (2000). The Potential of single-hitched donkeys (*Equuas asinus*) in cultivation tasks in Zimbabwe. J. Appl. Sci. S. Afr. 6: 45-54.
Dwyer CM (2009). Welfare of sheep: Providing for welfare in an extensive environment. Small Rumin. Res. 86: 14-21.
Eckersall PD (2000). Recent advances and future prospects for the use of acute phase proteins as markers of disease in animals. Rev. Med. Vet. 151: 577-584.
Elridge GA, Winfield CG, Cahill DJ (1988). Responses to cattle to different space allowances, pen sizes and road conditions during transportation. Aust. J. Exp. Agric. 28: 155-159.
Elrom K (2001). Review: Handling and Transportation of Broilers Welfare, Stress, Fear and Meat Quality. Part VI: The consequences of handling and transportation of chickens (*Gallus gallus domesticus*). Isr. J. Vet. Med. p. 56.
Ezanno P, Ickowicz A, Bocquier F (2003). Factors affecting the body condition score of N'Dama cows under extensive range management in Southern Senegal. Anim. Res. 52:37-48.
Ferguson DM, Warner RD (2008). Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? Meat Sci. 80:12-19.
Fitzpatrick J, Scott M, Nolan A (2006). Assessment of pain and welfare in sheep. Small Rumin. Res. 62: 55-61.
Fordyce G, Goddard ME (1984). Maternal influence on the temperament of Bos indicus cross cows. In: Proc. Aust. Soc. Anim. Prod. pp. 345-348.
Fratkin E (2001). East African pastoralism in transition: Maasai, Boran, and Rendille cases. Afr. Stud. Rev. 44: 1-25.
Gauly M, Mathjak H, Hoffman K, Kraus M, Erhardt G (2001). Estimating genetic variability in tempermental traits in German Angus and Simmental cattle. Appl. Anim. Behav. Sci. 74: 109-119.
Grandin T (1993). Behavioural acclimation during handling of cattle is persistent over time. Appl. Anim. Behav. Sci. 36: 1-9.
Grandin T (1998). The feasibility of vocalization scoring as an indicator of poor welfare during slaughter. Appl. Anim. Behav. Sci. 56: 121-128.
Grandin T (2000a). Handling facilities and restraint of range cattle. In: Grandin T (Ed). Livestock Handling and Transport Livestock, Second edition. CABI Publishing, New York, pp. 103-125.
Grandin T (2000b). Handling and Welfare of livestock in slaughter plants. In: Grandin T (Ed). Livestock Handling and Transport, CABI Publishing, New York, pp. 409-439.
Grandin T (2000c). Behavioural principles of handling cattle and other grazing animals under extensive conditions. In: Grandin T (Ed). Livestock Handling and Transport, CABI Publishing, New York, pp. 63-85.
Grandin T (2001). Cattle vocalizations are associated with handling and equipment problems at beef slaughter plants. Appl. Anim. Behav. Sci. 71: 191-201.
Grandin T (2006). Progress and challenges in animal handling and slaughter in the US. Appl. Anim. Behav. Sci. 100: 129-139.
Grandin T (2007). Introduction: effect of customer requirements, international standards and marketing system structure on the handling and transport of livestock and poultry. In: Grandin T (ed). Livestock Handling and Transport, 3rd edn. CAB International, Wallingford, UK.
Gregory NG (1998). Animal welfare and meat science. CAB International, Wallingford, Oxfordshire, UK, p. 298.
Gregory NG (2005). Recent concerns about stunning and slaughter. Meat Sci. 70: 481-491.
Gregory NG (2007). Animal Welfare and Meat Production, second ed. CAB International, Wallingford, UK.
Gregory NG (2008). Animal welfare at markets and during transport and slaughter. Meat Sci. 80: 2-11.
Homewood K, Rodgers WA, Arhem K (1987). Ecology of pastoralism in Ngorongoro Conservation area, Tanzania. J. Agric. Sci. 108: 47-72.
Immonen K, Ruusunen M, Hissa K, Puolanne E (2000). *Bovine* muscle glycogen concentration in relation to finishing diet, slaughter and ultimate pH. Meat Sci. 55: 25-31.
James B, Hazel B (2007). Rangeland as a common property resource: Contrasting insights from communal areas of Eastern Cape Province, South Africa. Hum. Ecol. 35: 97-112.
Kannan CB, Chawan CB, Kouakou B, Gelaye B (2002). Influence of packaging method and storage time on shear value and mechanical strength of intramuscular connective tissue of chevon. J. Anim. Sci. 80: 2383-2389.
Knowles TG, Warriss PD (2000). Stress physiology of animals during transport. In: Grandin T, ed. Livestock Handling and Transport. 2nd ed. Cambridge, MA: CABI Publishing. pp. 385-407.
Kuzmanvic Z, Elabjer I (2000). Influence of preslaughter resting time on bulls on meat temperature, colour and pH value. Czech J. Anim. Sci. 45: 511-518.
