Effect of the administration of different levels of solid feed on production performance, welfare, health status and antibiotic use in veal calves for white meat production

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SUMMARY

The study aimed at evaluating the effect of five different levels of solid feed administration on production performance, animal welfare, health status and antibiotic use in veal calves for white meat production.

A total of 1750 male Friesian calves (49.61±2.06 kg initial live weight) were randomly divided into five different dietary treatments (193±2.59 days). The five experimental groups differed in terms of amount of solid feed (SF) and milk replacer (MR) administered during the entire fattening period: i) "Solid feed 180 kg" (SF180); ii) "Solid feed 225 kg" (SF225); iii) "Solid feed 270 kg" (SF270); iv) "Solid feed 330 kg" (SF330); v) "Solid feed 380 kg" (SF380). Growth performances were evaluated as final live weight (FW) and average daily gain (ADG). At slaughter, dressing percentage (DP), hot carcass weight (HCW), carcass colour classification, and percentage of calves with a carcass weight lower than 110 kg, were recorded. Welfare and health status were assessed in terms of morbidity, mortality, number of calves moved into hospital pen, haemoglobin value and the incidence of calves with haemoglobin level lower than 7.25 g/dL (4.5 mmol/L) at 80 days of breeding. Antibiotic use was included (grams of active principle/head). The results showed a positive effect of increasing solid feed in terms of production performance and health status. A solid feed administration higher than 225 and 330 kg, significantly improved the ADG (SF180: 1.12±0.08 kg/d; SF225: 1.13±0.08 kg/d; SF270: 1.17±0.07 kg/d; SF330: 1.19±0.06 kg/d and SF380: 1.23±0.07 kg/d) and the FW (SF180: 265.61±14.78 kg; SF225: 268.97±15.35 kg; SF270: 279.34±13.40 kg; SF330: 276.31±11.07 kg and SF380: 286.13±14.62 kg). Similar trends were found in HCW, with calves from the SF180 and SF225 groups showing the significantly lowest weights (SF180: 142.47±6.39 kg; SF225 143.66±7.07 kg), followed by SF270 and SF330 groups (SF270: 148.78±6.57 kg; SF330: 146.28±9.45 kg), and calves from SF380 the highest weight (SF380: 150.65±9.43 kg). The increase in solid feed administration reduced the incidence of carcasses in the «white» colour category, while it increased in the pinkish category. Administration of solid feed above 270 kg, significantly reduced morbidity and mortality, with lower values in groups SF380 (morbidity 20.00% and mortality 3.71%) and SF330 (morbidity 22.85% and mortality 4.29%) compared to groups SF270 (morbidity 25.71% and mortality 5.14%), SF225 (morbidity 28.57% and mortality 5.71%) and SF180 (morbidity 28.57% and mortality 5.43%). Consequently, a consumption of solid feed above 270 kg significantly reduced the use of antibiotics (SF180: 120.83±45.10 g/head; SF225: 124.11±45.46 g/head; SF270: 118.97±50.25 g/head; SF330: 105.57±41.67 g/head; SF380: 103.70±40.30 g/head). Higher solid feed administration significantly increased the haemoglobin level, with less calves with haemoglobin lower than 7.25 g/dL in group SF270 compared to SF225 and SF180 and in group SF330 and SF380 groups compared to SF270.

The results of the study show that the administration of solid feed oriented towards an ad libitum availability, significantly improves both welfare and growth performance, in agreement with the law's indications aimed at maximizing welfare and reducing the consumption of antibiotics in livestock production.

KEY WORDS

Veal calves; solid feed; antibiotics; welfare; performances.

INTRODUCTION

Worldwide, surplus male dairy calves are mainly used for veal production in specialized fattening units under intensive rearing conditions, to produce white meat. Europe raises about 6 million calves per year for veal meat, resulting in more than 1000 thousand tonnes of carcass weight, and Netherlands, Spain, France and Italy are the main producing countries, contributing respectively for 25.7%, 24.8%, 18.9% and 9.1% to the total veal meat yearly production[1]. Outside the EU, veal is also produced in the United States (Indiana, Michigan, New York, Ohio, Pennsylvania and Wisconsin) (6% of the global production), Canada (4%), Australia (4%) and New Zealand (3%)[2]. In the United States special-fed veal represents a 1-billion-dollar industry[3].

