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Review

Meat in African context: From history to science

P. O. Fayemi and V. Muchenje*

Department of Livestock and Pasture Science, University of Fort Hare, Private Bag X1314, Alice, Eastern Cape, South Africa.

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The cultural proceedings of animal slaughter in Africa always give impression that portrays traditional slaughter method as cruel. So far, the knowledge gap on the meat quality traits from traditionally slaughtered animals has not been filled in the continent. No pre-slaughter welfare database has been generated or archived to characterize the severity of traumatic injury perceived to be inflicted on animals that were slaughtered for traditional purposes. The basis for condemning African perception on animal slaughter without stunning still remains subjective. As an alternative to the conventional stunning methods, this review recommends the use of biological stunners in African slaughter houses.

Key words: AASI, MNI, meat science, bio-stunners, welfare databases.

INTRODUCTION

Africa is one of the world's most ethnically diverse continents on earth (Fearon, 2003; Posner, 2004; Alberto and Eliana La, 2005). The continent has such a variety of people and cultures that relish meat and meat products as protein sources. Conventionally, the absence of meat (and in particular the red meat) is difficult to tolerate for long among many cultural groups in Africa (Lokuruka, 2006; Clark, 2009). In East Africa for instance, meat is at the top of the food hierarchy which provides the NgTurkana pastoral meat consumers of Kenya their cherished quintessential status. Hence, Africans elevate meat to a level where it serves as a vehicle to earn respect with and provide a measure of one's perceived rank and status in the community (Rogowski, 1980; Fiddes, 1991; Lokuruka, 2006).

Globally, meat consumption for people all over the world is part of what Bourdieu (1977) called our "habitus". This assertion supports the reason why meat has occupied a special place in human diets (Judge et al., 1975; Elliot and Ezenwa, 1988) and the need for this review article. As a focal point in the meals of many homes, this article appraises basic concepts in meat science and demystifies sundry issues connected with traditional slaughter in African traditional slaughter houses. The need to embrace the use of biological stunners for inducing death without pain (euthanasia) is also buttressed as an alternative to electrical, captive bolt and/or gas stunning methods.

BASIC CONCEPTS ON MEAT PRODUCTION AND MEAT SCIENCE

The second half of the 20th century has recorded a five-fold increase in meat production (Rosegrant et al., 2000; Speedy, 2003). Due to the growing human population (which is about seven billion), man now shares the planet and its resources with nearly: 1.0 billion pigs, 1.3 billion cattle, 15.4 billion chickens, 1.8 billion sheep and goats. Diverse vegetation patterns and human preferences in various agro-ecological zones have been implicated for the variation in animal population all over the world. For example, pigs are more prominent in the Far East; sheep in the Near East and beef in North and South America, Africa and Europe, respectively. The total world production of four major types of meat has an estimate of: 83.2 million tonnes for pork; 53.9 million tonnes for poultry; 53.2 million tonnes for beef and 7.0 million tonnes for mutton (Warriss, 2010). In effect, the dietary inclinations (Table1) and antithetical values attributed to meat have attracted different definitions from many

*Corresponding author. E-mail: vmuchenje@ufh.ac.za. Tel: +27 40 602 2059. Fax: +27 86 628 2967.

Abbreviations: AASI, Animal attitude scale index; **MNI,** meat normality index; **BCSS,** beef carcass classification system; **CSS,** carcass classification scheme.

Table 1. Some health benefits from meat.

S/N	Health benefits for eating meat
1	Meta-analysis shows inconsistent relationship between consumption of animal fat and protein with colorectal cancer.
2	Dietary polyamines such as putrescine, spermidine and spermine in chicken meat and other meat species support cell growth and differentiation.
3	Proteolysis of meat muscle generates a substantial number of multi-amino acid peptides used for nutraceutical therapy.
4	Meat has a strong angiotensin converting enzyme having the potential to cleave on any potent vasodilator and vasoactive peptides like angiotensin-I which inhibits the formation of angiotensin-II and thus relaxing the arteries, improving pumping efficiency of a failing heart and cardiac output in heart failure patients.
5	Meat contains biologically active peptides that could lower blood pressure and normalize biochemical and histopathological changes.
6	Presence of antioxidants in meat and offals enhances phase I and II detoxification reactions, protects the integrity of red blood cells, maintains cellular redox potential and normal brain function

