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**Original article**

# Compositional data on Belgian Blue double-muscled bulls[1, 2]

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**Abstract** — Compositional data of 17 Belgian Blue double-muscled bulls with empty body weight between 276 and 669 kg were analysed. Body composition only changed slowly and linearly within the investigated live weight range. Water, protein, fat and ash in the empty body varied between 65.8 and 72.0%, 18.9 and 21.2%, 3.5 and 9.7% and 3.0 and 4.% respectively. The chemical fat content in the empty body was remarkably low. The percentage of accreted energy as protein always remained higher than 50% of the total accreted energy, which is much higher than generally reported in literature. Caloric values for protein and fat were: 22.91 (± 0.90) $MJ \cdot kg^{-1}$ and 38.74 (± 1.53) $MJ \cdot kg^{-1}$ respectively. Carcass protein contained on average (in %) 8.8 Asp, 15.6 Glu, 5.3 Pro, 7.7 Gly, 6.6 Ala, 7.5 Leu, 7.4 Lys and 6.5 Arg, while the protein in the non-carcass parts contained (in %) 8.0 Asp, 12.7 Glu, 8.8 Pro, 15.1 Gly, 8.0 Ala, 6.6 Leu, 5.6 Lys and 7.2 Arg. The protein composition proved to be rather constant for the considered live weight range.

**double-muscling / body composition / bulls / Belgian Blue breed**

**Résumé** — **Composition corporelle du taurillon Blanc-Bleu Belge culard.** La composition corporelle de 17 taurillons Blanc-Bleu Belge culards, avec un poids vif vide compris entre 276 et 669 kg, a été analysée. La composition n'a changé que lentement et linéairement avec les poids étudiés. La quantité d'eau, des protéines, des lipides et des cendres dans la masse corporelle n'a varié qu'entre 65,8 et 72,0 %, 18,9 et 21,2 %, 3,5 et 9,7 % et 3,0 et 4,1 % respectivement. La teneur en lipides a été très basse. Le pourcentage d'énergie retenue en protéines est resté au-dessus de 50 % de l'énergie retenue totale, ce qui est beaucoup plus élevé que les données de la littérature. Les valeurs calorifiques pour les lipides et les protéines dérivées par régression ont été, respectivement, de 38,74 (± 1.53) $MJ \cdot kg^{-1}$ et 22,91 (± 0.90) $MJ \cdot kg^{-1}$. La composition des protéines de la carcasse a été en moyenne (en %)

[1] Communication No. 1120 of the department.
[2] See color illustrations on the web at www.edpsciences.org/docinfos/INRA-ANIMAL
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8.8 Asp, 15.6 Glu, 5.3 Pro, 7.7 Gly, 6.6 Ala, 7.5 Leu, 7.4 Lys et 6.5 Arg, et celle du cinquième quartier a été (en %) 8.0 Asp, 12.7 Glu, 8.8 Pro, 15.1 Gly, 8.0 Ala, 6.6 Leu, 5.6 Lys et 7.2 Arg. Ces compositions ont été relativement stables tout au long des variations de poids vif étudiées.

**culards / composition corporelle / taurillons / la race Blanc-Bleu Belge**

## 1. INTRODUCTION

At slaughter, a lot of animal tissues are considered as offal, with fat being an important part of it. From an economic point of view reduction of total fat in the body and in the carcass is very important. Besides, as fat is found to be responsible for cardiovascular diseases, a reduction of fat would also be of interest for reasons of public health [16, 22]. Sinclair and O'Dea [29] indicated that lean beef can be included in a cholesterol-lowering diet if the overall fat content of the diet is kept low. The only drawback of reducing fat content might be reduced flavour. Savell and Cross [26] recommended a minimum fat content in meat products of 3%.

As important differences in fat content exist between and within breeds, genetic selection is the first tool to improve leanness [3, 17, 27]. Therefore, data on the chemical composition of different breeds are of interest.

The Belgian Blue (BB) double-muscled (dm) bulls largely dominate the Belgian beef market. Their extreme conformation and very lean carcasses are their major advantages. No data are available on the chemical body composition of these animals. Within the frame of a research project to determine the dietary energy and protein standards for these animals, 18 bulls with varying live weight have been homogenised and analysed. Data on the body and carcass composition of these animals are given and discussed.