Traditionally, veal calves for white meat production, were feed for the hole fattening period with a low iron milk replacer and low amount of solid feed, to obtain the typical pale meat. This kind of management has been strongly criticized for poor animal welfare[4], because a too low amount of solid feed, limits

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the physiological development of the forestomach, and increase oral stereotypies, such as chewing, licking, tongue rolling[5,6], and digestive disorders, due to abomasal damages and hairballs formation in the rumen[7,8,9]. EU directive specified that veal calves from 8 to 20 weeks of age should be provided daily with an increasing quantity of at least 50 to 250 g of solid feed[4], but several evidences reported that this minimum amount of solid feed is still not enough to meet the real needs of the calves during the entire breeding period. Recent studies showed that the increase in the quantity of solid feed, even at six times higher than recommended, significantly reduced unnatural oral behaviours[10]. Also, calves free to choose the feed to eat, reconstituted milk, concentrate or long fodder, increased, between 3 and 6 months of age, from 25.0 ± 4.7% to 47.1 ± 2.1% the total amount of dry matter ingested from concentrate at the expense of milk, reaching a voluntary daily consumption of solid feed equal to 3205.5 ± 175 g of dry matter[11]. Berends et al. (2012a)[12] showed that an increase in the amount of solid feed inclusion in the diet, led to an improvement in growth performance.

Limitation in increasing solid feed administration is due to the increase in iron uptake that can alter the pale colour of the meat, impairing its marketability. However, Brscic et al. (2014)[13], found that feeding 140 kg of solid feed on dry matter basis in 201 days rearing period, did not affect carcass colour. Increasing solid feed administration without negative effect on carcass colour might reduce the production cost enhancing welfare[14]. Moreover, digestion disorders and not optimal physiological status also increases antibiotic consumption and antimicrobial use, and veal sector is one of the highest in drugs use of all food producing animal sectors[15,16]. For those reasons the correct balance between milk replacer and solid feed is fundamental to improve welfare but also to reduce the antimicrobial use, avoiding any negative potential effect on meat colour.

Thus, the aim of this study was to investigate the effect of different levels of solid feed and milk replacer administration on production parameters, health status and antibiotic use in white veal calves in an intensive rearing system.

MATERIALS AND METHODS

The study did not require any approval by the ethical board since no additional calf manipulations were needed. Calf haemoglobin was assessed on the blood samples routinely collected by the farm veterinary to comply with the minimum threshold value set by the European Directives on calf protection[4].

Farm and housing facilities

The study was carried out in commercial farm, located in Piemonte region in the north of Italy. According with the national and international laws, calves were housed individually for no more than the first eight weeks of life, and then in pens of five animals each[4]. The space allowance per animal was in line with legislation, both for the single cages (1.30 m length and 0.80 m width) and for the group pens (> 1.8 m^2/head). Calves were housed on slatted (< 2.5 cm) wooden floor, with a correct dimensioning of the manger (< 0.5 m/head). Calves were allowed to have social contact also in the individual cages thanks to the lateral partitions of cages that are provided with slotted fences. Fresh water is always available.

Feeding plan consists in two milk replacer meals (07:00 am 07:00 pm), and two solid feed administration after milk meal, starting from the second week of fattening The characteristics of milk replacer are reported in Table 1. All the calves receive the milk replacers in a bucket and the daily amount was delivered in two equal meals. The solid feed (Table 2), was administered in a dedicated bucket, starting from the second week of fattening and in quantities greater than the minimum amount required by law[4]. The solid feed was a mash between flakes cereals, meals cereals, meals protein raw materials, mineral and vitamin mix and pre-chopped and cleaned wheat straw. The quantities for milk replacer and solid feed were adjusted daily.

Animals and experimental protocol

A total of 1750 two weeks old Holstein Friesian male calves, were enrolled for the trial. At the arrival, all the calves were weighted (average initial weight of 49.61±2.06 kg) and randomly divided into five treatment groups (Table 3). All the calves were monitored for the entire fattening period, which lasted 193±2.59 days.

All the calves received the same type of milk replacers (MR) and also the same fibrous solid feed (SF). The five treatments groups involved 5 different increasing levels of solid feed administration, and a simultaneous parallel reduction of the milk replacer (Table 3).

Sanitary protocol

Animals were treated individually only after clinical signs of disease. Upon reaching specific morbidity thresholds, the entire group underwent metaphylactic mass treatment. Antibiotics administered were chosen by the veterinary staff of the farm accordingly with the Government and European guide lines to avoid antimicrobial resistant development.

Table 1 - Milk replacer characteristics.

Parameter, on as fed	Milk replacer
Humidity, %	6.00
Crude protein, %	20.00
Fat, %	18.30
Crude cellulose, %	0.40
Lactose, %	45.20
Starch, %	2.28
Ash, %	7.39
Iron, ppm	13.00

Table 2 - Solid feed characteristics.

