Nutrient digestibility of veal calves fed large amounts of different solid feeds during the first 80 days of fattening

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Abstract

The study aimed at evaluating nutrients apparent digestibility in veal calves fed 3 feeding plans based on milk-replacer plus large amounts of solid feeds differing in their composition during the first 80 days of fattening. Twelve Polish Friesian male calves (70.6±1.9 kg) were randomly assigned to one of the following feeding treatments: i) milk-replacer plus corn grain (CG); ii) milk-replacer plus 80:20 mixture (as fed basis) of corn grain and wheat straw (CGS); and iii) milk-replacer plus 72:20:8 mixture of corn grain, wheat straw and extruded soybean (CGSES). Calves received the same milk-replacer but the daily amount was restricted (96%) for CGSES calves to balance dietary protein. Total dry matter intake from milk-replacer and solid feeds was similar among treatments, but CGSES calves showed better growth performance than CG ones. Calves were introduced into a metabolism stall (1/open) during week 9 of fattening for a 3-day adaptation period and a 4-day digestibility trial. Calves fed CG showed the greatest DM, NFC, and ash digestibility while CGSES calves showed the lowest CP digestibility. Haemoglobin concentrations measured at day 5, 31 and 80 were similar among feeding treatments and significantly decreased over time. In CGSES treatment, the combination of milk-replacer with solid feed closer to a complete diet for ruminants led to better calves’ growth performance. However, the reduced protein digestibility with CGSES indicates that protein quality becomes a key factor when formulating diets for veal calves using alternatives to dairy sources.

Introduction

Veal calf feeding in Europe has notably changed with the provision of small amounts of solid feeds along with the traditional all-liquid diet required by the specific legislation (European Commission, 1997, 2008). This EU directive specified that veal calves from 8 to 20 weeks of age should be provided daily with an increasing quantity of 50 to 250 g of fibrous feed. Although it was not indicated type and source, the solid feed should also contain sufficient iron to ensure a minimum average blood haemoglobin (Hb) level.

Solid feeding generally improved calf welfare, performance, health and meat quality (Veissier et al., 1998; Morisse et al., 2000; Mattiello et al., 2002). Solid feeds should promote rumen development through microbial proliferation and volatile fatty acids (VFA) production (Church, 1988). However, rumen development could be affected by solid feed composition and intake (Van Soest, 1994; Bannink et al., 2006). At this regard, several authors observed that feeding young calves a high proportion of concentrates or inadequate dietary fibre in terms of NDF content and/or physical characteristics negatively affected ruminal fermentation, animal metabolism and health (Suárez et al., 2006b, 2007).

Numerous studies were carried out aiming at assessing effects of different solid feed sources and roughage to concentrate ratios (R:C) on growth performance, forestomach development, health status, and meat quality (Cozzi et al., 2002; Mattiello et al., 2002; Di Giancamillo et al., 2003; Berends et al., 2012) but little information is available on digestive and metabolic utilization of nutrients from solid feeds in veal calves. Labussiere et al. (2008b) reported a reduced digestibility of nutrients from solid feeds compared to that of nutrients from milk-replacer, and of protein in particular, which is limiting for growth in the early stages of calf fattening. On the contrary, greater digestibility coefficients of starch and fibre from solid feed were estimated in pre-weaned calves compared to those in real ruminants (Huhtanen et al., 2006; Bhatti et al., 2008). Nowadays, the knowledge of the apparent nutrient digestibility of solid feeds becomes particularly important when considering the growing interest of veal calf farmers to feed them large amounts as partial substitute of expensive milk-replacers. However, the combined provision of milk and solid may affect dietary nutrient utilization (Berends et al., 2012) especially during the early stage of fattening when microbial fermentation and rumen development are still limited in veal calves (Suárez et al., 2006a, 2006b). Veal calf farmers in Italy are prone at using large amounts of corn grain as solid feed for economic reasons, and for its low iron content that keeps veal meat pale. A study from Prevedello et al. (2012), showed that when feeding large amounts of solids, it is advisable to avoid the provision of corn grain alone replacing part of the cereal with a roughage source in order to improve calf health and prevent rumen mucosa alterations. The present study aimed at evaluating nutrients apparent digestibility of veal calves fed three feeding plans based on milk-replacer plus large amounts of solid feeds differing in their composition during the first 80 days of fattening.

