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The conversion of dopamine to epinephrine and nor-epinephrine is breed dependent

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Abstract

In previous reports, Nguni type cattle have shown to have a lower glycolytic potential with less glycogen measured in muscles 1 h post-mortem. With the release of catecholamines in the immediate pre-slaughter period, there is potential for depletion of muscle glycogen, because of the fact that epinephrine activates muscle adenylate cyclase and thereby stimulates glycogen breakdown. Epinephrine and nor-epinephrine are secreted as a result of any "fight or flight" situation. Tyrosine is a conditionally non-essential large neutral amino acid and the precursor of the neurotransmitters dopamine, nor-epinephrine and epinephrine. Ante-mortem stress experienced by an animal may be influenced by amino acids that provide substrates for neurotransmitter synthesis. The Nguni type cattle showed 55.8% and 55.1% greater urinary nor-epinephrine values than for the Brahman- and Simmental type cattle respectively. The Nguni type cattle showed 35.6% and 43.8% greater urinary epinephrine values than the Brahman- and Simmental type cattle respectively. The higher urinary nor-epinephrine and epinephrine levels measured in Nguni type cattle could either be explained by a greater neuronal out flux immediately prior to slaughter or a slower re-uptake.

Keywords: Meat tenderness, urinary catecholamines, beef breeds, dopamine
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Introduction

Domestic animals destined to be slaughtered are exposed to various stressors in the ante-mortem environment. These stressors include transport, handling, mixing and time of feed and water. These events stimulate the hypothalamic-pituitary-adrenal axis to drive a number of physiological changes such as energy depletion. These physiological changes have an economic impact on carcass yield and meat quality. Nutritional supplementation during the ante-mortem period may be effective in attenuating these conditions, thereby improving animal welfare, carcass yield, and meat quality (Schaefer *et al*., 2001).

Tyrosine

↓ tyrosine hydroxylase

3,4-Dihydroxyphenylalanine (DOPA)

↓ aromatic decarboxylase

Dopamine

↓ dopamine-β-hydroxylase

Nor-epinephrine

↓ transmethylase

Epinephrine

Figure 1 Synthesis of nor-epinephrine and epinephrine from tyrosine and their associated enzymes (Adapted from: D'Mello, 2003).

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Ante-mortem stress experienced by an animal may be influenced by amino acids that provide substrates for neurotransmitter synthesis. Tyrosine is a conditionally nonessential large neutral amino acid. Tyrosine is the precursor of the neurotransmitters dopamine (DA), nor-epinephrine (NE) and epinephrine (E) (D'Mello, 2003).

Exposure to stress increases the utilization and synthesis of DA, NE and E; the availability of tyrosine for catecholamine (CAT) synthesis can become rate-limiting under these conditions (Schaefer *et al*., 2001).

When CAT synthesis is compromised, animals become less resistant to stress, developing an array of counterproductive behavioural (learned helplessness) and physiological changes. These animals are unable to respond appropriately to stimuli and are unable to function normally, to the extent that even eating and sleeping are disturbed (Anisman & Zacharko, 1986; Lieberman, 1994).

Methods and Materials

One-hundred-and-eighty animals were slaughtered at the specified A-age (no permanent incisors) and fatness-class 2 - 3 (5 - 7 mm subcutaneous fat thickness). Sixty Brahman type (Bh-x), 60 Simmental type (Sm-x) and sixty Nguni type (Ng-x) crosses were used. The animals were slaughtered at the ARC-Irene abattoir. CAT's were measured in urine samples that were collected from the bladder with a syringe and needle approximately 12 minutes post-mortem, immediately after evisceration. Urine samples were preserved as described by Lowe *et al*. (2000) and analysed by HPLC-method as described by Gouarne *et al*. (2004). Concentrations of CATs are volume related and for this reason only creatinine corrected CAT concentrations were considered in the statistical analysis. Samples of the *m. longissimus* (20 g) were taken at one hour post-mortem and covered with aluminium foil, frozen in liquid nitrogen and then ultra frozen for the determination of energy values, e.g. glucose, glycogen and ATP-6-P.

Results and Discussion

Nguni type cattle had 55.8% ($P < 0.05$) and 55.1% ($P < 0.05$) greater urinary NE and 35.6% ($P < 0.05$) and 43.8% ($P < 0.05$) greater urinary E values than Brahman and Simmental type cattle which can either be explained a greater neuronal out flux immediately prior to slaughter or a slower re-uptake. Interestingly, from O'Neill *et al.* (2008), Nguni type cattle had a smaller glycolytic potential with less glycogen measured in muscles one hour post-mortem.

Table 1 Mean (±s.e.) post-mortem urinary nor-epinephrine and epinephrine levels in Nguni- (Ng-x), Brahman- (Br-x) and Simmental type (Sm-x) crosses

Urinary catecholamine	Breed type		
	Ng-x	Bh-x	Sm-x
Nor-epinephrine	4.72 ± 2.11^{b}	2.56 ± 1.04^{a}	2.48 ± 0.89^{a}
Epinephrine	3.37 ± 2.29^{b}	1.16 ± 0.66^{a}	1.714 ± 1.17^{a}

[a b] $P < 0.05$.
[a b] Different superscripts in the same row differ ($P < 0.05$).

Conclusion

Evidence shows clearly that Nguni type cattle have a greater catecholamine conversion rate to NE and E. Linked with this was the finding that Nguni type cattle have a smaller glycolytic potential than the Brahman- and Simmental type cattle. Therefore one can conclude that Nguni type cattle are genetically predisposed for a higher NE and E conversion rate with a subsequent lower glycolytic potential in the muscle.

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