[IN]FLUENCE OF NUTRITION ON MEAT QUALITY IN DOUBLE MUSCLED BULLS.

[VA]N VOOREN T.[1], VAN HOOF J.[1], VEREECKE D.[1], ISTASSE L.[2], DUFRASNE I.[2] and DESWYSEN A.[3].
[1]University of Ghent, Faculty of Veterinary Medicine, Laboratory of Hygiene and Technology of Food from Animal Origin, Wolterslaan 16, 9000 Ghent, [B]ON.L. Brussels, BELGIUM.
[2]University of Liège, Fac. of Vet. Med., "CENTRE DE RECHERCHE SUR L'ELEVAGE ET LES PRODUCTIONS FOURRAGERES EN HAUTE BELGIQUE", [Boulevard] de la Ferme 6, Bâtiment 39, Sart Tilman, 4000 Liège.
[3]University of Louvain, Fac. of Agronomic Sciences, Dept. of Genetics, Place Croix-du-Sud 2 bte. 14 - GENA, 1348 Louvain-la-Neuve.

[SUM]MARY

[Meat] quality, in particular the colour of the M. Longissimus dorsi (LD) in three groups of double muscled Belgian white blue (BWB) bulls [fed a] different ration, has been investigated. A most peculiar assessment was the occurrence of a different meat colour of the LD in one group, [in s]pite of the fact that all bulls were of the same BWB breed and were of nearly the same age when slaughtered. As this one group [(cont]aining 18 bulls) was fed corn (maize) silage during the fattening period (last five months of life), the pale visual impression, lower hue [and] higher brightness with the Hunter Lab might be due to the carotenoid pigments (beta-carotene and xanthophyll) of the corn. From [liter]ature, it is known that these fat soluble carotenoids can influence the colour of carcasses because of a yellow fat colour whereas these [pigm]ents do not influence the colour of the lean (CRAIG et al., 1959) (MORGAN & EVERITT, 1969). Finally, various factors (e.g. pigment [cont]ent, age, muscle fibre composition, ...) can be the cause of a paler meat colour.

[IN]TRODUCTION

[Fatt]ened double muscled BWB bulls are slaughtered usually at the age of approximately 15 - 20 months yielding a carcass weight of about [...] kg. Although the meat of this breed is known to have good quality characteristics in general, the colour of the lean is often reported as [pal]e (BOCCARD, 1981; BATJOENS et al., 1989). As the consumer prefers red beef meat, the retail market makes a complaint to the [sla]ughterhouse and the cattle breeder, who turns for his part to the producer of the fodder.

[MA]TERIALS AND METHODS

[A t]otal of 82 BWB bulls were used in the present trial.

[Gro]up A consisted of 28 bulls. They underwent a "pasture-experiment": a "low" and a "high" number of animals were turned into the field, [on] pastures of a same area, during a period of 6 months (grazing period). After this period, all 28 animals were put in a loose house in farm I [duri]ng a period of 3 months (fattening period) and the compensatoric growth was examined. The last 3 months (fattening period in loose [hous]e), all bulls were fed pulp (basic: 5.1 kg/day/animal), barley (2.2 kg/day/animal) and 1.1 kg soya meal per day per animal. Initial and [fin]al weights, based on single weighings, were used to calculate average daily gain. During the 6 months of grazing at pasture, the bulls had a [me]an growth of 1.1 kg per day. The last 3 months, during the fattening period, average weight gain was about 1.2 kg/day. At the end of the ["p]asture-experiment", the mean live weight of the animals was 498 kg. Three months later, when slaughtered, they weighed approximately [...] kg and were about 20 months old. Slaughter of all 28 fattened animals occurred in five times in the same slaughterhouse.

[A] second **group B** of 36 bulls was examined for the capacity of voluntary food intake. Besides, production characteristics and genetic effects [we]re studied: the animals were male descendants of 3 sires. As calves, the bulls were housed in a loose house system and were never grazing [be]fore the experiment started. They were fed concentrate for young cattle till the age of approximately 6 months. After this initial period, the [bu]lls were supplied with concentrate feeding (10% spelt) and housed in farm II (loose house system). During the experiment, the animals had [an] average daily gain of approximately 1.4 kg, and a final live weight of 615 kg. Slaughter occurred in 6 times in a different slaughterhouse [than] the two other groups.