Sources: Abdulatef and Michio, 2010; Alexander et al., 2009; Fox and Ward, 2008; Ruby and Heine, 2011.

authors. People who endorse social hierarchy and human dominance over nature consume more meat and, vegetarians who do not; consume more fruits and vegetables (Allen and Baines, 2002). Kinsman et al. (1976) therefore defined meat as 'those animal tissues that are suitable for use as food'. All processed or manufactured products that might be prepared from these tissues are thus included in this definition. While tissues from nearly all species of animals can be used as meat, the aquatic organisms, cattle, games, rabbits and other domestic animals are renowned sources of meat (Olomu, 1995; Muchenje et al., 2009a; Fayemi et al., 2011).

Although, meat is composed of numerous tissues such as adipose, epithelial, connective and nervous tissues, the major component is the muscle (Aberle et al., 2002; Warriss, 2010). As a corollary to this, Olomu (1995) defined 'meat as that part of the striated muscle that is found in various anatomical parts of an animal'. These parts consist of the: trachea, spleen, lung, ears, lips, snout, tongue, diaphragm, heart, liver, intestines and oesophagus. It also includes the skeletal system with or without the overlying fat (Fernandes et al., 2010). The bone, sinew, nerve and blood vessels which may or may not have been separated in the process of dressing for sale or the table, are considered meat as well (Lawrie, 2001). In other words, 'meat is the properly dressed flesh or edible parts of the muscle and offals derived from food animals (Olomu, 1995; Gracey et al., 2008)'. Herbivores, crustaceans, reptiles, mollusks, amphibians, games or avian species which are sufficiently mature and in good health at the time of slaughter are considered to be meat species in Africa (Olomu, 1995; Hoffman, 2000; Fayemi et al., 2011). Conceptually, the broad field of science that studies the unique characteristics of muscle and other animal tissues as they are transformed into meat is regarded as meat science (Aberle et al., 2002). Meat science therefore, encompasses the market activities of packers, processors and purveyors or that segment of the industry that converts live animals into food products and then distributes such products to merchandisers (Aberle et al., 2002; Gracey et al., 2008).

Nonetheless, meat science is not limited to the study of tissues, but also include various components or facets of the meat industry, beginning with animal production and ending with the preparation of carcass for consumption. In Africa, a pace-setting study on the carcass characteristics of indigenous small stock was published in Botswana about 34 years ago. This article absolutely gave meat science a scientific bearing in our continent (Owen et al., 1977). Each decade since 1977 has therefore got a definite hub in meat science researches. For example, studies on Carmel meat in a pastoralist Sub-Saharan African was the focus in the 1980s (Morton, 1983; Yousif and Babiker, 1989). The growth of carcass tissues, hormonal and metabolic status of meat species came to the centre stage in the 1990s in Zambia (Yambayamba et al., 1996). Since 2000 till date, other prominent articles have been tailored towards, meat breed characterization (Brand et al., 2009; Strydom et al., 2000; 2009); nutrient composition (Schonfeldt et al., 2010); fatty acid profiling (Mushi et al., 2010; Mapiye et al., 2011); growth physiology of meat species (Webb et al., 2005; Simela and Merkel, 2008); meat fermentation (Nabil et al., 2006; El-Khateib, 2007; Yagoub and Muhammed, 2008); sensory characterization (Muchenje et al., 2008; Mushi et al., 2008; Chulayo et al., 2011);

Table 2. Perception of some African Ethnic groups on Animal slaughter.

