Textured vs pelleted feed impact on dairy heifers pre-weaning

Laura Marchia, Francesca Degola∗, Rosario Pitino, Afro Quarantelli, Marica Simon.

a University of Parma, Department of Medicine and Surgery, Parma, Italy
b University of Parma, Department of Veterinary Science, Parma, Italy
c University of Parma, Department of Chemistry, Life Sciences and Environmental Sustainability, Parma, Italy

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The first three months of life is the most critical period for the young calf, and nutrition plays an essential role for a successful weaning program. The effects of starter feed physical form have been widely investigated in the last decades, but results are variable and often inconsistent. We compared the impact of texturized and pelleted starters on growth performances during the artificial pre-weaning period on replacement female dairy calves. A total of 16 calves were divided in two independent groups, fed with pelleted or texturized starter and monitored from 2 to 44 days of life. Morphometric traits as well as health status, growth performances, feed intake and efficiency were recorded weekly. An interesting significance (p=0.013) was found for the weight increment, that starting from 5th week showed higher values in animals fed with texturized rather than pelleted feedstuff, although no differences were obtained for the feed efficiency. Despite the lack of significant differences, the trends observed for weight increment and health status, suggest some advantages in the use of texturized feedstuff during the pre-weaning period.

Keywords: calves pre-weaning nutrition, texturized feed, growth performances

1 Introduction

Calves management has been demonstrated to exert a major effect on the rearing costs, due to the high requirements in terms of care time expenditure and nutrition handling, especially during the pre-weaning period. The first three months of life is the most critical period for the young calf, due to environmental and nutritional stressors, hence the success of this phase strongly depends on a sound nutritional program. Early and restricted-milk feeding weaning strategies have been applied to contain feeding cost of rearing young calves (Boulton et al., 2015, Boulton et al., 2017), and to promote starter feedstuff consumption in dairy calves. One of the major critical points is the correct development of the reticulorumen, which is undeveloped at birth and requires considerable metabolic alterations (such as the establishment of a microbial ecosystem) as well as morphological modifications (such as rumen mucosae papillae and rumen wall muscle development) in order to switch to solid feeding (Khan et al., 2016, Ragionieri et al., 2016, Baldwin et al., 2004). Dating back to the work of Newman and Savage (1938) who compared the efficacy of dry calf-starter feedstuff with mixture texture modifications, the effects of starter feed physical form have been widely investigated. Authors found that young dairy calves fed with a partially pelleted starter feedstuff grew at slightly slower rates than calves fed with unpelleted starters, being the pelleted feedstuff less palatable to calves from 2 to 6 weeks of age. As reported by Terrè et al. (2015), feeding a texturized starter feed containing rolled barley, corn and oats (with or without straw provision) was not able to maintain rumen pH or promote growth and intake compared with offering a pelleted starter feed with chopped straw. However, when whole corn was used in the texturized starter feed, rumen pH was equivalent to that obtained with a pelleted starter feed and straw supplementation. On the other hand, when evaluating the effects of pelleted feedstuff as complete or complementary diet component, Lassiter et al. (1955) demonstrated

∗ Corresponding author: Francesca Degola, University of Parma, Chemistry, Life Sciences and Environmental Sustainability, Parco delle Scienze 11/A, Parma, Italy. E-mail: francesca.degola@unipr.it
that no nutritional advantages were found to feed starters in a pelleted format to calf, even though the calves fed pelleted starter had a slightly higher intake than the others. The interest on the role of the physical structure and composition of feeds during weaning period is still driving researches in the last decades, as several studies recognized that initiation of solid feed intake and its composition could affect ruminal development and, in turn, many aspects of animal growth performances (Bach et al., 2007, Porter et al., 2007, Tamate et al., 1962, Sutton et al., 1963). In fact, under artificial rearing, an even and balanced transition from liquid to solid feeding allows the physical and metabolic development of the rumen, the improvement of the salivary apparatus, the rumination behavior onset and tissues adaptation. This represent a key factor to achieve levels of solid feed consumption and digestion capable to sustain growth during and after weaning (Khan et al., 2011). The rumen development results greatly influenced by the nature and the amount of solid feed consumed, since carbohydrates are considered easily fermentable and thus thought to stimulate rumen development also through changes in the forestomach epithelium (Baldwin et al., 2004). In addition, and especially when the particle size of starter feedstuff is not adequate, the introduction of some dietary fiber is recommended in order to maintain abrasion and peeling effect in rumen and avoid its abnormal development in young calves (Greenwood et al., 1997). However, due to the potential accumulation of undigested fiber, this can lead to a decrease in voluntary intake of starter feedstuff (Drackley, 2008). It has been pointed out that texturized feeds seem to increase starter feedstuff intake in comparison to pelleted starter feedstuff, but such intake is not always accompanied by improvements in growth performances (Bach et al., 2007; Porter et al., 2007). The present field-controlled study is aimed at comparing the impact of textured and pelleted starters on growth performances during the artificial weaning of replacing female calves including the evaluation of economic aspects related to the application of the two different feedstuffs physical forms.