Ladewig J, Smidt D (1989). Behaviour, episodic secretion of cortisol and adrenocortical reactivity in bulls subjected to tethering. Horm. Behav. 23: 344-360.
Lammens V, Peeters E, De Maere H, De Mey E, Paelinck H, Leyten J, Geers R (2007). A survey of pork quality in relation to pre-slaughter conditions, slaughterhouse facilities, and quality assurance. Meat Sci. 74: 381-387.
Lanier JL, Grandin T, Green R, Avery D, McGee K (2001). A note on hair whorl position and cattle temperament in the auction ring. Appl. Anim. Behav. Sci. 73: 93-101.
Lay Jr. DC, Friend TH, Randel RD, Bowers CL, Grissom KK, Nevendorff DA, Jenkins OC (1998). Effects of restrictive nursing on physiological and behavioural reactions of Brahman calves to subsequent restraint and nursing. Appl. Anim. Behav. Sci. 56: 109-119.
Lawrie RA, Ledward DA (2006). Lawrie's Meat Science. 7th ed. Woodhead Publishing, Cambridge, England.
Lott DF, Hart BL (1977). Aggressive domination of cattle by Fulani herdsmen and its relation to aggression in Fulani culture and personality. Ethos, 5: 174-186.
Mahlangu D (2009). ANC joins row over bull-killing ritual. TimeLIVE. Available online http://www.timeslive.co.za/news/article218055.ece. Accessed on 6 December 2009.
Mapiye C, Chimonyo M, Dzama K (2009a). Seasonal dyanamics, production potential and efficiency of cattle in the sweet and sour communal rangelands in South Africa. J. Arid Environ. 73: 529-536.
Mapiye C, Chimonyo M, Dzama K, Raats JG, Mapekula M (2009b). Opportunities for improving Nguni cattle production in the smallholder farming systems of South Africa. Livest. Sci. 124:196-204.
Maria GA, Villarroel M, Sanudo C, Olleta JL, Gebresenbet G (2003). Effects of transport time and ageing on aspects of beef quality. Meat Sci. 65: 1335-1340.
Martinez A, Schoenig S, Andresen D, Warren S (2006). Ingestible pill for heart rate and core temperature measurement in cattle. In: Proc. Annu. Int. Conf. of the IEEE Eng. Med. Biol. Soc. pp. 3190-3193
Minka NS, Ayo JO (2007). Effects of loading behaviour and road transport stress on traumatic injuries in cattle transported by road during the hot-dry season. Livest. Sci. 107: 91-95.
Mnguni ME (2006). An investigation into the commercial and the Zulu traditional modes of slaughtering, butchering, culinary properties and service with special reference to socioculturasl ritual behaviors in KwaZuluNatal. Available on http://ir.dut.ac.za/bitstream/handle/10321/77/Mnguni_2006.pdf?sequence=40. Accessed on the 6 December 2009.
Mounier L, Dubroeucq H, Andanson S, Veissier I (2006). Variations in meat pH of beef bulls in relation to conditions of transfer to slaughter

and previous history of the animals. J. Anim. Sci. 84: 1567-1576.
Moyo B, Masika PJ (2009). Tick control methods used by resource-limited farmers and the effect of ticks on cattle in rural areas of the Eastern Cape Province, South Africa. Trop. Anim. Health Prod. 41: 517-523.
Muchenje V, Dzama K, Chimonyo M, Raats JG, Strydom PE (2008a). Tick susceptibility and its effects on growth performance and carcass characteristics of Nguni, Bonsmara and Angus steers raised on natural pasture. Animal, 2: 298-304.
Muchenje V, Dzama K, Chimonyo M, Raats JG, Strydom PE (2008b). Meat quality of Nguni, Bonsmara and Angus steers raised on natural pasture in the Eastern Cape, South Africa. Meat Sci. 79: 20-28.
Muchenje V, Dzama K, Chimonyo M, Strydom PE, Hugo A, Raats JG (2008c). Sensory evaluation and its relationship with physical meat characteristics of beef from Nguni and Bonsmara steers raised on natural pasture. Animal, 2: 1700-1706.
Muchenje V, Dzama K, Chimonyo M, Strydom PE, Hugo A, Raats JG (2009a). Some biochemical aspects pertaining to beef eating quality and consumer health: a review. Food Chem. 112: 279-289.
Muchenje V, Dzama K, Chimonyo M, Strydom PE, Raats JG (2009b). Relationship between pre-slaughter stress responsiveness and beef quality in three cattle breeds. Meat Sci. 81: 653-657.
Muchenje V, Hugo A, Dzama K, Chimonyo M, Raats JG, Strydom PE (2009c). Cholesterol levels and fatty acid profiles of beef from three cattle breeds raised on natural pasture. J. Food Comp. Anal. 22: 354-358.
Munksgaard L, DePassille AM, Rushen J, Herskin MS, Kristensen AM (2001). Dairy cows'fear of people:social learning, milk yield and behaviour at milking. Appl. Anim. Behav. Sci. 73: 15-26.