Ethnic group	Slaughter procedure
Pedi people, South Africa	1. Goats are transported over 2500km and cattle, in unsuitable vehicles. 2. Animals are treated with such reverence and being called 'kgomo ke modimo mo nko e metsa' {a beast is a god with a wet nose. 3. Slaughter done in the presence of other cattle using a slaughter weapon (an assegai, plunged behind the animal's left shoulder to pierce the heart) and often monitored by Society for the Prevention of Cruelty to Animals (SPCA).
Zulu people	1. Forcing the animal to move some distance 2. Stabbing of the animal on the stomach by using a spear
Vahera people, Zimbawe	1. The legs of the animals are tightly tied with rope below the abdomen so that the knot exerts pressure on the abdomen in order to facilitate rapid flow of blood. 2. Three legs of the animal only are tied, while the other leg is forced to hook at the back of the head 3. A group of strong men pull three legs of the animals and cut its neck without stunning.
The Maassai, Kenya and Northern Tanzania	1. No stunning ; no anaesthesia 2. Bleeding of live animals for traditional reasons
Egyptian abattoir (Bassateen)	1. Subjecting cattle to the stress of restrain box which traps their bodies and rotate them 140 degrees 2. Wrestling with the animal prior to slaughter; routine stabbing; tendon and throat slashing of a conscious animal knife.

Sources: AAVA, 2010; Fratkin, 2001; Mnguni, 2006; Ndou et al., 2011.

meat quality traits of conventional (Cloete et al., 2008; Muchenje et al., 2009; Safari et al., 2009) and non-conventional meat species (Hoffman, 2000); and pre-slaughter welfare of animal in low input systems (Muchenje et al., 2008; 2009a,b).

PERCEPTION ON TRADITIONAL SLAUGHTER IN AFRICA

Prior to slaughter and during the actual process (Table 2 and Figure 1), human-animal interactions usually involve constant penetration of animal flight zones (Ndou et al., 2011). In some Asian countries, there are beliefs that stress benefits some meat quality traits, such as tenderness. These convictions result in cattle being baited with dogs and chased through streets by mounting stockman equipped with goads (Gregory, 2007). The traditional slaughter method embraced by the Zulus (in South Africa), as well involves forcing the animal to move some distance before slaughter or stabbing in the stomach by using a spear. Bare hand is sometimes employed as a slaughter technique and vocalization is expected in the process (Mnguni, 2006). The commemorative ceremony and post-burial funerals of traditional priests in some African communities consider strangulation of live birds as normal. Feed deprivation, agitation, ululating, noise and passing of provocative vocals are also considered as idea African norms and values in the course of traditional slaughter (Table 2 and Figure 1). Thus, a school of thought has berated the processes involved in African traditional slaughter as unwillingness to conform to Western style or indisposition to implement animal welfare standards (Ndou et al., 2011). In response to this, it should be noted that there are "no nice ways" of killing animals (Gracey et al., 2008).

All the moral and ethical answers to questions on animal slaughter can only be answered based on the religious, political or economic circumstances and perhaps, animal attitude scale index (AASI) of individuals concerned. In his view, Thorpe (1965) advocated for a revision of the theory that animals are mere insentient automata and also, of the opinion that they are like humans in their feelings and anxieties. Basically, the act of animal slaughter must be carried out in a way to cause minimum stress or pain. This implies that brutality to animals presented for slaughter must also be avoided through compliance to humane handling and Animal Protection Acts (Gregory, 2007; Animals Protection Act- Act No. 71 of 1962; Meat Safety Act- Act No. 40 of 2000, Government Gazette Notice 1106, Republic of South Africa). However, compliance is apparently imperative because protracted pre-slaughter stress affects both the glycogen and lactic acid concentration in the muscle. The