## 2. MATERIALS AND METHODS

### 2.1. Experimental design

The 18 bulls originated from a feeding trial involving 46 BB dm bulls. They were purchased in the market with a live weight between 275 and 325 kg. The total experimental period was divided in three phases (ca. 360–460 kg, 460–570 kg, 570–680 kg) to investigate the effect of phase-feeding on animal performance [6]. The animals were divided over four treatments (group 1, 2, 3 and 4), with different energy and protein combinations [6], but all diets were fed ad libitum. Net energy in the rations varied between 7.25 and 8.26 MJ·kg$^{-1}$ dry matter (DM), while protein content varied between 68 and 103 g DVEc·kg$^{-1}$ DM (DVEc = true protein digested in the small intestine, corrected for a negative degraded protein balance). The negative control group (group 1; $n$ = 10) constantly received a low protein level combined with a moderate energy level. With each phase, the protein level of group 2 ($n$ = 12) decreased, while the energy level remained moderate during the total

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List of abbreviations:
BB: Belgian Blue; CC: right carcass half; CV: coefficient of variation; dm: double-muscled; DM: dry matter; EB: empty body; EBW: empty body weight; fLW: fasted live weight; LBM: lean body mass; LW: live weight; NCP: non-carcass parts; RSD: residual standard deviation; SD: standard deviation.

trial. The energy level of group 3 (*n* = 12) increased with each phase while the protein content remained high during the three phases. Group 4 (*n* = 12) received rations with increasing energy levels and decreasing protein levels. The feeding scheme is illustrated in Figure 1.

At the beginning of the trial, after the first and the second phase and at the end of the trial, 2, 1, 1 and 2 bulls respectively of the groups 2, 3 and 4 were slaughtered and homogenised to determine chemical body composition. These bulls were selected out of their group solely based on their live weight (LW), in order to have a homogeneous spread over the total investigated LW interval. LW ranged from 309 to 723 kg.

## 2.2. Slaughtering procedure and chemical analyses

The 18 bulls were slaughtered in the experimental slaughterhouse of the Ghent University, 5 km away from the Department. Bulls were not fasted before slaughter.

After stunning, bulls were rapidly exsanguinated. During the slaughtering procedure all non-carcass parts (NCP), including all removable fatty tissues (subcutaneous and internal), were separated from the carcass and gathered. De Campeneere et al. [8] described the detailed slaughtering procedure. Empty body weight (EBW) was determined as LW minus gut fill. At the end of the slaughtering procedure the weight of the right carcass half (CC; including half of the tail) was determined.

CC and the NCP were prepared for analysis according to the procedure described by De Campeneere et al. [8]. Water, protein, fat, ash and energy in the CC as well as in the NCP were separately analysed. Protein and fat were analysed according to the EU methods (Publication European Communities No. L179/9 and No. L 15/29 (method B) respectively). The gross energy content was determined using an IKA-calorimeter C7000. Amino acid composition of the protein of the CC and NCP was determined, after hydrolysis according to Bech-Andersen et al. [4], with an Eppendorf LC3000 amino acid analyser. From a standard, tyrosine recovery was determined to be only 65%. Results of analysis of tyrosine were therefore corrected to 100%. Water, protein, fat, ash, energy and amino acid composition of the protein in the empty body (EB) were calculated from the results of the CC and NCP composition. Lean body mass (LBM) was calculated as the EBW minus total fat weight.

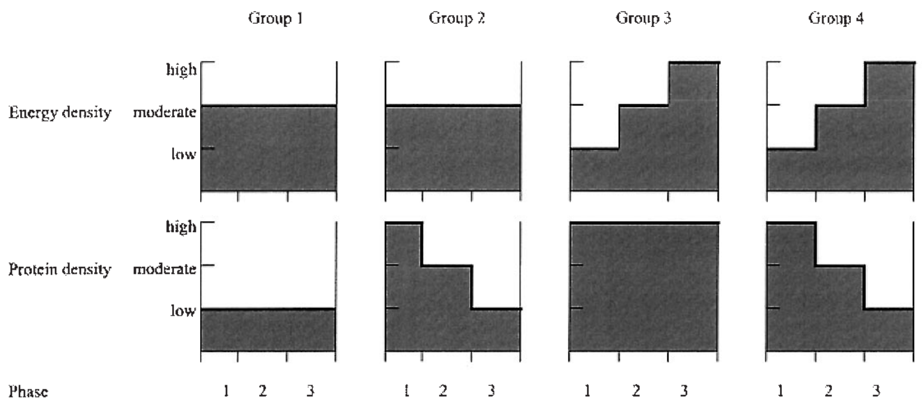


**Figure 1.** Overview of the four treatments: protein and energy density of the ration in each of the three phases.

Due to technical problems, compositional data from one animal were unreliable. The results of that animal were excluded from all statistical analyses. The compositional data are therefore based on 17 observations.