2 Material and methods

The study was conducted following the Directive 2010/63/EU guidelines ruling the care and use of experimental animals.

2.1 Farm measurements and health score

A farm located in the North of Italy (N 44.668, E 10.514) was involved in the trial and 16 replacing Holstein female calves born between January and May were observed from the end of the colostral phase until 44 days of life. Animals were subjected to a long-term weaning program (60 days of life). The total experimental period lasted 42 days. Body weight (BW), height at withers (HW), height at rump (HR), heart girth circumference (CRF) and rump width (CW) were measured weekly, for a total of six measurements for each trait. Feed consumption and animal health were checked daily, in order to add feedstuff and begin therapies if needed. Moreover, fecal score was evaluated weekly as described by Larson et al. (1977), i.e. 1 = normal, 2 = soft, 3 = runny, 4 = watery.

Feed intake was determined and recorded weekly based on the feed administered and orts. Feed efficiency (FE) was calculated as a ratio between average daily gain (ADG) and the sums of daily feedstuff and daily milk intake on a dry matter (DM) basis. Crude protein intake (CPI) was calculated as sum of feedstuff CPI (on DM basis) and milk CPI (on DM basis). The crude protein (CP) efficiency was calculated as ADG/CPI.

2.2 Housing management and weaning protocol

Calves were fed with 6 L d⁻¹ of colostrum within 4 h from birth, until 2 d of age. After the colostral phase, two groups of eight randomly selected female calves were separated and assigned to “Texturized feedstuff” (Te) and “Pelleted feedstuff” (Pellet) groups. Each calf was housed in individual pen (1.0 × 1.6 m), located in a well-ventilated barn, sanitized and bedded with straw during the whole trial. Bedding was refreshed daily. Calves of both groups from the third day of life were fed with 5 L d⁻¹ of pasteurized whole milk administered twice daily (at 07:00 am and 7:00 pm) until 60 days of age. Milk was administered at the temperature of 40 °C. The related feedstuff and water were available ad libitum.

2.3 Feed composition

Both pelleted and texturized feedstuff supplied in the present study had the same formulation and therefore the same chemical composition (Table 1), and consisted of a mixture of (on DM basis): flaked maize (10.00%), cracked maize (13.19%), beet pulp shreds (24.95%), soybean meal (12.92%), whole soybean rolled (11.48%), carob pulp (7.86%), soybean hulls (3.69%), sunflower meal (4.19%), rolled barley (2.04%), maize cake (2.03%), oat hulls (1.70%), dry ear maize ground (1.21%), barley...
meal (0.81%), cane molasses (0.69%), calcium carbonate (0.72%), monocalcium phosphate (0.44%), sodium bicarbonate (0.35%), sodium chloride (0.59%), dry yeast from Saccharomyces cerevisiae (0.26%), mineral-vitamin premix (0.88%).