Materials and methods

This study was satellite to a wider research that aimed at fine-tuning veal calf diets promoting efficient use of concentrates and roughages.

Animals, feeding plans and management

The trial was carried out at a commercial veal calf farm located in the Veneto region, Italy, considering 12 of the 78 Polish Friesian male calves used by Prevedello et al. (2012). Calves were housed in collective pens of 5 or 6 animals each located in the same fattening unit after their balancing according to their initial BW. Calves housed in 5 contiguous pens
were allotted to one of the 3 feeding treatments: i) milk-replacer plus corn grain alone (CG); ii) milk-replacer plus a 80:20 mixture (as fed basis) of corn grain and wheat straw (CGS); and iii) milk-replacer plus a 72:20:8 mixture (as fed basis) of corn grain, wheat straw and extruded soybean, respectively (CGSES). Further details regarding the feeding plans and the experimental design are reported by Prevedello et al. (2012).

According to the feeding schedules of the farm, a starter milk-replacer containing 50% of skim-milk powder (Spraymes Rosso 50, Sloten Italia Srl, Crema, Italy) was provided during the first 3 weeks of fattening and then calves were gradually shifted to grower and finisher milk-replacer with 30% of skim-milk powder (Spraymes Verde Unico Energy 30, Sloten Italia Srl) (Table 1). During the first 80 days of fattening, the daily amount of milk-replacer powder and its concentration in the liquid diet progressively increased from 350 to 1600 g/calf (as fed) and from 6% to 9.6%, respectively, and milk was delivered in 2 equal meals at 07:00 and 17:00 h in individual buckets equipped with a teat. Type and concentration of milk-replacer were the same for the 3 treatments but CGSES calves were supplied with a restricted daily amount of milk-replacer (96%) to balance the higher protein content of the solid mixture including extruded soybean (Table 1). Administration of the different experimental solid feeds started on week 3 of fattening. In each group pen, solid feeds were distributed twice a day in a common manger right after the consumption of the milk-replacer, with calves individually separated by headlocks until most of the solid feed was consumed (approximately 30 min) in order to avoid competition among pen-mates. Regardless of the treatment, also the daily amount of solid feed was increased from the initial 50 to 800 g/calf (as fed) at day 80.

Dietary samples were collected and chemically analysed for dry matter (DM), crude protein (CP), ether extract (EE), ash, and iron content according to the methods of Association of Official Analytical Chemists (AOAC, 1990), and for NDF as proposed by Van Soest et al. (1991). The non-fibrous carbohydrate content (NFC) was calculated as 100 – (NDF+CP+EE+ash). The energy content of the diets was expressed in Unité Fourragère Viande units and was calculated using the INRA (1988) reference tables. Chemical composition of milk-replacers and solid foods provided during fattening are reported in Table 1.

**Experimental trial**

The study considered the first 80 days of fattening of the calves used for the digestibility trial. Calves were individually weighted at the arrival at the farm (d-0) and at day 80 to calculate their average daily gain (ADG) in this early stage of fattening. Daily feed intakes of milk-replacer powder and of solid feeds were measured by weighing the amounts delivered and the residual (in individual buckets for milk and in common manger for solid) and calculated by subtracting residual from delivered amounts and dividing for the number of pen-mates.

Individual blood samples were taken from the jugular vein after the morning feeding at day 5, 31, and 80 of fattening for analysis of Hb levels. Samples were collected using Vensafe tubes containing K3EDTA (Terumo Europe N.V., Leuven, Belgium) and Hb was measured by the automated analyzer Coulter STKS (Instrumentation Laboratories, Lexington, MA, USA). Calves that showed haemoglobin levels below 8.5 g/dL at the first Hb check or below the minimum legal threshold of 7.25 g/dL at the following checks were injected with iron dextrane (Endofer, Fatro Spa, Ozzano Emilia, BO, Italy) according to the protocol proposed by Cozzi et al. (2002).