### 2.3. Statistical analysis

In order to study if body composition was influenced by the treatments, four covariance analyses (GLM – General factorial, SPSS 8.0 for Windows [30]) were performed according to the following model:

$$X_{ij} = \mu + a\,T_i + b\,EBW_j + E_{ij}$$

with: $X_{ij}$ = % body fat, water, protein or ash, $\mu$ = overall mean, $T_i$ = the treatment (group 2, 3 or 4) as a fixed factor and $EBW_j$ as the covariant.

Means and standard deviations (SD) (Tab. I) were calculated using SPSS 8.0 for Windows [30].

Equations predicting body components (Tab. II) were derived based on linear regressions using SPSS 8.0 for Windows [30] according to the following model:

$$Y_i = \mu + a\,fLW_i$$

with $Y_i$ = the body component as dependent variable, $\mu$ = overall mean and $fLW_i$ = fLW (fasted live weight) as independent variable.

Caloric values for fat and protein were derived based on a linear regression using SPSS 8.0 for Windows [30] according to the following model:

$$Y_i = \mu + a\,F_i + b\,P_i$$

with $Y_i$ = total body energy as dependent, $\mu$ = overall mean and $F_i$ = kg fat and $P_i$ = kg protein in the body as independent variables. The resulting coefficients of the fat and protein mass are an estimation of the caloric value of fat (a) and protein (b) respectively.

## 3. RESULTS AND DISCUSSION

### 3.1. Body compositional data

Covariance analysis excluded any influence of the treatment on the composition. This is in agreement with the results of a parallel feeding trial [6], in which exactly the same four treatments were applied on 4 groups of 26 animals. The different treatments had no influence on carcass composition (estimated from rib-cut dissection). As such, all compositional data could be pooled for analysis.

In Table I, data on the weight and the composition of the NCP, the CC and the EB, as well as on LBM and fLW of the 17 bulls are listed. The results of the homogenisations showed very low fat contents in the dm animals, especially when the large range in EBW is taken into account. In the carcasses, the fat content only varied between 3.1 and 7.4%. As expected, the chemical fat content in the NCP was somewhat higher and ranged from 4.6 to 18.4%. The LBM varied between 90.3 and 96.5% of the EBW.

Earlier results ([5, 10] and several others) showed that the proportion of fatty tissue in BB dm bulls is very low. Fiems et al. [10] found 11.3% fatty tissue in the carcass of BB dm bulls and 21.7% for BB bulls with normal conformation fed the same ration. Clinquart et al. [5] found for the same parameter 11.6% for BB dm bulls and 24.2% for non-dm bulls of the BB breed. In the same trial, Holstein bulls were involved and their carcasses contained on average 25.2% fatty tissue. In comparison, Ledger et al. [18] found fatty tissue contents in the carcasses of a mixed population of Boran and Hereford × Boran steers, with a slaughter weight between 137 and 448 kg, ranging from 6.3 to 40.0%. Karnuah et al. [15] mentioned fatty tissue proportions in the carcass varying from 13 to 37.8% for Japanese Black × Holstein steers. Robelin et al. [24] compared results of different experiments and calculated the lipid weight in the body at two different LBM: 250 and

400 kg. For Angus or Hereford steers, lipid weight equalled 68 and 224 kg respectively, for Black and White bulls 34 and 112 kg and for Limousin bulls 23 and 48 kg, respectively. From our results, we calculated that corresponding lipid weight would be 13.2 and 22.9 kg respectively. It should be considered that comparison over different

**Table I.** Mean, standard deviation (SD) and range for the weight and composition of the non-carcass parts, the right carcass half and the empty body and for the lean body mass and the fasted live weight.