[A] third **group C**, composed of 18 bulls, was never grazing and was housed in farm I (same farm as the first group, A). The animals were [fe]d during the experiment and were fed corn silage (basic: 4.4 kg corn silage per day per animal; this is 60% of the ration), 1.4 kg pulp and [...] kg soya meal. The whole plant corn was ensiled at a different dry matter content, resulting in 3 sorts of corn silage: a first silage consisted [of] corn of a first cut (youngest corn) and contained 25% dry matter. The silage produced with corn of a second cut had a dry matter content of [...]%. The third silage contained 32% dry matter. The corn silages were fed to the bulls (mean initial weight: 310 kg) devided in three pens of [...] animals each, during a period of approximately 168 days. During the experiment, the animals had an average daily increase in weight of [ab]out 1.3 kg. At the slaughterhouse, the bulls had a mean live weight of around 533 kg and were 15 months old (same age as these of group [...]). The animals were slaughtered in the same slaughterhouse as group A, in three times.

[O]ne hour after slaughter, the pH was measured (pH_1) and a LD muscle sample of about 1 cm^3 was collected for histochemical computer [im]age analysis. The samples were immediately frozen in liquid nitrogen and stored afterwards at -80 °C. Another sample of about 50 grams [wa]s taken for analyses of moisture-, protein- and fat content and myoglobin content (mg Mb/g meat). At the slaughterhouse, live weight and hot carcass weight were also noted. Two or three days after slaughter, the final pH was measured and a monocostal cut (7 - 8th rib collected. The Hunter Lab device was used for objective measuring brightness (L) and hue (a/b). The method of Grau & Hamm was ap to evaluate water holding capacity (WHC). A cut (2.5 cm thick) was weighed, put into a poly-ethylene bag and stored in a refrigerator °C for seven days. The bag was put in such a way that drip was not coming in contact with the meat. At the end of the storage period, was reweighed and the drip was calculated as percentage of the initial weight. The same cuts were used for cooking loss determination were heated in open plastic bags in a waterbath at 75 °C. After heating (during 50 minutes) they were cooled in cold tap water to temperature, bags were drained en cuts were mopped gently dry with paper tissue. The difference between raw and heated weight recorded as cooking loss, and expressed as percentage of the raw weight. Warner - Bratzler peak shear force (WB - shear mounted Instron 1140) was determined perpendicular to the fibre direction on samples obtained from the heated cuts.

Data are given as means ± standard error, statistically analysed with Students t-test and controlled with one way analysis of variance Duncan.

RESULTS AND DISCUSSION

In group A, the factors were not considered because no effect on meat quality was recorded. So the group of 28 bulls was uniform regard to meat quality. In group B, the meat quality was not influenced by the sires. In group C, no significant differences in meat qu existed for the three groups that were fed the different corn silages.

In table 1, the mean values of the different quality characteristics are given. Significant differences were observed in pH_1, final pH, carcass weight, cooking loss, shear force and chemical composition. Drip and water holding capacity were not affected by feeding. average pH_1 is lowest (significant difference) in the LD of group C and final pH is higher in the LD with lowest pH_1. Similar findings observed before, especially when carcasses had undergone high voltage electrical stimulation (not published). Carcasses (halves) that stimulated showed an accelerated pH-drop but final pH was significantly higher compared with the halves that were not stimulated.

The higher mean hot carcass weight of group B (table 1) in the present experiment may be due to origin, farm and/or fodder. LOCHNER al. (1980) showed that meat tenderness can be related to muscle temperature in the very early post mortem period. WARNER et al. (19 showed that a grazing period does not influence meat tenderness in calves. The significant differences in % of moisture, protein and fat be due to the feed.

The most remarkable difference recorded, was a different colour (brightness and hue) of the LD of the bulls in group C. There significant higher brightness and lower hue compared to the two other groups. Only the bulls of group A were turned into the field (months) and it is not unusual for cattle reared on grass to yield dark-coloured lean as well as coloured fat (CRAIG et al., 1959) (FORR 1982). In the present trial however, the LD of these animals did not have darker lean. DINIUS and CROSS (1978) showed that fat colour be reduced by concentrate feeding.

The different meat colour in group C can be explained by several causes or effects. Initially, it was assumed that the pale hue was du yellow carotenoid pigments of the corn, because of the significant higher mean b-value, that stands for yellow colour. As carotenoid pigm are fat-soluble, "yellow" carcasses (because of a yellow fat colour) could be expected at the slaughterhouse. However, no visual differen in comparison with other commercially slaughtered bulls (of the same breed) slaughtered at the same time, were observed. Nevertheless, facts can explain why the "yellow" colour of the LD is not due to the corn, fed during the fattening period (last 168 days of life).

