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## Research on pre-slaughter stress and meat quality: A review of challenges faced under practical conditions

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### Abstract

Transportation and handling of animals are important components in meat production systems. Animals destined for slaughter are stressed by factors such as loading, transportation, restraint, handling, and novelty of the slaughter environment, adverse weather conditions, hunger, thirst and fatigue. When an animal is stressed in the pre-slaughter environment, there is a rapid release of enzymes, cortisol and catecholamines which may lead to depletion of glycogen, high meat ultimate pH (pH<sub>u</sub>) and dark cuts. Pre-slaughter stress also affects the physiology of the animal resulting in an increase in creatine kinase (CK) activity, glucose, lactate and other blood metabolites. Pre-slaughter stress and meat quality is a wide topic and some research have been done albeit was conducted under experimental and controlled conditions. In real life situations many variables are not controlled. Data collection in practical conditions is complex because it is difficult to accurately take some of the measurements; for example the onset of the release of the enzymes and hormones. Moreover, there are difficulties in taking measurements from slaughterhouses and butcheries. Challenges that researchers, marketers and consumers face under practical conditions either on-farm, research stations, transfer centres, slaughter plants, abattoirs or butcheries; with regard to pre-slaughter stress and meat quality may affect the quality of the final products developed under such conditions. This review therefore aims to give a detailed outline on pre-slaughter stress, meat science research and challenges under practical conditions.

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**Keywords:** Abattoirs, animal behaviour, animal welfare, meat industry, meat science, practical conditions, pre-slaughter stress

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### Introduction

Most animals such as cattle are transported at least once in their lifespan; from the source/farm to auction centres or abattoirs. Through the processes of rounding up, kraaling, loading, transporting and off-loading cattle at the abattoir, there are animal welfare compromises. Fear of either the handling procedures and novelty of the environment makes the animal feel pain (Villarreal *et al.*, 2003; Grandin, 2006; Ohl & van der Staay, 2012). Stress experienced during routine handling and restraint procedures reduces productivity and efficiency (Dodzi & Muchenje, 2011). Apart from causing poor meat quality and economic losses, stress has negative implications on animal welfare (Hemsworth *et al.*, 2011). Although animal welfare and meat quality has become a critical issue in the meat industry, not much research has been carried out under practical conditions. Animal welfare in relation to road transportation has received much attention in terms of experimental research (Stockman *et al.*, 2013). The effects of road transportation on animal welfare are difficult to monitor and validate under practical conditions because of differences in speed limits, terrain of the road and stoppages within the process. This is one major problem among the challenges that exist when conducting research on-farm, transfer centres, slaughter plants/abattoirs, animal markets, and butcheries.

Several studies that include pre-slaughter stress (Muchenje *et al.*, 2009; Miranda-de la Lama *et al.*, 2009, 2010), meat quality (Muchenje *et al.*, 2008a), consumer perception (Muchenje *et al.*, 2008b; Dyubele *et al.*, 2010; Chulayo *et al.*, 2011; Ngambu *et al.*, 2011; Xazela *et al.*, 2011), animal behaviour at pastures (Dodzi & Muchenje, 2011; Kilgour, 2012) and the effect of supplementation on meat quality (Marume *et al.*, 2012; Xazela *et al.*, 2012) have been conducted under experimental conditions. Countries like Latin America, Japan, USA and South Korea have examined pre-slaughter stress taking into account the incidence

it has on bruising and poor meat quality due to adverse handling during transportation of animals and behaviour at lairages. Although this topic has received limited attention in South Africa, few studies (Chulayo, 2011; Gajana, 2011; Vimiso & Muchenje, 2012) have addressed pre-slaughter stress and meat quality under practical conditions. These authors have realised that there are several challenges with community-based or industry-based research such as difficulties with data collection, small sample sizes, reliability of data collected and in some cases non-cooperation by stakeholders. This mini-review therefore focuses on outlining challenges found when assessing pre-slaughter stress and meat science research under practical conditions.