| | Mean | SD | Range |
|---|---|---|---|
| Non-carcass part weight (kg) | 124.0 | 34.9 | 73.3–178.5 |
| Non-carcass parts | | | |
| water (kg) | 82.7 | 20.1 | 50.7–118.6 |
| protein (kg) | 24.9 | 7.6 | 13.4–35.3 |
| fat (kg) | 13.3 | 8.0 | 4.4–32.7 |
| ash (kg) | 4.3 | 1.2 | 2.4–7.2 |
| energy (MJ) | 1110 | 444 | 559–2068 |
| water (%) | 66.7 | 3.4 | 59.2–71.7 |
| protein (%) | 19.7 | 1.4 | 16.4–22.1 |
| fat (%) | 10.0 | 3.7 | 4.6–18.4 |
| ash (%) | 3.5 | 0.5 | 2.5–4.9 |
| energy ($MJ \cdot kg^{-1}$) | 8.6 | 1.4 | 6.5–11.6 |
| Right carcass half weight (kg) | 173.6 | 48.8 | 101.5–247.6 |
| Right carcass half | | | |
| water (kg) | 121.7 | 32.8 | 72.3–170.7 |
| protein (kg) | 35.3 | 10.2 | 20.3–49.7 |
| fat (kg) | 8.8 | 4.2 | 4.1–16.5 |
| ash (kg) | 6.9 | 2.4 | 3.5–10.6 |
| energy (MJ) | 1211 | 392 | 692–1844 |
| water (%) | 70.3 | 1.5 | 67.4–72.7 |
| protein (%) | 20.3 | 0.5 | 19.5–21.2 |
| fat (%) | 4.9 | 1.2 | 3.1–7.4 |
| ash (%) | 3.9 | 0.4 | 3.0–4.4 |
| energy ($MJ \cdot kg^{-1}$) | 6.9 | 0.5 | 6.1–7.9 |
| Empty body weight (kg) | 471.6 | 132.3 | 276.4–668.8 |
| Empty body | | | |
| water (kg) | 325.7 | 85.7 | 195.4–457.9 |
| protein (kg) | 95.2 | 27.9 | 54.0–134.7 |
| fat (kg) | 31.2 | 16.4 | 12.6–64.6 |
| ash (kg) | 17.6 | 6.0 | 10.1–26.8 |
| energy (MJ) | 3530 | 1233 | 1944–5722 |
| water (%) | 69.4 | 1.9 | 65.8–72.0 |
| protein (%) | 20.1 | 0.6 | 18.9–21.2 |
| fat (%) | 6.3 | 1.8 | 3.5–9.7 |
| ash (%) | 3.7 | 0.3 | 3.0–4.1 |
| energy ($MJ \cdot kg^{-1}$) | 7.4 | 0.7 | 6.4–8.7 |
| Lean body mass (kg) | 440.5 | 118.2 | 260.6–618.9 |
| Fasted live weight (kg) | 506.0 | 134.9 | 308.0–710.0 |

**Table II.** Empty body composition (water: EBWa, protein: EBP, fat: EBF and ash: EBA; kg and %), empty body energy (EBEn; MJ) and LBM (lean body mass; kg and %) estimated from fLW (fasted live weight; kg).

| Unit | Prediction equation | $adjR^2$ | RSD | CV | *P*-value of the model |
|---|---|---|---|---|---|
| kg | EBWa = 5.80 + 0.632 (± 0.017) × fLW | 0.99 | 9.3 | 2.9 | 0.000 |
| | EBP = –9.07 + 0.206 (± 0.005) × fLW | 0.99 | 2.7 | 2.8 | 0.000 |
| | EBF = –22.68 + 0.106 (± 0.015) × fLW | 0.75 | 8.3 | 26.6 | 0.000 |
| | EBA = –4.11 + 0.043 (± 0.003) × fLW | 0.94 | 1.5 | 8.5 | 0.000 |
| | LBM = –1.60 + 0.874 (± 0.017 × fLW | 0.99 | 9.4 | 2.1 | 0.000 |
| MJ | EBEn = –951 +8.86 (± 0.59) × fLW | 0.93 | 317 | 8.9 | 0.000 |
| % of EBW | EBWa = 74.2 – 0.0096 (± 0.003) × fLW | 0.44 | 1.41 | 2.0 | 0.002 |
| | EBP = 19.0 + 0.0022 (± 0.001) × fLW | 0.18 | 0.57 | 2.8 | 0.052 |
| | EBF = 1.93 + 0.0086 (± 0.003) × fLW | 0.36 | 1.47 | 23.3 | 0.006 |
| | EBA = 3.01 + 0.0013 (± 0.001) × fLW | 0.22 | 0.31 | 8.4 | 0.032 |
| | LBM = 98.1 – 0.0086 (± 0.003) × fLW | 0.36 | 1.47 | 1.6 | 0.006 |
| $MJ \cdot kg^{-1}$ EBW | EBEn = 5.754 + 0.0032 (± 0.001) × fLW | 0.36 | 0.54 | 7.3 | 0.006 |