Yellow maize contains appreciable amounts of carotenoid pigments, cryptoxanthin in particular. However, maize contains only small amo of beta-carotene (FORREST & VANDERSTOEP, 1985), one of the pigments selectively absorbed by cattle, and this may explain why inclusion of maize silage in the ration of intensively-fed bulls did not result in any colouration of the fat (MORGAN & EVERITT, 1969).

A second explanatory reason is the fat-soluble character of carotenoid pigments. As the meat of the LD of double muscled BWB conta approximately only 0.6% fat, it would be very doubtful that a fat-soluble yellow pigment would influence the meat colour of this low-fat lo The average fat content of the LD of the 18 bulls in group C is 0.7% with a minimum and maximum of respectively 0.25 and 1.1 Moreover, fat content in the muscle is not correlated to hue in this group.

These two facts explain that the lower hue is probably not affected by ration as opposed to a first assumption.

Several facts can be the cause of a different (paler) meat colour of the LD.

A higher brightness (and lower hue) can be due to a pH-drop in stress-susceptible animals, resulting in a PSE-like meat. As there were extreme pH-drops recorded in the carcasses of the animals in our trial, this cause can be excluded.

Young bulls have a paler meat colour than older ones, because of a lower pigment content and a more anaerobic muscle fibre composition metabolism. Excluding group A (because of the older age), a significant difference in meat colour was determined between group C and containing animals that were approximately of the same age when slaughtered.

...wer pigment content (myoglobin) also results in a paler colour. A significant difference in myoglobin content between group C and A ...le 1) can explain the lower hue of group C. However, the paler colour of group C compared to group B can not be explained by a ...ference in myoglobin content since no significant difference was observed. Besides, a significantly different myoglobin content between ...p A and B does not result in a different meat colour. EGGER (1991) and DUFEY (1991) showed that the haemoglobin bloodlevel in ...es can give an indication of the future meat colour of carcasses.

...known that the LD of double muscled bulls is paler than the LD of common breeds because of a lower pigment content and a more ...erobic muscle metabolism. The fact that all animals in the experiment belonged to the same double muscled Belgian white blue breed, can ...lude this factor of variation.

...able 2, the results of image analysis of some animals of group C and B are given. For practical reasons, only 10 animals of group C and ...of group B have been analysed. Significant differences were observed in the amount of IIA fibres (not stained; oxydative and glycolytic ...abolism) and IIB fibres (intermediate stained; glycolytic metabolism). The number of IIA fibres in the LD of animals in group B ...umber these of animals in C. They also have a larger mean cross-sectional area. Finally, this results in a significant lower average relative ...a of IIA fibres (%) in group C. The opposite was recorded for IIB fibres: a higher number of IIB fibres in group C which results in ...proximately 75% relative area of these fibres in the LD of the animals of group C. So the LD of the animals of group C had a lower ...idative and higher glycolytic metabolism which can explain the paler colour: glycolytic myofibres do not need as much myoglobin as ...idative myofibres, which includes a lower pigment content. There is no significant difference in the anaerobic factor (ANF = (O% IIA + ...% IIB) / O% I) but the aerobic factor (AF = (O% I + O% IIA) / O% IIB) is significantly lower for the LD in group C (table 2).

...NCLUSION

...e fodder does not seem to influence meat colour in a direct way within the Belgian white blue breed. The more anaerobic muscle ...mposition of group C, fed corn silage, can be due to the fodder which can be considered as an indirect cause of the pale colour as a ...nsequence.

...is not excluded that other factors are the reason for the pale meat colour. Further investigation is needed and running at the present to find an ...planation for these findings.

...EFERENCES

...ATJOENS, P., VAN HOOF, J. and VEREECKE, D. (1989). The influence of the muscle fibre composition on some meat quality characteristics in young bulls. Proc. Vol. III, 35th ICoMST, 1989 Copenhagen, 1082 - 1087.

...OCCARD, R. (1981). Facts and reflections on muscular hypertrophy in cattle: double-muscling or cullard. Developments in meat science - ... Ed. by Lawrie R., Applied Science Publishers, 1 - 28.

...RAIG, H. B., BLUMER, T. N. and BARRICK, E. R. (1959). Effect of several combinations of grass and grain in the ration of beef steers ...n the colour characteristics of lean and fat. J. Anim. Sci., 18, 241 - 248.

...NIUS, D. A. and CROSS, H. R. (1978). Feedlot performance, carcass characteristics and meat palatability of steers fed concentrate for ...ion periods. J. Anim. Sci., 47, 1109 - 1113.