## Discussion

### *Animal welfare and pre-slaughter stress*

Animal welfare stresses ranges from physical (high ambient temperature, vibration and changes in acceleration, confinement, noise and crowding) to psychological (breakdown of social groupings and mixing with unfamiliar animals, unfamiliar or noxious smells and novel environment) during pre-slaughter handling. During this period, animals are prone to weight loss, produce poor meat quality and considerably reduced profit for the producer (Adzitey, 2011). Although much progress has been made in developing new indices of animal welfare, no single measure can be used alone. Several measures that include the behaviour of animals at the abattoir (Table 1), biochemical and physiological measurements may be used. There is a need to integrate these measures so as to come up with better results and recommendations for improved animal welfare (Dawkins, 2006; Bourguet *et al.*, 2011).

Animal behaviour refers to the scientific study of everything animals do, whether they are single-celled organisms, invertebrates, fish, amphibians, reptiles, birds, or mammals (Bourguet *et al.*, 2011). It involves investigating the relationship of the animals with their physical environment as well as with other organisms such as their interaction with humans. The assessment of animal behaviour is still a highly debated issue in domestic animals as is the case with behavioural indicators in response to fear or pain during pre-slaughter. Poor environmental conditions may lead to stress that can be exhibited in the form of abnormal behaviour. Animals that are experiencing pain, fear, discomfort, thirst and hunger in a certain environment exhibit abnormal behaviour (Dodzi & Muchenje, 2011). A combination of both behavioural and physiological measures has been used to assess animal welfare (Broom, 1991).

Individuals of the same species; same breed and reared under the same conditions show a wide variability in behaviour (Miranda-de la Lama *et al.*, 2011). Studies have shown that cattle and sheep react to stressful settings (e.g. at the abattoir) with increased concentrations of catecholamines and creatine kinase activity (Muchenje *et al.*, 2009; Chulayo, 2011). Release of these hormones and enzymes adversely affect meat quality due to rapid glycolysis and increased lactate production, resulting in elevated blood lactate (Lewis *et al.*, 2006). Stress causes changes in the immune system mainly due to physiological changes (Ekiz *et al.*, 2012). Such changes include increased heart rate, respiratory rate and temperature. Stress in pigs activates the hypothalamic pituitary-adrenal axis causing release glucocorticoids into the blood stream (Lewis *et al.*, 2006). In general, an increase in physiological stress or physical activity in farm animals during pre-slaughter handling leads to depletion of muscle glycogen reserves, which may result in a higher ultimate meat pH, greater water holding capacity, darker meat colour and tougher meat (Muchenje *et al.*, 2009; Ekiz *et al.*, 2012). However, animals that are accustomed to humans at an early stage of their life exhibit less fear towards the latter and stress-related behaviours at the abattoir. Conducting research on pre-slaughter stress and meat quality under real life conditions may help in implementing easier technologies and practices/procedures that enhance good welfare of animals and meat quality. However, conducting studies under such conditions is quite challenging.

### *Challenges of pre-slaughter stress and meat science research under practical conditions*

There are several challenges that may negatively impact the quality of research conducted under practical conditions such as abattoirs. These challenges include locating a convenient study site, transport arrangements, small sample sizes in some cases, problems with blood sample collections, preservation and

**Table 1** Presentation of the general behaviour observed at the abattoir and in various sections within the slaughter floor