trials is difficult. However, there is obviously a drastic reduction in fat content in BB dm bulls even when compared with the Limousins, which were the leanest in the study of Robelin et al. [24]. Besides the genetic predisposition for a high lean percentage, there is another, less important, reason why the fat contents of our results are lower than in some other studies. The very high fat contents in the Angus and Hereford steers are partly due to castration. Augustini and Branscheid [2] compared German Fleckvieh bulls and steers at different LW. Tissue fat in the carcass varied from 6.9% at 200 kg to 14.8% at 650 kg for bulls and for steers from 8.2 towards 23.7% respectively. In Belgium the BB dm animals are traditionally fattened as bulls, which are known to have a markedly higher ratio of lean-to-fat than do castrated males [14]. Another possible reason for a lower fat content at a comparable live weight, could be a difference in maturity. Owens et al. [19] indicated that animals have similar fat % at similar proportion of their mature weights. Hays and Preston [14], calculated that at 68%, 78% and 88% of the mature weight, carcasses of steers will on average contain 22%, 26% and 30% fat, respectively. However, since mature weight of the BB dm bulls is not different from that of Limousin bulls [25], this cannot explain the differences found. However, whereas Limousin bulls are considered to be late maturing, BB are more likely to be extreme late maturing bulls [7]. Although the above comparison of our results with literature is very difficult since animals were not fed the same ration, the very low fat contents of the BB dm bulls are remarkable, especially since the animals in this study were fed intensively (65% concentrates on DM base). These first compositional data from chemical analysis of the total body, obviously confirm the extreme leanness of this type of animal.

### 3.2. Influence of fLW on body composition

The composition of the EB was highly correlated with the fLW when both elements were expressed in kg, with for water and protein an $adjR^2$-value ($R^2$-value adjusted

**Table III.** Accretion in g·kg$^{-1}$ growth or MJ·kg$^{-1}$ growth of the different body components of the BB dm bulls for different LW intervals in comparison with other data and % of the accreted energy as protein and fat.

| LW interval | Water | Protein | Fat | Ash | Energy | % of energy accretion | |
|---|---|---|---|---|---|---|---|
| | g·kg$^{-1}$ | | | | MJ·kg$^{-1}$ | as protein | as fat |
| 325–375 kg | 654 | 197 | 73 | 38 | 7.57 | 64.8 | 35.2 |
| 375–425 kg | 645 | 199 | 82 | 39 | 7.87 | 62.4 | 37.6 |
| 425–475 kg | 636 | 201 | 90 | 40 | 8.17 | 60.4 | 39.6 |
| 475–525 kg | 627 | 203 | 98 | 41 | 8.47 | 58.6 | 41.4 |
| 525–575 kg | 618 | 205 | 106 | 43 | 8.77 | 56.9 | 43.1 |
| 575–625 kg | 609 | 207 | 114 | 44 | 9.07 | 55.4 | 44.6 |
| 625–675 kg | 600 | 209 | 122 | 45 | 9.38 | 53.9 | 46.1 |
| 675–725 kg | 590 | 211 | 130 | 46 | 9.68 | 52.6 | 47.4 |
| Robelin et al. [24] (Limousin bulls) | | | | | | | |
| 304–440 kg | 632 | 191 | 104 | – | 8.49 | 52.0 | 48.0 |
| 440–543 kg | 563 | 205 | 181 | – | 11.36 | 39.7 | 60.3 |
| 543–646 kg | 437 | 194 | 244 | – | 14.31 | 31.8 | 68.2 |
| Calculated from Schulz et al. [27] (German Friesian bulls) | | | | | | | |
| 152–267 kg | 551 | 160 | 73 | 35 | 7.14 | 56.8 | 43.2 |
| 267–370 kg | 480 | 173 | 193 | 43 | 8.84 | 35.0 | 65.0 |
| 370–480 kg | 488 | 158 | 281 | 43 | 10.39 | 25.2 | 74.8 |
| 480–576 kg | 318 | 120 | 504 | 25 | 12.57 | 12.5 | 87.5 |

for the total population) of 0.99 and a residual standard deviation (RSD) of 9.3 kg (2.9%) and 2.7 kg (2.8%) respectively. The fat mass was less well correlated with fLW: adj$R^2$ = 0.75 and RSD = 8.3 kg (26.6%). Table II shows the equations predicting EB composition from fLW, when the dependent variable is expressed in kg or in %. The adj$R^2$ of the relative equations are less high. However, the CV (coefficient of variation) of these were always lower than the CV of the equations predicting absolute composition (Tab. II).

