Dry and tough meat in Belgian Blue cattle caused by a genetic defect in the ATP2A1 gene

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Introduction: Belgian blue cattle (BBC) breed is well known for its double-muscling phenotype due to the fixation of a loss-of-function mutation in the myostatin (MSTN) gene. It is directly associated with a lower muscle collagen content resulting in increased meat tenderness much appreciated by consumers. However, since several years, Belgian meat cutters reported the occasional obser- vation of meat cuts that were described as 'tough and dry'. Most of the affected muscles were located in high-value cuts in the hindquarter: i.a. *m. glutaeobiceps*, *m. semimembranosus* and *m. quadriceps femoris*. In the worst cases i.a. *m. longissimus dorsi* and *m. semitendinosus* were also impacted. A genome-wide association study pinpointed a single significantly associated locus on chromosome 25, encompassing the *ATP2A1* gene coding for the SERCA1 protein. A previous reverse genetic screen identified a breed- private missense mutation (R143W) in this gene. The prevalence of the condition is estimated at 12.5% and its severity correlates with R143W allelic dosage, causing increased meat toughness and hence carcass depreciation. The mutation is partially dominant with a penetrance of 43% and 100% in R/W and W/W animals respectively. Direct selection against the mutation is currently un- derway. Here we present the meat quality properties of affected animals.

Materials and Methods: *Carcass phenotyping* Meat quality phenotypes were classified into six discrete categories (C) of increas- ing severity (0, 1, 1.5, 2, 2.5 and 3). C0 corresponds to carcasses without any macroscopic meat defect. Upon cutting of the car- casses, all affected animals (C > 0) exhibited exudate at the surface of the inside round, and a 'dry and tough' feeling of the *m. ad- ductor femoris* and inner parts of the *m. glutaeobiceps*, *m. semimembranosus* and *m.quadriceps femoris* (C1 and 1.5), as well as of the i.a. *m. semitendinosus* and *m. longissimus dorsi* for the most severe cases (C2 to 3). In this study only culled cows were included. A total of 243 carcasses was selected and graded in the meat cutting plant, and genotyped afterwards.

Meat phenotyping To further describe the dry and tough meat syndrome, the medial part of the *m. glutaeobiceps*, being the key muscle in the detection of the syndrome, was collected from 26 affected BBC cows and 21 unaffected BBC cows, as a subsample of the 116 non-C0 and 127 C0 carcasses used to investigate the phenotype-genotype correlation. The pieces were collected at the cutting plant between 3 and 7 days post mortem and analyzed for ultimate pH, EZ-driploss, CIE L*a*b* colour, colour stability (Δa*), thaw and cooking losses, Warner-Bratzler shear force, sarcomere length, dry matter, texture profile and protein solubility.

Results and Discussion: *Carcass phenotyping* A total of 116 non-C0 and 127 C0 carcasses were graded. From the 127 C0- carcass- es, 86% was free of the R143W allele and the other 14% carried a single copy. The non-C0 carcasses were all carriers of the R143W allele, as heterozygote (90%) or as homozygote (10%). Homozygotes were only found at the worst affected carcasses (C1.5 and higher). To conclude, wild type animals always deliver normal quality carcasses, while homozygotes are always affected and heterozygotes can be both, varying from C0 to C3.

Meat phenotyping The affected (non-C0) and non-affected (C0) animals had no difference in age (54.6 vs. 57.1 months) and car- cass weight (536 vs. 540 kg). The color of non-C0 meat appeared significantly darker (L*=43.0 instead of 46.1), less red (a*=22.4 vs. 25.1) and less yellow (b*=21.7 vs. 26.6). After storage for 7 days under light, the a*-value of both ended at the same level (5.97 vs. 5.93). The ultimate pH was almost the same in both groups (5.72 vs. 5.68), marking a clear difference between this described phenomenon and DFD-meat. The 'dry' feeling of the non-C0 meat was confirmed with a significantly higher dry matter content (27.4% vs. 26.6%) and lower thaw and cooking losses (7.19% vs. 8.42% and 26.5% vs. 28.3%), despite the non-significant differ- ence in drip loss (2.11% vs. 2.71%). The 'tough' feeling of the non- C0 meat was confirmed by the significantly higher hardness (40.7N vs. 29.5N) and higher shear force values (55.7N vs. 37.7N). The difference in these texture properties could partially be explained by the significantly shorter sarcomere length of non-C0 meat (1.40µm vs. 1.51µm) as a direct result of distorted fiber relaxations caused by the mutation in the *ATP2A1* gene. However, no biochemical explanation for the dryness could be provided, with no differences in sarcoplasmatic and myofibrillar protein solubility used as indicator for protein denaturation.

Conclusion: The 'though and dry meat syndrome' in Belgian blue cattle breed is indisputably linked with the R143W mutation in the *ATP2A1* gene, and can be described with distinctive symptoms, palpable for experienced butchers and measurable in the lab.

Key words: Belgian Blue, Mutation, Meat quality