...UFEY, P.-A., (1991). Comparaison entre veaux anémiques et non anémiques quant à la qualité de la viande. Revue suisse Agric., 23 (2), ...85 - 88.

...GGER, I. (1991). Influence de deux niveaux de fer et de cuivre sur les performances zoötechniques et la couleur de la viande chez le veau à ...engrais. Revue suisse Agric., 23 (1), 15 - 20.

...ORREST, R. J. (1982). A comparison of the growth and carcass characteristics of steers reared on pasture and finished for varying periods ...n corn or grass silage. Can. J. Anim. Sci., 62, 1079 - 1088.

...ORREST, R. J. and VANDERSTOEP, J. (1985). A comparison of grass and corn silages for finishing steers. Can. J. Anim. Sci., 65, ...69-772.

...OCHNER, J. V., KAUFFMAN, R. G. and MARSH, B. B. (1980). Early post mortem cooling rate and beef tenderness. Meat Sci., 4, ...27-241.

...ORGAN, J. H. L. and EVERITT, G. C. (1969). Yellow fat colour in cattle. N.Z. Agric. Sci., 4, 10 - 18.

...ARNER, R. D., MORRIS, D. C., TAYLOR, J. W., CURRIE, J. R., GAUNT, G. M., TRUSCOTT, T. G. and STAFFORD, R. (1988). ...nfluence of rearing and age at slaughter on carcass and meat quality of veal calves. Proceedings of the Australian Society of Animal ...roduction, 17, 350 - 353.

table 1 Quality characteristics of LD

group	C (n = 18)	A (n = 28)	B (n = 36)
farm	I	I	II
food	corn silage, pulp, soya meal	pulp, barley, soya meal	concentrate (10% spelt)
pH_1 b*	6.51 ± 0.20	6.61 ± 0.24	6.64 ± 0.12
final pH a** b**	5.55 ± 0.07	5.48 ± 0.05	5.46 ± 0.03
hot carcass weight (kg) a** b** c**	343 ± 41	384 ± 38	418 ± 40
drip (%)	5.4 ± 1.3	5.7 ± 1.4	5.9 ± 1.1
water holding capacity (%)	32.6 ± 2.5	31.2 ± 2.4	32.1 ± 3.0
cooking loss b* c*	24.3 ± 2.7	23.3 ± 4.2	21.6 ± 2.9
Warner-Bratzler (N) a** c**	40.5 ± 9.5	57.4 ± 18.1	41.7 ± 7.9
moisture (%) b** c**	75.9 ± 0.5	75.7 ± 0.4	75.1 ± 0.5
protein (%) a* b** c**	21.6 ± 0.5	22.0 ± 0.3	22.6 ± 0.5
fat (%) a*	0.7 ± 0.3	0.5 ± 0.2	0.6 ± 0.3
L a** b**	38.9 ± 3.0	34.5 ± 2.6	35.5 ± 2.0
a/b a** b**	1.6 ± 0.2	1.8 ± 0.2	1.8 ± 0.1
Mb-content a** c*	2.7 ± 0.7	3.6 ± 0.8	3.1 ± 0.9
a (red colour)	15.2 ± 0.9	14.8 ± 1.3	14.7 ± 0.9
b (yellow colour) a** b**	9.6 ± 1.0	8.1 ± 0.9	8.2 ± 0.8

*, **: significant at $p < 0.05$ and $p < 0.01$ respectively
a: significant differences C <-> A, b: sign. diff. C <-> B, c: sign. diff.A <-> B
Mb-content: mg myoglobin/gram raw meat

table 2 Muscle fibre composition of LD

group	C (n = 10)	B (n = 23)
% I	25 ± 3	25 ± 6
% IIA b*	21 ± 3	26 ± 6
% IIB b*	54 ± 3	49 ± 5
% area I	10.95 ± 2.43	11.77 ± 3.02
% area IIA b**	13.94 ± 2.31	20.88 ± 6.82
% area IIB b**	75.12 ± 3.78	67.36 ± 7.06
surface I (μ^2)	1516 ± 327	1758 ± 405
surface IIA b**	2309 ± 305	3025 ± 595
surface IIB	4920 ± 465	5170 ± 763
AF b*	0.34 ± 0.07	0.50 ± 0.18
ANF	8.57 ± 2.18	8.07 ± 2.41

*, **: significant at $p < 0.05$ and $p < 0.01$ respectively
b: sign. diff. C <-> B
AF = (O% I + O% IIA) / O% IIB
ANF = (O% IIA + O% IIB) / O% I