The equations in the upper part of Table II demonstrate that an increase of the fLW with 1 kg, corresponds with an accretion of on average 632 g water, 206 g protein, 106 g fat and 43 g ash. However, from the relative equations, the accretions of the different components for different live weight intervals were calculated (Tab. III). Protein accretion increased from 197 g to 211 g per kg LW increase and fat increased from 73 g to 130 g per kg for the same interval. The ash content of the accreted tissue increased with increasing LW from 38 to 46 g·kg$^{-1}$ growth. Gross energy content also increased, due to the increase in fat accretion. The total accretion, as the sum of the four components, never equalled 1 000 as the components are part of the empty body, while the growth is expressed in kg LW.

Comparison (Tab. III) of our data with data of Limousin bulls [24] and German Friesian bulls [27] indicate that the BB dm bulls do not accrete more protein per kg gain than the Limousin bulls. On the other hand an important increase in fat accretion was found in Limousins in comparison with the BB dm bulls. The Friesian bulls [27] accrete importantly less protein per kg growth, especially at higher LW. For a comparable weight interval, fat accretion in BB dm bulls is extremely low when compared to the results of the Friesian bulls. The difference between the breeds increases with increasing LW. At 500 kg, the calculated fat content in one kg growth was 98 g for the BB dm bulls, 181 g for the Limousins and 504 g for the German Friesians.

When comparing both meat types, the lower fat content and the similar protein content within each kg growth implicate a smaller net energy requirement for tissue accretion in BB dm bulls than in Limousin bulls. This is shown in Table III, in which the energy accreted for each kg growth is listed for the different breeds and weight intervals. For BB dm bulls this energy retention varies from 7.57 to 9.68 MJ per kg growth, while for Limousins it varies from 8.49 towards 14.31. In the same table the percentage of the energy accreted as protein or fat is given for the different breeds and intervals. From these figures it is very obvious that throughout the whole LW interval more than 50% of the accreted energy is accreted as protein in BB dm bulls. For Limousins this figure decreased towards 31.8% and for German Friesians towards 12.5% at higher live weights.

Owens et al. [20] indicated that energetically, the efficiency of fat accretion is approximately 1.7 times that of protein. But because more water is stored with deposited protein than with deposited fat, lean tissue gain is four times as efficient as accretion of fatty tissue. This means that BB bulls do not only produce more meat at the same slaughterweight, but the energy cost to accrete each kg weight during growth is also much lower. This is in agreement with Greenhalgh [13] who concluded that the most effective way of producing lean meat without excessive fat is to use intact males of late maturing breeds, and to slaughter them while still immature. The BB dm bulls are therefore quite appropriate and efficient for beef production.

### 3.3. Caloric values

From the results of the energy determinations on the one hand and the protein and fat determinations on the other hand, caloric values for protein and fat were calculated. For the total body, energy content of one kg protein and one kg fat was 22.91 (± 0.90) and 38.74 (± 1.53) MJ. The corresponding values for the CC and the NCP were 23.46 (± 1.25) and 38.57 (± 3.04) $MJ \cdot kg^{-1}$, and 22.84 (± 0.89) and 37.54 (± 0.85) $MJ \cdot kg^{-1}$ respectively. These values are in accordance with figures found in literature (Tab. IV). Based on 6 references a mean caloric value

**Table IV.** Caloric values ($MJ \cdot kg^{-1}$) of protein and fat in the empty body.

| | Type of animals | Protein | Fat |
|---|---|---|---|
| Our results (mean ± standard error) | Belgian Blue double-muscled bulls | 22.91 ± 0.90 | 38.74 ± 1.53 |
| Literature | | | |
| Andrew et al. [1] | Holstein cows | 23.30 | 38.49 |
| Ferrell et al. [9] | Hereford heifers | 23.49 | 39.62 |
| Garrett and Hinman [11] | Hereford steers | 23.18 | 39.27 |
| Paladines et al. [21] | Sheep | 22.51 | 39.47 |
| Robelin and Geay [23] | Bulls of various breeds | 22.93 | 39.20 |
| Waldo et al. [31] | Holstein steers | 22.71 | 37.61 |
| Mean of 6 references | | 23.02 | 38.94 |