Parameter, on as fed	Solid feed
Humidity, %	9.80
UFC, unit	1.10
Crude protein, %	14.50
Fat, %	4.45
NDF, %	17.25
Starch, %	45.65
Sugar, %	2.54
Ash,%	3.95
Iron, ppm	31.75

Table 3 - Groups and treatments.

Group	N° of calves	Initial weight, kg	Feeding treatment
SF180	350	48.97±2.12	180 kg solid feed, 360 kg milk replacer
SF225	350	49.37±2.34	225 kg solid feed, 330 kg milk replacer
SF270	350	49.66±1.62	270 kg solid feed, 300 kg milk replacer
SF330	350	50.23±2.02	330 kg solid feed, 265 kg milk replacer
SF380	350	49.81±2.19	380 kg solid feed, 235 kg milk replacer

Detected parameters

Growth performance and health

On day_0 (arrival), and three days before slaughter, all animals were weighed. The average daily gain (ADG) was then calculated. The total milk replacer and solid feed intakes were detected daily on the basis of the quantities effectively consumed every day. Then, the feed conversion rate (FCR) was calculated as follow:

$$FCR = \frac{Total\ MR\ intake\ (kg) + Total\ SF\ intake\ (kg)}{Weight\ gain\ (kg)}$$

Animals were inspected twice a day by the farm veterinary and technicians trained staff. Every case of morbidity was recorded as well as mortality. Every medical treatment, either individual or mass treatments, was reported. The grams of antibiotic used per head was then calculated on the basis of the concentration of the pharmaceutical product, the doses administered, and the number of treatments done. The calves that needed to be moved to the hospital pen were also registered. At the slaughterhouse the incidence of calves with a carcass weight lower than 110 kg, was recorded.

Haemoglobin level

Calves' haemoglobin levels and percentage calves with a level of haemoglobin lower than 7.25 g/dL were also used as health indicators. Haemoglobin concentration was assessed by the farm Veterinary to comply with the threshold value set by the European Directives (haemoglobin level must to be over than 7.25 g/dL or 4,5 mmol l^{-1})[4]. Haemoglobin was measured, for each calf, on blood samples collected at day_{80} of the fattening cycle, from the jugular vein after the morning feeding, and using vacutainer tubes containing K3 EDTA. On the basis of the haemoglobin level, calves with risk of becoming anaemic were treated with iron.

Table 4 - Total solid feed and milk replacer consumption.

Group	Milk, tot kg/head	Solid Feed, tot kg/head
SF180	345	170
SF225	320	225
SF270	300	270
SF330	270	335
SF380	240	400

Carcass characteristics and meat colour

Carcass weight was evaluated on hot carcass (HCW) and then dressing percentages (DP) were calculated from the following formula: Dressing % = (HCW/live weight) x 100.

Carcasses colour were assessed on cooled carcass at 24 hours post mortem, by a certified expert in carcass evaluation, using a 5-point scale, were 1 was the optimal colour (white) and 5 the worst and darkest colour (dark rose).

Statistical analysis

Data were analysed with the GLM (General Linear Model), procedure of SAS (version 9.3 - SAS Inst. Inc., Cary, NC, USA). The level of significance to indicate differences stated in the ANOVA model were $P<0.05$.

RESULTS AND DISCUSSION

Solid feed and milk replacer intake

Solid feed and milk replacer intake for the different groups, are reported in Table 4. Data showed an excellent correspondence with the theoretical amount planned by the protocol and the amount consumed along the study. Coherently with the objectives of the study, animals in the groups with the highest amount of solid feed were able to intake a higher amount of solid feed then predicted. Gottardo et al. (2000)[17] highlighted that veal calves are motivated to eat solid feed in an amount that clearly exceeded the amount recommended by animal welfare regulation directives. Webb et al. (2014)[11] showed that calves from 3 to 6 months of age, free to choose between long fodder, concentrate or reconstituted milk, increased the voluntary intake of concentrate at the expense of milk, reaching a daily consumption of solid feed higher than 3.2 kg of dry matter.

Growth performance

Growth performance and feed conversion rate are reported in Table 5. Calves from the SF180 group showed the lowest ADG (1.12±0.08) while the ADG significantly increased ($P<0.05$), as the solid feed intake increases, reaching the highest growth in the SF380 group (1.23±0.07). Significant differences were found between SF180 and SF225 in comparison to SF270 and

Table 5 - Growth performance.