The apparent nutrient digestibility trial was carried out during week 9 of the fattening by inserting 1 metabolism stall in 4 randomly selected pens per each feeding treatment. Each metabolism stall was 150 cm long and 60 cm wide and was equipped with a plastic pan located underneath the fully slatted floor for faeces collection. One calf per pen (4 calves/feeding treatment) was randomly selected and was introduced into the metabolism stall for a 3-day adaptation period and a 4-day digestibility trial. The calf in the metabolism stall could eat, drink, stand and lie, perform standing/lying transitions, and have visual and physical contact with pen-mates but could not turn around. Each calf had free access to drinking water provided in a bucket and milk-replacer and solid feed were supplied in the manger according to the regular feeding schedule of the farm for week 9. During the 4-day digestibility trial, individual daily intake of milk-replacer powder and of solid feed was calculated by weighing the amount distributed at each meal and the residual amount after the meal. Samples of milk-replacer and of solid feeds were taken at each meal and stored for laboratory analysis. The faeces produced by each calf during the 4-day digestibility trial were collected daily from the plastic pans underneath the floor slats. The individual faecal output was collected, thoroughly mixed, weighed and sampled. All samples were deep frozen at -18°C and stored until laboratory analysis. Right after thawing, samples were dried for 48 h at 60°C and ground in a Retsch GM 200 mill (Retsch Technology GmbH, Haan, Germany). Dry matter, CP, EE, and ash contents were analysed according to the methods of the Association of Official Analytical Chemists (AOAC, 1990), and NDF content was analyzed using reference values proposed by INRA (1988) for the solid feed ingredients. *Ingredient composition of starter: 50% skimmed milk powder, 22% whey powder, 18% oil and fat, 4% starch, 3% wheat protein, and 3% premix; ingredient composition of grower/finisher: 42% whey powder, 30% skimmed milk powder, 23% oil and fat, 2% starch, and 3% premix.*

**Table 1. Analysed nutrient composition (mean±standard deviation) of the feeds provided to veal calves throughout the fattening period.**

| Milk-replacer          | Solid feed (as fed basis) |
|------------------------|----------------------------|
| **Starter**            | **Grower/Finisher**        |
| DM, %                  | 96.5±0.2                   | 96.5±0.4                   |
| CP, % DM               | 23.8±0.6                   | 21.1±1.4                   |
| EE, % DM               | 18.7±0.3                   | 22.8±1.0                   |
| NDF, % DM              | 0.2±0.1                    | 0.4±0.1                    |
| NFC, % DM              | 49.9±0.4                   | 46.9±0.9                   |
| Ash, % DM              | 7.4±0.2                    | 7.8±0.3                    |
| Iron, mg/kg            | 5.6±0.8                    | 7.9±1.2                    |
| UFV, Ag DM             | 1.29                       | 1.09                       |

| Corn grain             | Corn grain+straw (80:20)   | Corn grain+straw+extruded soybean (72:20:8) |
| DM, %                  | 87.5±0.3                   | 88.3±0.8                   |
| CP, % DM               | 9.1±0.2                    | 8.0±0.1                    |
| EE, % DM               | 3.6±0.2                    | 3.1±0.4                    |
| NDF, % DM              | 10.7±0.4                   | 25.3±4.8                   |
| NFC, % DM              | 75.3±0.5                   | 61.5±4.9                   |
| Ash, % DM              | 1.3±0.1                    | 2.1±0.3                    |
| Iron, mg/kg            | 17.8±2.1                   | 32.1±4.2                   |
| UFV, Ag DM             | 1.29                       | 40.5±7.9                   |