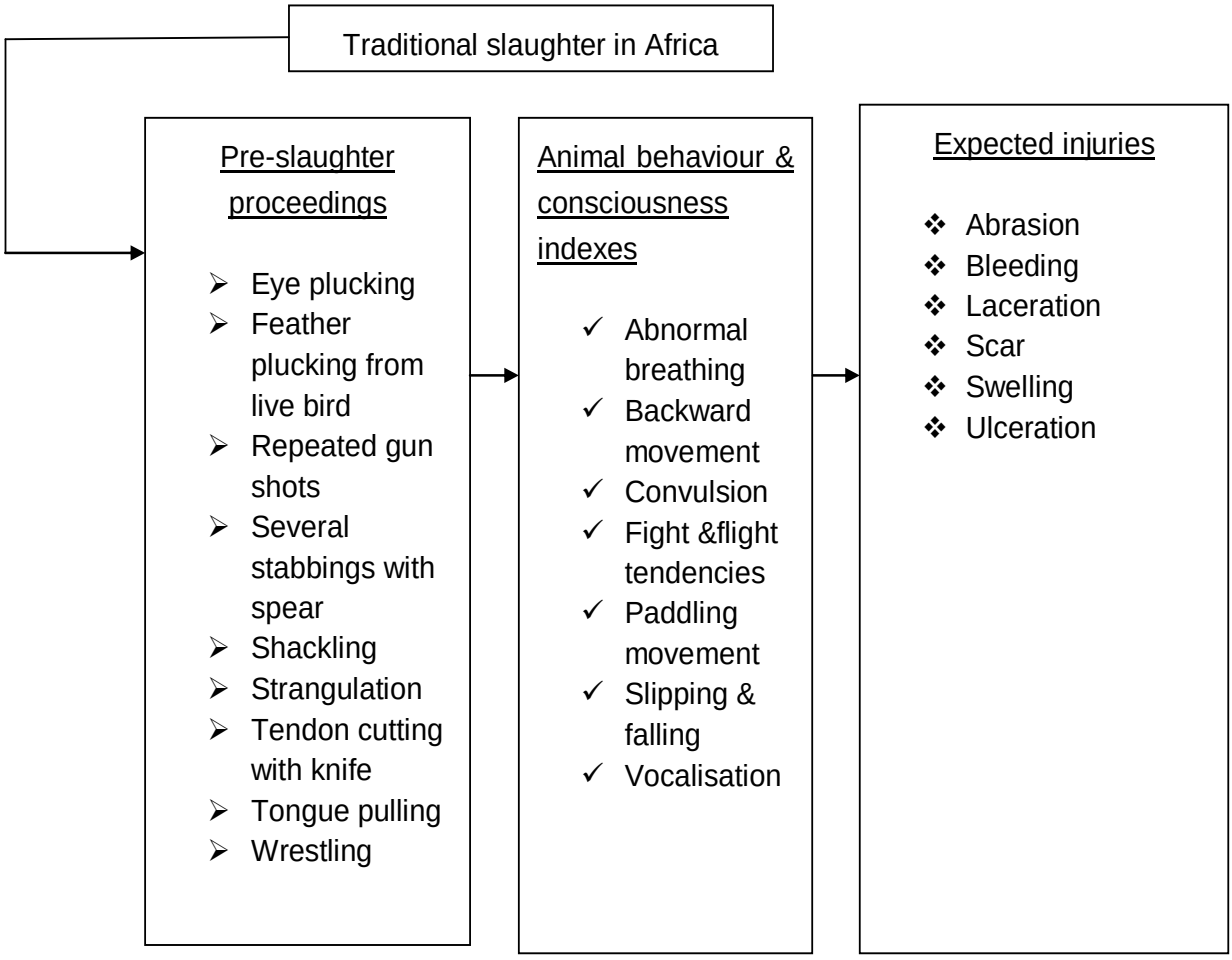

Figure 1. African's norms and values on pre-slaughter handling and slaughter expectations. Sources: Lokuruka, 2006; Mnguni; 2006; Gregory, 2007; Clark, 2009; SAPA, 2009; Ndou et al., 2011.

observed consequence has always been abnormal rise in the pH of meat beyond the critical range of 5.5 to 6.0 as recommended by Muchenje et al. (2009). The production of dark meat, poor carcass grading, reduced shelve life and price volatility have also been the outcome (Tarrant and Grandlin, 2000; Ferguson and Warner, 2008; Kannan et al., 2002; O'Nell et al., 2006).

While these facts are not intended to distort African viewpoint on traditional slaughter (Table 3 and Figure 1), it rather shows the existence of 'knowledge gap' on the meat quality traits from animals that are subjected to traditional proceedings before slaughter. It equally confirms paucity of valid information about the expected physical-chemical properties of meat sourced from various African slaughter processes and ceremonies. The need to generate and also archive meat quality traits (such as pH, colour, tenderness and shelf life) for every meat species used for notable African ceremonies is hereby advocated. Archiving this information will make it possible to get unbiased range of data for predicting meat quality standards from traditional slaughter.