Group	Fattening, day	Initial weight, kg	Final weight, kg	ADG, kg/head/day	FCR
SF180	193	48.97±2.12	265.61±14.78^a	1.12±0.08^a	2.38
SF225	194	49.37±2.34	268.97±15.35^a	1.13±0.08^a	2.48
SF270	197	49.66±1.62	279.34±13.40^b	1.17±0.07^b	2.48
SF330	190	50.23±2.02	276.31±11.07^b	1.19±0.06^b	2.68
SF380	192	49.81±2.19	286.13±14.62^c	1.23±0.07^c	2.71

*a,b,c= $P<0.05$

Table 6 - Health status: mortality, morbidity, antibiotic use, calves with carcass weight lower than 110 kg, calves moved to the hospital pen.

Group	Morbidity, %	Mortality, %	Antibiotic, g/head	HCW <110 kg, %	Moved to hospital pen, %
SF180	28.57[a]	5.43[a]	120.83±45.10[a]	6.00	1.71
SF225	28.57[a]	5.71[a]	124.11±45.46[a]	7.14	2.00
SF270	25.71[a]	5.14[a]	118.97±50.25[a]	6.00	1.71
SF330	22.85[b]	4.29[b]	105.57±41.67[b]	7.14	1.43
SF380	20.00[b]	3.71[c]	103.70±40.30[b]	5.14	1.43

*a.b.c = P<0.05

SF330 groups, and between those and SF380. The difference in average daily gain between SF180 and SF380 calves was 110 g/head/day. As a result, also the final weight was statistically improved by the increasing of solid feed intake, following a pattern similar to the average daily gain. Those results are in line with previous researches that reported an improvement in ADG in calves fed with a great amount of solid feed, starting from the early phases of fattening period[12]. Early administration of solid feed in correct amount, improved rumen development, triggering rumen fermentation and activity that led to volatile fatty acids production, especially butyrate, fundamental for the rumen papillae development[12,18]. Also, the physical structure of solid feed contributed to the muscular development and expansion of ruminal volume[19], and then to rumen efficiency[10,18,19]. Berends et al. (2012b)[20], in a study carried out on calves housed in metabolic chambers, also found a better nitrogen and energy retention when solid feed was fed in comparison to calves fed only with milk replacer, but also when the amount of solid feed administered increased. As the solid feed intake increases, the feed conversion rate (FCR) increased numerically, reporting a slight, numerical, negative effect of increased level of solid feed administration on feed efficiency. In fact, the SF180 group showed the lowest FCR (2.38) while increased gradually in the other groups, with only a numerical difference, with the SF380 showing the highest (2.71). Besides improving rumen activity and functionality, the increase in solid feed intake lowered the feed efficiency. In spite of it, improving rumen development and functionality enhances animal welfare and health, resulting in better growing performances and allows to use, in an efficient way anyway, different feed sources, more typical for a ruminant, that are not in competition with human nutrition. This can help in increasing the sustainability of the hole system.

Health status

Health status along the entire rearing period is reported in Table 6. The administration of higher amount of solid feed had a statistically positive effect on the main health indices as morbidity, mortality, and antibiotic consumption. Indeed, the increase of solid feed showed a significantly lower incidence of morbidity in group SF380 (20%), and SF330 (22.85%), followed by groups SF270, SF225 and SF180 (25.71%, 28.57% and 28.57%, respectively). Same trend was observed in mortality rate, with a reduction to the increase of solid feed administration, and the lowest significant value in group SF380 (3.71%) compared to all the others groups. Also, calves in group SF 330 (4.29%) showed a significantly lower mortality then calves in groups SF270, SF225 and SF180 (5.14%, 5.71% and 5.43%, respectively).

As a reflection of the lower morbidity and mortality, the antibiotic use significantly decreased as the consumption of solid feed increases. The groups SF180, SF225 and SF270 showed the highest antibiotic consumption per head (120.83±45.10, 124.11±45.46 and 118.97±50.25 g/head, respectively), while the groups SF330 and SF380 the lowest (105.57±41.67 and 103.70±40.30 g/head respectively) (P<0.05).

These results are consistent with those of Cozzi et al. (2002)[21], that reported a lower number of medical treatments for respiratory and gastrointestinal diseases in veal calves fed with higher amount of solid feed.

The improvement in health condition, increasing the solid feed administration, can be explained by the improvement in rumen development and activities, stress conditions reduction, and higher level of haemoglobin, with less risk of sub clinical and clinical anaemia[22,23]. Indeed, a greater availability of solid feed allows the rumen to an early and correct development, implementing natural behaviours such as rumination, with a significant reduction in chronic stress. Chronic stress strongly impairs immune system, increasing the probability for calves to contract pathologies, and then, increases antibiotics treatments[24].