DM, dry matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; NFC, non-fibrous carbohydrate content calculated as: 100 – (NDF+CP+ether extract+ash). UFV, Unité Fourragère Viande estimated using reference values proposed by INRA (1988) for the solid feed ingredients. *Ingredient composition of starter: 50% skimmed milk powder, 22% whey powder, 18% oil and fat, 4% starch, 3% wheat protein, and 3% premix; ingredient composition of grower/finisher: 42% whey powder, 30% skimmed milk powder, 23% oil and fat, 2% starch, and 3% premix.*
as proposed by Van Soest et al. (1991). The non-fibrous carbohydrate content (NFC) was calculated as 100 – (NDF+CP+EE+ash). Total tract apparent DM, CP, EE, ash, NDF, and NFC digestibility coefficients were calculated by the equation: (total nutrient consumed minus the nutrient excreted) divided for total nutrient consumed and expressed as percentages.

**Statistical analysis**

All data were at first submitted to descriptive statistics for location parameters (mean and standard deviation). The animal was the statistical unit for data recorded at individual level such as body weight, digestibility coefficients and haemoglobin concentrations. Pen was the statistical unit for feed intake data and ADG. Data regarding initial body weight, ADG, feed intake and digestibility coefficients (average of the 4-day trial) were submitted to one-way ANOVA with Proc GLM (SAS 9.2; SAS Institute Inc., Cary, NC, USA) and the model considered the feeding treatment effect. Body weights were analysed with a mixed model that considered the fixed effects of feeding treatment, weighing day (repeated option), and interaction feeding treatment × weighing day and the random effect of the animal within feeding treatment. Haemoglobin data were analysed with a similar mixed model that considered the fixed effects of feeding treatment, day of sampling (repeated option) and their interaction, and the random effect of the animal within feeding treatment. Differences were considered significant for P≤0.05.

**Results and discussion**

In the first 80 days of fattening, CGSES calves showed a higher final body weight and ADG compared to CG calves although DMI were similar among feeding treatments (Table 2). Milk-replacer intake resulted similar among feeding treatments despite the planned restriction for CGSES calves. Although roughage provision is known to reduce DMI in young cattle (Noces and Kesler, 1980), all calves consumed the entire amount of solid feed delivered regardless of the feeding treatment. In a previous study by Suarez et al. (2007), the substitution of corn with 30% of straw in the solid feed for veal calves reduced both, DMI and ADG in the first 10 weeks of fattening. In the current study, the substitution of corn grain with 20% of straw did not worsen and even improved CGS and CGSES calves’ growth performance, respectively. Moreover, the restriction to 96% of milk-replacer for CGS calves and its partial substitution by a solid feed mixture that included extruded soybean showed positive effects on growth in this early stage of fattening. This encouraging result might be linked to the orientation of the solid feed composition towards a more physiological diet for ruminants (Coverdale et al., 2004). Although the dietary iron provided by the 3 solid feeds was apparently different (Table 1), feeding treatments did not affect blood Hb concentrations (P=0.689) that were on average 9.9±0.7, 10.2±0.7, 10.8±0.7 g/dL for CG, CGS, and CGSES calves, respectively. A possible explanation for these unexpected results may be related to the lower bioavailability of iron from solid feeds rich in NDF such as those containing straw considering that this micro mineral is bound to the NDF fraction (Cozzi et al., 2002). As expected for veal calves from previous studies (Reece and Hotchkiss, 1987), haemoglobin levels in the current trial decreased over time and they were significantly lower (P<0.001) at day 80 compared to the preceding sampling.

![Figure 1. Blood haemoglobin concentrations (least means±SEM) of four veal calves per feeding treatment at days 5, 31 and 80 of fattening. CG, milk-replacer plus corn grain (black); CGS, milk-replacer plus a 80:20 mixture (as fed basis) of corn grain and wheat straw (white); CGSES, milk-replacer plus a 72:20:8 mixture (as fed basis) of corn grain, wheat straw and extruded soybean (gray). Different letters refer to the significant effect of the day of fattening for P<0.001. Modified from Prevedello et al. (2012).](image)