ANIMAL STEREOTYPIES: STUNNING AND MEAT NORMALITY INDEX (MNI)

This standard will not only provide database for meat species that are subjected to African traditional proceedings, but also their "pre-slaughter welfare database" as well. These databases will either assist to uphold or modify African norms and beliefs on all proceedings connected with their practices and expectations when animals are being slaughtered for meat (Table 2; Figure 1). In practice, most animals are known to exhibit stereotypic behaviours in the process of stunning, bleeding or slaughter regardless of the method(s) used. Stereotypies, which are forms of repetitive, invariant behavioural patterns exhibited by captive animals, are abnormal behavioural processes that are indicative of poor welfare (Broom, 1991; Gracey et al., 2008; Gruber et al., 2010). In this respect, it is often observed when animals are stunned through captive bolt, electricity or gas (Mason, 1991; Gregory, 2007). The elicitation of these broad ranges of behaviors among individual

Table 3. South African standards on meat classification.

Roller marker's code	Carcass' characteristic
AAA	1. The colour of the roller mark on the carcass is PURPLE 2. Indicating that the meat is from a young animal (no permanent incisors) and thus, the most tender meat.
ABAB	1. The colour of the roller mark on the carcass is GREEN 2. Indicating that the meat is from a young animal in transition to an adult animal (1-2 permanent incisors) and thus, tender meat.
BBB	1. The colour of the roller mark on the carcass is BROWN 2. Indicating that the meat is from an adult animal (1-6 permanent incisors) and thus, less tender but with a lot of flavor.
CCC	1. The colour of the roller mark on the carcass is RED 2. Indicating that the meat is from an adult animal (>6 permanent incisors) and thus, less tender but perfect for stews.
Fatness	
Fat classes	**Carcass characteristics**
000	No visible fat on carcass
111	A very lean carcass
222	A lean carcass
333	A medium fat carcass
444	A fat carcass
555	An over-far carcass
666	An excessively fat carcass
Conformation	
Conformation class	**Carcass characteristics**
1	Very flat carcass
2	Flat carcass
3	Medium carcass
4	Round carcass
5	Very round carcass
Carcass damage	
Damage rating	**Carcass characteristics**
1	Slight damage where very little meat was removed.
2	Moderate damage where fat and some meat of certain muscle were removed to get rid of meat and fat that would not be fit for human consumption.
3	Serious damage where muscle must have been cut deep to get rid of meat and fat not fit for human consumption.

Adapted from Red Meat Industry Forum (RMIF), 2010.

animals could be due to poor animal handling, improper contact with the stunner or inadequate stunning voltage or electrical current (Grandlin, 1997; von Borell, 2001; Gruber et al., 2010). The aftermath of this has always been failure to reach meat normality level for the species concerned.

Contrary to a growing body of evidence and advocacy that meat normality index (MNI) is obtainable through non-traditional stunning method yet, none of the conventional stunning methods has attained this feat (Gruber et al., 2010). An ideal MNI has not been achievable in many slaughter houses because animals offered for slaughter still experience varying degrees of pains in the process of stunning and slaughter. A

combination of stereotypical behaviours such as nervousness, balking, excitement, fear, avoidance, vocalization, aggression and other physiological reactions that are symptomatic of stress have been nauseatingly recorded in the abattoir (Knowles and Warriss, 2007; Gruber et al., 2010). The elicitations of painful behaviours and emotional stress on stunned animals have shown that the onset of unconsciousness is not immediate as a perceived threat to homeostasis still holds (Ashley, 2007). Going by the fact that conventional stunning methods have not produced optimal level of 'unconsciousness' on stunned animals, an alternative approach is required. The animal tracking method of using toxic biological materials like the: beetle larvae, scorpion or spider essence, cactus juice and a lethal mixture of snake venom on targeted animals were used by the Sans' for inducing insensibility (Mitchell et al., 1996; Lewis-Williams, 1978). As an alternative, the use of patentable non-toxic concoction or bio-stunners is hereby recommended to eliminate all avoidable stereotypical behaviours and also, boost animal pre-slaughter welfare. In lieu of this, animal welfare data bases should be generated and archived for various meat species that are subjected to all traditional slaughter proceedings or slaughtered for different African traditional ceremonies. Barcoding of "the manifest behaviours" from such slaughter procedures can then be used for standardizing African perception of animal slaughter and the expected meat quality from each animal species.