**Table V.** Means, standard deviations (SD) and ranges for the protein composition (%) of the carcass, the non-carcass parts and the empty body of 17 BB dm bulls.

| | Cys | Asp | Met | Thr | Ser | Glu | Pro | Gly | Ala | Val | Iso | Leu | Tyr[1] | Phe | His | Lys | Arg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Right carcass half | | | | | | | | | | | | | | | | | |
| Mean | **1.08**$^{a}$ | **8.84**$^{a}$ | **2.33**$^{a}$ | **4.08**$^{a}$ | **3.71**$^{a}$ | **15.57**$^{a}$ | **5.25**$^{a}$ | **7.71**$^{a}$ | **6.61**$^{a}$ | **4.79**$^{a}$ | **4.23**$^{a}$ | **7.53**$^{a}$ | **4.08**$^{a}$ | **3.84**$^{a}$ | **3.55**$^{a}$ | **7.37**$^{a}$ | **6.45**$^{a}$ |
| SD | 0.13 | 0.29 | 0.13 | 0.23 | 0.40 | 0.72 | 0.57 | 0.39 | 0.23 | 0.19 | 0.14 | 0.25 | 0.16 | 0.12 | 0.15 | 0.44 | 0.22 |
| MIN | 0.94 | 8.41 | 2.14 | 3.36 | 2.22 | 14.15 | 4.44 | 7.10 | 6.20 | 4.52 | 3.99 | 7.08 | 3.83 | 3.64 | 3.35 | 6.08 | 5.96 |
| MAX | 1.33 | 9.36 | 2.70 | 4.33 | 4.01 | 16.81 | 6.75 | 8.31 | 6.96 | 5.08 | 4.46 | 7.89 | 4.45 | 4.00 | 3.83 | 8.03 | 6.89 |
| Non-carcass parts | | | | | | | | | | | | | | | | | |
| Mean | **1.23**$^{b}$ | **8.01**$^{b}$ | **1.34**$^{b}$ | **3.45**$^{b}$ | **4.42**$^{b}$ | **12.68**$^{b}$ | **8.83**$^{b}$ | **15.06**$^{b}$ | **8.03**$^{b}$ | **4.55**$^{b}$ | **2.57**$^{b}$ | **6.63**$^{b}$ | **2.78**$^{b}$ | **3.78**$^{a}$ | **2.26**$^{b}$ | **5.59**$^{b}$ | **7.22**$^{b}$ |
| SD | 0.16 | 0.44 | 0.11 | 0.22 | 0.24 | 0.74 | 2.12 | 1.43 | 0.38 | 0.32 | 0.19 | 0.45 | 0.29 | 0.21 | 0.16 | 0.31 | 0.36 |
| MIN | 0.83 | 7.32 | 1.16 | 3.11 | 4.06 | 11.29 | 2.80 | 13.35 | 7.43 | 4.04 | 2.21 | 5.83 | 2.18 | 3.48 | 2.00 | 5.08 | 6.55 |
| MAX | 1.47 | 8.72 | 1.51 | 3.93 | 4.79 | 13.79 | 12.48 | 18.75 | 8.89 | 5.23 | 2.80 | 7.49 | 3.35 | 4.26 | 2.63 | 6.18 | 7.87 |
| Empty body | | | | | | | | | | | | | | | | | |
| Mean | **1.12** | **8.63** | **2.08** | **3.92** | **3.89** | **14.83** | **6.16** | **9.59** | **6.97** | **4.72** | **3.81** | **7.30** | **3.75** | **3.82** | **3.22** | **6.92** | **6.64** |
| SD | 0.11 | 0.30 | 0.12 | 0.21 | 0.32 | 0.69 | 0.81 | 0.58 | 0.21 | 0.18 | 0.15 | 0.27 | 0.19 | 0.13 | 0.13 | 0.38 | 0.22 |
| MIN | 0.95 | 8.11 | 1.88 | 3.29 | 2.77 | 13.37 | 4.57 | 8.81 | 6.54 | 4.44 | 3.56 | 6.90 | 3.50 | 3.63 | 3.04 | 5.81 | 6.16 |
| MAX | 1.33 | 9.06 | 2.38 | 4.21 | 4.19 | 16.00 | 8.26 | 10.70 | 7.31 | 5.05 | 4.04 | 7.79 | 4.18 | 4.05 | 3.47 | 7.41 | 7.15 |

[a,b] Means in the same column with equal superscripts are not significantly different ($P < 0.05$).
[1] Tyrosine recovery was only 65%, the values corrected to 100% are listed.