<b>Variable</b>	<b>Description</b>	<b>Stage</b>
<b><i>Behavioural reactions</i></b>		
Slipping (no of times)	At least one leg skidding	Unloading, Traceability corridor, Slaughter corridors
Falling (no of times)	At least one knee on the floor	Unloading, Traceability, corridor, Slaughter corridors
Vocalisation (no of times)	Intentional vocalisations (excludes gasps, sighs and groans)	Unloading, Traceability corridor, Slaughter corridors, Restraining boxes
Compression (no of times and no of scans)	Animal having a curved back because it is lacking space between two other animals or between 1 animal and a barrier or wall	Slaughter corridors
Backward movements (no of times)	Making 1 or more steps backwards	Slaughter corridors, Stunning box
Bumping into rear door (no of times)	Bumping into the rear door of the stunning box when walking backwards	Stunning box
Head lifting (no of times)	Upwards movement of the head	Stunning box
Kicks (no of times)	Kicks given in the rotary box	Rotary box
Head rising (no of times)	Upward movement of the head due to increased neck tension	On the slaughter line
<b><i>Slaughter procedure</i></b>		
Time spent in the abattoir (h)	Delay between unloading and bleeding	Abattoir
Transport duration (min)	Delay between departure from the exploitation and arrival at the abattoir	Transport
Unloading duration (min)	Delay between the first and the last animal getting of the lorry	Unloading
Time spent in the traceability corridor (s)	Delay between the entering and exiting the traceability corridor	Traceability corridor
Time spent in the slaughter corridor (min)	Delay between the entering and exiting the halal or the conventional slaughter corridor	Slaughter corridor
Delay until stunning (s)	Delay between the entrance into the stunning box and the last shot	Stunning box
Delay until inversion of the rotary box (s)	Delay between the entrance into the rotary box and the beginning of the inversion of the rotary box	Rotary box
Delay until bleeding (s)	Delay between the entrance into the restraining box and the beginning of the bleeding	Restraining boxes (stunning or rotary box)

Source: (Bourguet *et al.*, 2011).

analysis, urine and meat specimen collections and the reliability of data since experimental unit measurements may be highly variable (Engstrom *et al.*, 2010). Data collection under practical conditions is complex because of the difficulty of accurately taking some of the measurements; for example, the onset of the release of the enzymes and hormones. In addition, taking measurements from slaughterhouses and butcheries is often difficult to accomplish. A lot of effort and diplomacy is required to convince the abattoir personnel, farmers and butchery managers to allow researchers to use the premises and other available resources.

Involving abattoir personnel, farmers and butchery managers in research activities such as collection of blood samples, urine samples and cutting carcasses to get the required samples may not be easy because such activities interfere with normal duties and routine operations. The other huge challenge is that some butchery owners may be reluctant to have carcasses that were tempered with if the research should include getting meat samples. Those who agree may offer parts not necessarily used when conducting some specific studies. This may also result in reduced sample sizes (Engstrom *et al.*, 2010), numbers of breeds as well as age and sex categories. Furthermore, the selection of experimental units may not be easy. Categorising the units, for example, according to the age groups, sex and origin may also present difficulties such as interfering with abattoir operations.

Information on when animals arrive at the abattoir is another huge challenge since this may mostly depend on other stakeholders, for example the farmers and transporters. It may also be difficult to get some measurements (Engstrom *et al.*, 2010), namely the time taken and/or distance travelled by animals to the abattoir, weather conditions and vehicle measurements. Language, gender and cultural barriers between the researchers and abattoir staff and management may also affect research under practical conditions (Goma *et al.*, 2001; Gillespie *et al.*, 2007). Ultimately, publishing work from such studies may be a problem since they may be considered 'scientifically' insignificant or inappropriate or being defined rare studies.

In order to minimise the negative effects of the problems explained above, the researcher needs to explain to the stakeholders the overall objectives, benefits and procedures to be followed when conducting research under such practical conditions (Goma *et al.*, 2001). Where research demands giving feedback; all the participating bodies should cooperate so as to improve production efficiency although this usually happens only after some time (Gillespie *et al.*, 2007). An efficient and useful feedback system relies on reliable data collection at the farm, abattoir and/or at the butcher. Developing a good working relationship among all the partners involved in such research brings a huge potential of minimising some of the challenges raised above. Despite these challenges, technologies developed under practical conditions tend to be more easily adopted by the stakeholders (Goma *et al.*, 2001; Gillespie *et al.*, 2007). Therefore, research on pre-slaughter stress and meat quality can be a better way of resolving these challenges by suggesting and coming up with new innovations for improvement in the meat industry sector.

## Conclusion

Conducting pre-slaughter and meat science research is important in devising good welfare technologies for slaughtering animals and in improving the quality of meat. Although there are challenges in conducting such studies under real life situations, technologies developed under these conditions may be easier to transfer because of the quick feedback that may affect the participating stakeholders. Therefore, there is a need to conduct more research under practical conditions on pre-slaughter stress and meat quality for the meat industry sector improvement.

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