OFFALS: THE ATYPICAL MEAT SOURCES FOR AFRICANS

Apart from the muscle, offals are also rated as prized meat sources in a number of African ethnic groups. In many African countries, offals are common ingredients in the cuisine and are widely consumed by a large proportion of the populace as an important nutritious food sources (Ockerman and Basu, 2004, 2007). In practical terms, these offals are a culinary term used to refer to the entrails and internal organs of butchered animals or the edible parts of slaughtered animals with the exception of hide and skin (Olomu, 1995; Fernandes et al., 2010). Literally, the word offals share its etymology with the German words; "*Abfall*" (*offall* in some Western German Dialects), *afval* in Dutch and Afrikaans. These Germanic words all mean 'garbage' or 'off-fall', referring to that which has fallen off during butchering or any part of slaughtered animal that is excised from the carcass in the process of evisceration and dressing (Fox, 2003; Magoro, 2007). Specifically, offals include the: liver, heart, kidneys, trachea, spleen, brain, pancreas, trotters (feet), tongue, tail, thymus glands or sweetbreads and tripe or stomach lining, (Olomu, 1995; Aberle et al., 2002) as shown in Figure 2.

In some cuisines, the head and eyeballs, natural binder, blood plasma, cow-heels, gut (casings), omentum, pluck (oesophagus, trachea, lungs), pericardium, associated lymph nodes, spleen, trotters, udder, pillars of the diaphragm and rind are also regarded as offals (Fernandes et al., 2010; Warriss, 2010). These atypical meat commodities are indis-pensable in the food security of many rural populations (Esenbuga et al., 2008). Due to its affordability and unique taste, it makes classic, frugal and essential parts of the cultural "food basket" for majority of the population in Southern Africa (Magoro, 2007). While using offals as a way of keeping traditional and heirloom recipes alive, certain offal products are still found on the menus of high-class restaurants in Africa and beyond as 'variety meats or as fancy meats' (Magoro, 2007; Warriss, 2010). Based on consumers' choice, offals can be grouped into two major classes or four sub-divisions as shown in Figure 2.

MEAT CLASSIFICATION SCHEMES IN AFRICA

Particularly in Africa, whether offals or the typical meat, both of them require a measure of standardisation or grading. Meat standards and grading are terms that are often used interchangeably while discussing carcass appearance, cuts, estimated yield and eating quality. The development of carcass classification and schemes evolved from a necessity to describe the carcass using standard terms to facilitate trading. This has been addressed by the United Nations promoting standard languages on carcasses, cuts, trim levels and cutting lines (Polkinghorne and Thompson, 2010; Strydom, 2011). In general, carcass grading has been expressed in three ways. First, it is the ranking of carcasses in a hierarchy for the traits of interest; secondly, it is the granting of a value class to carcasses in the light of preconceived ideas with reference to quality and thirdly, it is the placing of different values on carcasses for pricing purposes, depending on the market and requirements of traders (Polkinghorne and Thompson, 2010).

In some parts of the world, carcass grading and classification were introduced in the late 1800s in the beef marketing chain due to advances in the transport and refrigeration of frozen beef from South America, Australia and New Zealand to Europe. In South Africa for instance, beef description systems started in 1932 with the carcass grading system which was used from 1985 and was later replaced by a carcass classification system from 1992. Changing from grading system to classification system became necessary due to some intelligible reasons (Anon, 2005). Marketing opinion polls have shown that consumers want simple grading designations for red meat. The existing livestock and meat marketing systems all share the major defects of poor market transparency, imprecise product description at the point of first hand selling and inadequate feedback in the supply chain to the beef producer (Price, 1995; Anon, 2005; AHDB