| Table 2. Growth performance and feed intake of calves (LSmeans±SEM) in the first 80 days of fattening. |
|---------------------------------------------------------------|------------------------------|-------------------------------|---------------------|
| Feeding treatment                                            | CG                           | CGS                          | CGSES              |
| Number of calves                                             | 4                            | 4                            | 4                  |
| Body weight, kg                                              | 72.8±1.9                     | 67.2±1.9                     | 71.9±1.9           | 0.121              |
| Day 1                                                        | 124.1±1.7                    | 127.7±1.8                    | 132.9±1.6          | 0.021              |
| Day 80                                                       | 712.7±22.4                   | 760.5±24.6                   | 818.8±21.4         | 0.021              |
| Average daily gain, g/d                                       | 1178.1±6.8                   | 1178.1±6.8                   | 1157.9±6.8         | 0.070              |
| Feed intake, g of DM/d                                       | 569.4±19.2                   | 576.4±19.2                   | 546.2±19.2         | 0.516              |

CG, milk-replacer plus corn grain; CGS, milk-replacer plus a 80:20 mixture (as fed basis) of corn grain and wheat straw; CGSES, milk-replacer plus a 72:20:8 mixture (as fed basis) of corn grain, wheat straw and extruded soybean; DM, dry matter.
days (Figure 1). A single CG calf was injected with iron after the first Hb check, none of the calves were injected after the second Hb check and one calf per feeding treatment was injected after the third check. There was no feeding treatment effect on the DMI also during the 4-day digestibility trial at week 9 of fattening (Table 3). Feeding treatments significantly affected apparent digestibility of DM, CP, NFC, and ash while no difference were observed for apparent digestibility coefficient of EE and NDF (Table 3). Calves fed CG showed the greatest DM digestibility compared to those fed CGS and CGSES, suggesting an improved feed efficiency in calves fed milk-replacer plus corn grain alone. This is in accordance with findings by Labussiere et al. (2008a) who reported that the inclusion of 11% of straw in the cur- rent study might also explain the lower apparent digestibility of CP, NFC, and ash in CGS and CGSES, suggesting an improved digestibility of CP, NFC, and ash in CGS and CGSES compared to CG calves. Calves fed CG showed intermediate digestibility coefficients for these nutrients. Digestibility of NDF did not differ among feeding treatments (Table 3) and this result was unexpected considering findings by Labussiere et al. (2008a) who reported lower NDF digestibility coefficients for veal calves fed a solid feed that included straw. Possible explanations for our results might be either a high individual variability or a similar degradation of this nutrient among feeding treatments. Support to the latter hypothesis might come from the fact that in veal calves small quantities of the solid feed enter the rumen at each meal allowing a longer retention time for fibrous particles and their more complete degradation by rumen microorganisms (Huhtanen et al., 2006; Bhatti et al., 2008). Regarding protein digestibility, Dawson et al. (1988) reported that pre-ruminant calves digest proteins from milk sources more efficiently than soy proteins. In our study, milk-replacers were mainly based on dairy proteins (Table 1) and consistent with the previous assumption, a higher CP digestibility was observed in calves fed the entire dose of milk-replacer (CG and CGS) compared to those for which milk-replacer was restricted and partially replaced by a vegetable protein source (CGSES). Therefore, since protein is the first factor limiting calves growth during the early stage of fattening (Roy et al., 1971), in order to avoid the waste of dietary protein, digestibility of vegetable sources should be carefully estimated when formulating feeding plans for veal calves in which a dairy-based milk-replacer is partially substituted by solid feeds in the first part of the fattening cycle.

Conclusions

The evaluation of the apparent nutrient digestibility of solid feeds in veal calves is important particularly when considering that the increasing prices of milk-replacer spurred farmers to partially replace liquid diet by fibrous feed and solid feeds became a consistent part of the diet. The positive effect observed on growth performance in the early stage of fattening with a solid feed mixture based on corn grain, straw and extruded soybean suggests a good potential of this feeding strategy. However, the lower protein digestibility of this solid feed mixture indicated that protein quality should be an important issue when formulating diets for veal calves in which milk-derived proteins are partially substituted by vegetable sources.

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