



Young Blond d'Aquitaine, Angus and Limousin bulls differ in emotional reactivity: Relationships with animal traits, stress reactions at slaughter and *post-mortem* muscle metabolism

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ABSTRACT

The present study investigated relationships between reactivity during tests, stress reactions at slaughter and animal traits in young Blond d'Aquitaine (BA), Limousin (LI) and Angus (AN) bulls. Behavioural and physiological reactivity of animals was evaluated during rearing using a "Human test" (exposure to human presence and handling) and an "Umbrella test" (exposure to a sudden event, the opening of an umbrella). During both tests, bulls were also subjected to social isolation and novelty. Three weeks after the tests, bulls were slaughtered in an experimental abattoir and stress reactions were evaluated using *ante-mortem* behavioural and physiological measurements, and indicators of *post-mortem* muscle (*Longissimus dorsi*: LD and *Semitendinosus*: ST) metabolism. Animal traits (morphological measures, basal cortisol level and testosterone level) were also recorded. BA reacted more strongly to the tests than AN, while LI had often intermediate levels. In the Human test, BA and LI spent more time vigilant than AN. In the Umbrella test, BA turned their head backwards more often, were further away from the umbrella and expressed more startle responses than AN. At slaughter, AN showed lower LD pH_{3h} and higher LD and ST pH_{30h} after bleeding. Regression analyses showed that up to 25.3 and 39.7% of the variability between individuals in early *post-mortem* ST and LD pH_{40min} was explained by differences in heart rate minutes before slaughter, and stress reactions during the reactivity tests, respectively, at least partly removing breed effects. Ultimate pH was more strongly related to physical traits, specifically dressing percentage. Models are in accordance with existing knowledge on the biological relationships between these traits and *post-mortem* metabolism. Overall, results show that the breeds differed in stress reactions during reactivity tests and in *post-mortem* pH decline. A considerable part of the breed effects on early *post-mortem* pH decline was explained by certain stress reactions during the reactivity tests or immediately before slaughter (pH_{40min}, pH_{3h}) and physical traits (pH_{30h}).

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1. Introduction

During the slaughter period animals are exposed to various potentially stress-inducing factors of psychological origin, such as social disturbances, handling and novelty, or physical origin, such as food and water deprivation, pain or fatigue (Ferguson and Warner, 2008; Terlouw et al., 2008). Individuals differ in their perception and

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their evaluation of such stressful situations, explaining differences in behavioural and physiological reactions even if animal are subjected to similar slaughter procedures (Lensink et al., 2001; Hemsworth et al., 2002; Terlouw and Rybarczyk, 2008; Deiss et al., 2009). Individuals show consistency in their reactions to different stressful situations, including at slaughter. In calves, reactivity to the farmer predicted ease of loading and unloading as well as *post-mortem* muscle metabolism (Lensink et al., 2001). Normand cull cows that were more reactive to unfamiliar situations and social disruption had also increased stress reactions at slaughter, as shown by elevated heart rates during the slaughter procedure and faster *post-mortem* muscle metabolism, compared to less reactive counterparts (Bourguet et al., 2010). Similar results were found for lambs (Deiss et al., 2009) and pigs (Terlouw et al., 2005; Terlouw and Rybarczyk, 2008). Today, no data exist on the relationship between the reactivity profile and stress at slaughter for young bulls, which represent an important part of the beef industry (Micol and L'Herm, 2010). Young bulls are considered more behaviourally reactive than cows (Bourguet et al., 2011). In addition, irrespectively of gender, breeds may differ in their reactivity to stress (Boissy and Le Neindre, 1997; Grandin, 1997; Voisin et al., 1997). The present study examined emotional reactivity to various potentially stressful situations and stress reactions at slaughter in Angus, Blond d'Aquitaine and Limousin young bulls. Relationships between stress reactivity in different situations and *post-mortem* muscle pH were studied, while taking into account zootechnical characteristics.