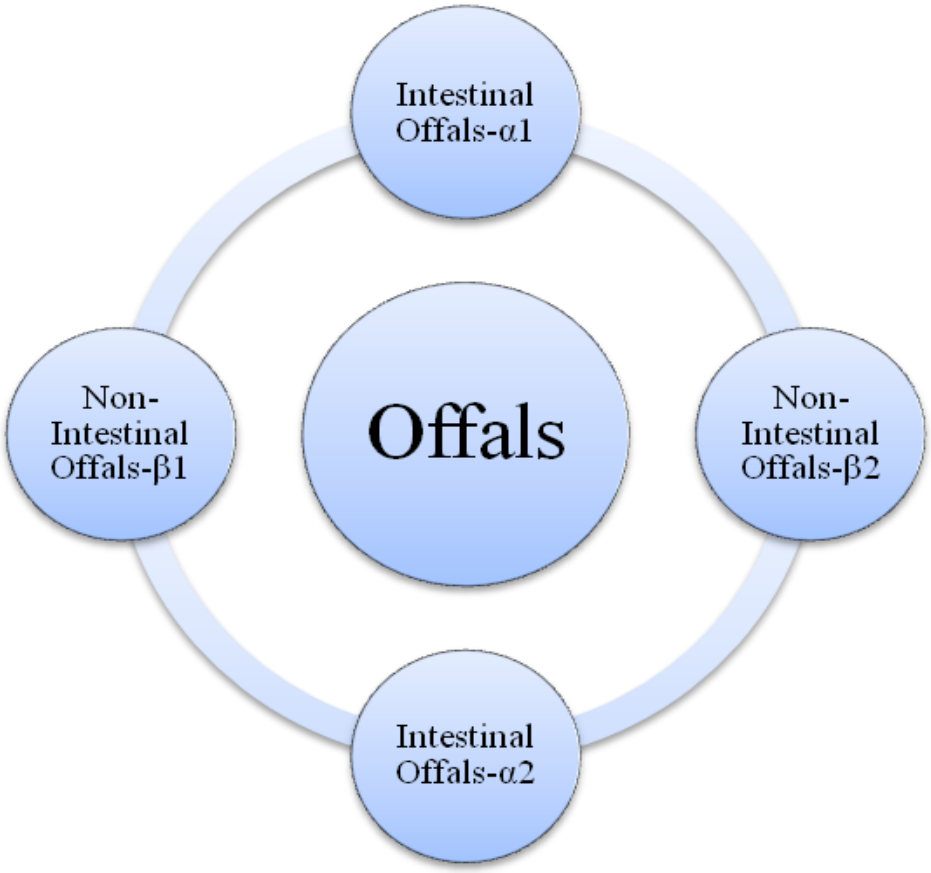

Figure 2. Classification of different offals. Intestinal offals-α1, the large intestine; small intestine; rumen. Intestinal offals-α2, abomasum; omasum; reticulum; rectum. Non-intestinal offals-β1, liver; head; lung; kidney; oesophagus; trachea; spleen. Non-intestinal offals-β2, brain; nose; ear; blood; legs; tail; tongue.

Industry Consulting, 2008). Thus, carcass classification scheme was introduced to address the perceived deficiencies in the marketing system of beef (Anon, 2006; Polkinghorne and Thompson, 2010; RMIF, 2010).

The South African meat industry and meat science terrain alone has the meat standardisation and carcass classification system in Africa. The South African standard on 'beef carcass classification system (BCSS)' (Table 2) distinguishes the country as a leader in meat science initiatives in our continent. So far, no other African nation has been able to produce and uphold a comprehensive BCSS for beef as South Africa. One major defect though, is that the attention on carcass classification scheme (CCS) is only concentrated on the *longissimus* muscle of cattle, there is however nothing for mutton, chevon, chicken, fish, games and offals from each of them. This is clearly a knowledge gap calling for intervention.

CONCLUSION AND RECOMMENDATION

It is obvious that African flare for meat is incontrovertible. Meanwhile, research efforts on meat need to be tended towards:

1. Archiving and barcoding peculiar meat quality traits of meat from animals that are slaughtered for African traditional purposes.
2. Developing non-toxic biological stunners that can induce unconsciousness or death, better than the conventional methods of stunning.
3. Animal welfare data bases should be generated from all animal species that are subjected to traditional slaughter proceedings or slaughtered for traditional ceremonies.
4. Developing and sustaining the interest in meat standardisation for meat species such as chevon; chicken; mutton; games and fish in all African nations.

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