Napolitano F, Cifuni GF, Pacelli C, Riviezzi AM, Girolami A (2002). Effect of artificial rearing on lamb welfare and meat quality. Meat Sci. 60: 307-315.
Ndlovu T, Chimonyo M, Muchenje V (2009a). Monthly changes in body condition scores and internal parasite prevalence in Nguni, Bonsmara and Angus steers raised on sweetveld. Trop. Anim. Health Prod. 41: 1169-1177.
Ndlovu T, Chimonyo M, Okor AI, Muchenje V, Dzama K, Dube S, Raats JG (2009b). A comparison of nutritionally-related blood metabolites among Nguni, Bonsmara and Angus steers raised on sweetveld. Vet. J. 179: 273-281.
Novak P, Vokralova J, Kunc P (2004). Welfare conditions of dairy cows from the point of performance efficiency. Research Institution of Animal Production Prague, Czech Republic.
Ortiz-Pelaez A, Pritchard DG, Pfeiffer DU, Jones E, Honeyman P, Mawdsley JJ (2007). Calf mortality as a welfare indicator on British cattle farms. Vet. J. 176:177-181.
Petherick JC, Holroyd RG, Doogan VJ, Venus BK (2002). Productivity, carcass and meat quality of lot-fed *Bos indicus* cross steers grouped according to temperament. Aust. J. Exp. Agric. 42: 389-398.
Ramaswamy NS (1998). Draught animal welfare. Appl. Anim. Behav. Sci. 59: 73-84.
Roderick S, Steveson P, Ndungu J (1999). The production parameters influencing the composition and structure of pastoral cattle herds in a semi-arid area of Kenya. Anim. Sci. 68: 201-209.
Ruiz-de-la-Torre JL, Velarde A, Diestre A, Gispert M, Hall SJG, Broom DM, Manteca X (2001). Effects of vehicle movements during transport on the stress responses and meat quality of sheep. Vet. Res. 148: 227-229.
SAPA (2009). Judgment on Zulu bull killing expected Friday. News. South Africa. In Time LIVE. Available on http://www.timeslive.co.za/news/local/article216261.ece. Accessed on 3 December 2009.
Silva JA, Patarata L, Martins C (1999). Influence of ultimate pH on bovine meat tenderness during ageing. Meat Sci. 52: 453-459.
Smith DG, Pearson RA (2005). A review of the factors affecting survival of donkeys in Semi-arid regions of Sub-Saharan Africa. Trop. Anim. Health Prod. 37: 1-19.
Smith GC, Pendell D L, Tatum JD, Belk KE, Sofos JN (2008). Post-slaughter traceability-review. Meat Sci. 80: 66-74.
Strappini AC, Metz JHM, Gallo CB, Kemp B (2009). Origin and assessment of bruises in beef cattle at slaughter. Animal, 3: 728-736.
Tarrant V, Grandin T (2000). Cattle transport. In: Grandin T (ed). Livestock Handling and Transport Livestock, Second edition, CABI Publishing, New York, USA.
Tarrant PV, Kenny FJ, Harrington D (1988). The effect of stocking density during 4h transport to slaughter on behaviour, blood constituents and carcass bruising in Friesian steers. Meat Sci. 24: 209-222.
Tarrant PV, Kenny FJ, Harrington D, Murphy M (1992). Long distance transportation of steers to slaughter: effect of stocking density on physiology, behaviour and carcass quality. Livest. Prod. Sci. 30: 223-238.
The Citizen 2009. Bull killing saga won't end after Friday judgment: expert. News. South Africa. Available on http://www.thecitizen.co.za/index/home.aspx?pDesc=2,1,27. Accessed on 4 December 2009.
Veissier I, Le Neindre P (1988). Cortisol responses to physical and pharmacological stimuli in heifers. Reprod. Nutri. Dev. 28: 553-562.
Vessier I, Butherworth A, Bock B, Roe E (2008). European approaches to ensure good animal welfare. Appl. Anim. Behav. Sci. 113: 279-297.
Voisinet BD, Grandin T, Tatum TD, O'Connor SF, Struthers JJ (1997a). Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. J. Anim. Sci. 75: 892-896.
Voisinet BD, Grandin T, Tatum TD, O'Connor SF, Tatum JD, Deesing MJ (1997b). *Bos indicus-cross* feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Meat Sci. 46: 367-377.
Warris PD (1990). The handling of cattle pre-slaughter and its effects on carcass and meat quality. Appl. Anim. Behav. Sci. 28: 171-186.
Warris PD, Brown SN, Adams SJM (1994). Relationship between subjective and objective assessment of stress at slaughter and meat quality in pigs. Meat Sci. 38: 329-135.
West JW, Mullinix BG, Bernard JK (2003). Effects of hot, humid weather on milk temperature dry matter intake, and milk yields of lactating dairy cows. J. Dairy Sci. 86: 232-242.