2. Material and methods

2.1. Animals and housing

A total of 72 bulls, 24 Blond d'Aquitaine (BA), 24 Limousin (LI) and 24 Angus (AN), aged 16–17 months, were purchased from commercial farms. Until purchase, rearing environment and therefore experience differed between animals and this has been kept in mind during the interpretation of the results (cf Discussion section). During 4 months until slaughter, the bulls were housed in 6 m × 6 m pens with straw bedding in the experimental farm of the research centre with 4 animals of the same breed per pen. They received a morning and evening meal representing a daily quantity of 12 kg of concentrate and 3 kg of hay. Water was provided *ad libitum*. The experiment was conducted in two identical replicates of 12 bulls per breed and per replicate over two successive years (2008–2009).

Experimental procedures and animal holding facilities respected French animal protection legislation, including licensing of experimenters. They were controlled and approved by the French Veterinary Services.

2.2. Reactivity tests

Three weeks before slaughter, each bull was individually submitted to two different reactivity tests (see below) conducted on two consecutive days. About 30 min before each test, the 4 bulls were quietly removed together from their home pen and introduced into a familiar crush to be

equipped with a heart rate monitor. Four days before the test, bulls had been introduced in same crush to be shorn at the place of the heart rate electrodes. During all preparations, bulls of the same rearing group were treated together to avoid isolation stress. After equipping bulls with the heart rate monitor, the 4 animals were re-introduced to their home pen to habituate to the monitor. Testing started after at least 10 min of habituation.

2.2.1. Human test

The Human test aimed to evaluate reactivity to the presence of an inactive human and to handling (Boivin et al., 1994; Gauly et al., 2001; Bourguet et al., 2010). It was conducted in an unfamiliar test arena (6 m × 6 m, concrete floor and 2 m high solid walls, Fig. 1a) and organised in 5 phases. In the first phase, the tested bull remained in the test pen during 45 s (phase 1: absence of the human). Subsequently, a familiar stockperson equipped with a stick (1 m) entered the test pen and remained stationary in the entrance zone (Fig. 1a) of the test arena (phase 2: stationary human). Forty-five seconds later, the stockperson moved the bull into the handling zone (phase 3: moving), where the stockperson tried to maintain him for 30 s (phase 4: maintenance). If this succeeded, the stockperson carried out a series of 5 strokes at the level of the top of the thigh (phase 5: stroking).

It was decided that if at any stage an animal became aggressive, the test would be stopped. It was further decided that if during phase 3 the bull could not be introduced into the handling zone within 120 s the test would also be stopped. In addition, if during phase 4, the bull left the handling zone before 30 s, or during phase 5, he left the handling zone before receiving the series of 5 strokes, phase 3 would be started again, followed by phases 4 and 5, as described above. Phase 3 would be started no more than 5 times in total. If the bull could not be maintained in these 5 attempts or did not accept the series of 5 strokes, the test would be stopped (Table 1). The same stockperson participated in all tests.

2.2.2. Umbrella test

The Umbrella test took place the day after the Human test and aimed to evaluate reactivity to a novel object (a closed umbrella) and a sudden event (the sudden opening of the umbrella, see Table 1). It was conducted in an unfamiliar straight corridor (12 m × 0.8 m, concrete floor and 2 m high solid walls, Fig. 1b). During the first phase, the umbrella was absent and the tested bull was maintained in the umbrella zone of the corridor via an iron bar (7 cm diameter) placed across the corridor behind the animal at 1 m height and 3 m from the site where the umbrella would be presented (phase 1: absence of the umbrella). Thirty seconds later, an experimenter introduced the umbrella (red coloured, 50 cm) in front of the bull (at 20 cm pointed towards his muzzle) via a 10 cm × 10 cm aperture located in the exit door (phase 2: closed umbrella). During this phase (30 s), the animal was maintained in the umbrella zone of the corridor and could freely interact with the closed umbrella. Subsequently, the umbrella was opened while at the same time the horizontal bar was removed by a second experimenter allowing the animal to walk freely

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