**Table VI.** Protein composition (%) of some data from literature.

| | Cys | Asp | Met | Thr | Ser | Glu | Pro | Gly | Ala | Val | Iso | Leu | Tyr | Phe | His | Lys | Arg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Williams et al. [32] (preruminant Friesian calves; n = 8) | | | | | | | | | | | | | | | | | |
| | 1.3 | 8.1 | 1.7 | 4.0 | 4.4 | 12.9 | 8.1 | 11.3 | 7.1 | 3.9 | 2.8 | 6.9 | 2.5 | 3.6 | 2.5 | 6.4 | 7.0 |
| Gerrits et al. [12] (Holstein Friesian × Dutch Friesian calves: 84 kg; n = 8) | | | | | | | | | | | | | | | | | |
| | 1.3 | 8.7 | 2.1 | 4.1 | 4.5 | 13.9 | 7.2 | 9.9 | 7.0 | 5.0 | 3.8 | 7.2 | 3.1 | 4.0 | 3.1 | 7.1 | 7.4 |
| Gerrits et al. [12] (Holstein Friesian × Dutch Friesian calves: 162 kg; n = 10) | | | | | | | | | | | | | | | | | |
| | 1.2 | 8.6 | 1.9 | 4.1 | 4.4 | 13.9 | 7.3 | 10.2 | 7.1 | 4.9 | 3.8 | 7.1 | 3.0 | 3.9 | 3.2 | 7.1 | 7.5 |

for protein and fat was found to be 23.02 and 38.94 MJ·kg$^{-1}$ respectively.

### 3.4. Protein composition

The data in Table V, on the protein composition of the CC, the NCP and the EB of the 17 homogenised bulls indicate that there is very little variation between animals in protein composition. Although protein compositions of the CC and of the NCP were quite comparable, the proportion of each amino acid in the CC protein is always, except for phenylalanine, significantly different from the proportion in the NCP protein. For five amino acids (methionine, proline, glycine, isoleucine and histidine) a difference of more than 50% was found between their proportion in the protein of CC and NCP. Glycine content in the protein of the NCP was 95% higher than in the CC protein. The proline content was most variable within the protein of the total EB (SD = 13%).

In general, amino acid composition of the protein was very constant over the considered weight interval (data not shown). For the carcass, only the proportion of tyrosine in the protein was significantly correlated with EBW ($r = -0.68$; $P < 0.01$). It should be reminded that tyrosine recovery was not 100% and therefore figures on tyrosine concentrations are less reliable. For the NCP proportions, three amino acids, glycine ($r = 0.78$, $P < 0.001$), alanine ($r = 0.57$, $P < 0.05$) and tyrosine ($r = -0.66$, $P < 0.01$), were significantly correlated with EBW. EB protein composition is calculated from carcass and non-carcass protein composition. Therefore, the amino acid proportions in the EB are always intermediate between those of the two compartments. The proportion of glycine and phenylanaline in the EB were significantly correlated with EBW: $r = 0.61$ ($P < 0.05$) and $r = -0.72$ ($P < 0.01$) respectively.

In literature very few data are available on protein composition in ruminants. Williams [32] analysed protein composition of 8 preruminant calves after total homogenisation. Gerrits et al. [12] analysed Holstein Friesian × Dutch Friesian calves at 83 and 162 kg. Their results (Tab. VI) are rather comparable with ours. This indicates that for ruminants protein composition is probably rather stable and universal. This is in agreement with Simon [28] who concluded that whole-body amino acid composition is comparable across species.

## 4. CONCLUSION

The composition of the BB dm bulls has revealed to be quite stable and to change only slightly and linearly with increasing live weight. From the compositional data it is obvious that the BB breed has a quite unique low-fat composition. This is not only interesting because the energy-input for accretion to reach a comparable slaughter-weight is much smaller, but also because a larger part of the energy retained in the animal can be consumed as lean.

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