Regarding the risk of anaemia, in Table 7 are reported the results of haemoglobin levels and incidence of calves with haemoglobin level lower than 7.25 g/dL. Average haemoglobin significantly increased as the solid feed intake increases. Statistical differences were found between groups SF180 and SF225 (8.38±0.74 and 8.42±0.63g/dL, respectively), and groups SF330 and SF380 (8.83±0.61 and 8.99±0.43 g/dL, respectively). In addition, no calves showed haemoglobin level lower than 7.25 g/dL in the groups SF330 and SF380, while groups SF180 and SF225, showed an incidence of calves with haemoglobin level lower than 7.25 g/dL, close to 10%. Increasing the solid feed administration along the fattening period from 225 kg to 270 kg, significantly reduced by 4 times the incidence of calves with haemoglobin lower than 7.25 g/dL.

These results are in line with the findings of previous researches that established a positive effect of solid feed intake on the

Table 7 - Health status: haemoglobin.

Group	Haemoglobin at d_{80}, average, g/dL	Haemoglobin <7.25 g/dL, %
SF180	8.38±0.74[a]	10.57[a]
SF225	8.42±0.63[a]	9.14[a]
SF270	8.62±0.59[ab]	2.00[b]
SF330	8.83±0.61[b]	0.00[c]
SF380	8.99±0.43[b]	0.00[c]

*a.b.c = P<0.05

Table 8 - Slaughtering performance.

Group	DP, %	HCW, kg	Colour 1, %	Colour 2, %	Colour 3, %	Colour 4, %	Colour 5, %
SF180	53.64±0.58^{a}	142.47±6.39^{a}	35.15^{a}	36.28	20.85	7.72^{a}	0.00
SF225	53.41±0.33^{a}	143.66±7.07^{a}	32.01^{ab}	34.57	23.42	10.00^{ab}	0.00
SF270	53.26±0.60^{ab}	148.78±6.57^{bc}	26.57^{bc}	32.00	26.29	15.14^{bc}	0.00
SF330	52.94±0.71^{ab}	146.28±9.45^{b}	25.71^{c}	29.73	25.71	18.57^{c}	0.28
SF380	52.65±0.88^{b}	150.65±9.43^{c}	27.42^{bc}	30.28	25.16	17.14^{c}	0.00

*a.b.c = P<0.05

haemoglobin level and in reducing the risk of anaemia in white veal calves, thanks to the iron content present in solid feed[21,22]. Studies also showed that pyloric lesions, the most common type of abomasal lesions in veal calves that contribute to increase morbidity and mortality, are reduced by the increase of solid feed intake[9].

No statistically significant differences were found in terms of calves moved to the hospital pen and in calves with a final carcass weight lower than 110 kg, signs of animals with poor health conditions and growth performance (Table 6).

Slaughtering performance and carcass colour

Data about slaughtering performance and carcass colour are reported in Table 8. In agreement with growth performance, the increase in solid feed administration significantly increased carcass weights. Groups SF180 and SF225 showed the lightest carcasses (142.47±6.39 kg and 143.66±7.07) and calves in group SF380 the heaviest (150.65±9.43 kg). A slight reduction in the dressing percentage is visible as the feed intake increases, with the group SF380 showing the significantly lowest dressing percentage (52.65±0.88%).

The increase in solid feed administration also affected carcass colour, and then the carcass distribution in the different colour classes. Higher level of solid feed corresponded to a statistical lower percentage of carcasses in the first colour category and, correspondingly, to a significant higher percentage of carcasses in the fourth category (P<0.05). Those result are mainly due to the higher iron content of the solid feeds that lead to a higher level of myoglobin in muscles, as demonstrated from several studies[21,22], and confirmed by the haemoglobin levels found in the calves from different groups. Studies showed that the increase in solid feed administration in veal calves for white meat production, doesn't affect the meat palatability traits, highlighting the absence of negative effects on consumer palatability satisfaction[25,26].

CONCLUSIONS

Results of the present study highlight that increasing the solid feed administration in veal calves for white meat production, effectively improve growth performance and animal welfare and health. Administration of solid feed in larger and increasing quantities, significantly reduce morbidity, mortality and the antimicrobial use. Considering the small negative effects found on carcass colour, the increase in solid feed administration in veal calves for white meat production, can much better satisfy the consumers demand with a product with higher value in terms of welfare and antibiotics use.

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