Table 1 Chemical composition expressed on a dry matter (DM) basis of calf starter feedstuff stated on the label

| Item          | Starter feedstuff (%) |
|---------------|------------------------|
| DM (% as fed) | 87.00                  |
| EE            | 4.36                   |
| CP            | 17.01                  |
| Cellulose     | 13.22                  |
| Lignin        | 3.24                   |
| aNDFom        | 25.63                  |
| Starch        | 21.98                  |
| Ash           | 8.62                   |

1DM - dry matter; EE - ether extracts; CP - crude protein; aNDFom - amylase treated neutral detergent fibre ash corrected.

2Feedstuff ingredients (DM basis): cracked maize 23.19%, beet pulp shreds 24.95%, soybean meal 12.92%, whole soybean rolled 11.48%, carob pulp 7.86%, sunflower meal 4.19%, soybean hulls 3.69%, rolled barley 2.04%, maize cake 2.03%, oat hulls 1.70%, dry ear maize ground 1.21%, barley meal 0.81%, cane molasses 0.69%, calcium carbonate 0.72%, sodium chloride 0.59%, monocalcium phosphate 0.44%, sodium bicarbonate 0.35%, dry yeast from Saccharomyces cerevisiae 0.26%, mineral-vitamin premix 0.88%. The mineral vitamin premix was composed per kg: 25,000 U.I. Vitamin A, 2,000 U.I. Vitamin D3, 50 mg Vitamin E (alfatoc. 91%), 8 mg Vitamin B1, 10 mg Vitamin B2, 7.5 mg Vitamin B6, 0.03 mg Vitamin B12, 100 mg Vitamin PP, 0.2 mg Biotin, 1,000 mg choline chloride, 100 mg Fe, 50 mg Zn, 20 mg Cu, 50 mg Mn, 0.5 mg Co, 2 mg I, 0.25 mg Se.

The difference between the pelleted and texturized feedstuff was only their physical form: the pelleted starter was composed only by maize flakes (10% on DM basis) and pellet particles of 5 mm of diameter and 15 mm in length including all the other ingredients. The texturized starter feedstuff was mainly composed by flaked and cracked maize, rolled barley and soybean, carob pulp and maize cake particles, and a small proportion of pellets (5 mm of diameter and 15 mm in length). The latter included all the remaining listed ingredients.

The pasteurized whole milk was sampled at the beginning of the trial and chemically analyzed as described in Righi et al. (2016); it was composed (on DM basis) of 26.15% CP, 28.46% EE and 37.69% lactose.

2.4 Statistical analysis

Weekly measures (morphometric traits, BW, intake, ADG, FE and CP efficiency) of each group were analyzed using the repeated measures procedure of the General Linear Model of the SPSS for Windows software package (version 26.0; SPSS Inc., Chicago, IL). Group, interval and their interaction were used as fixed factors. Body weight, HW, HR, RW and CRF at each interval were covaried for their value at the beginning of the experiment, while ADG, weight increment, starter intake and CPI were covaried for BW at the beginning of the trial. Data were reported as least squares means and statistical significance was set at p≤0.05.
3 Results and discussion

The fecal score was monitored within the experimental period as health indicator, and no significant differences were found between groups, with average values of 1.99 in the Te group and 1.86 in the Pellet group (Figure 1). In partial agreement with the average score observed, it should be highlighted that Quigley et al. (2018) found higher fecal scores when texturized feedstuff was administrated to calves.

![Fecal score](image)

Figure 1 Influence of feedstuff physical form, pelleted (Pe) and texturized (Te), on feces quality, observed from 2 to 44 days of age. Mean Fecal score values for the entire treatment period are represented. Error bars represent standard error of the mean.

Morphometric evaluation underlined that no differences between the two treatments were obtained for BW, HW, HR, RW and CRF during whole experiment. As expected, the week factor was significant for BW, HR and CRF (\(p \leq 0.001\), \(p = 0.032\) and \(p = 0.003\), respectively) as a consequence of the physiological growth of the calves (Table 2).

The ADG during the experimental period did not differ between groups (Table 3). The interaction between treatment and week was significant for weight increment (\(p = 0.013\)); such evidence was thought to be consistent with the numerical variations in BW values. As reported by Mirzaei et al. (2016) calves fed texturized starter feedstuff have greater intake and weight gain when compared with those fed pelleted starter feedstuff. However, in the cited work ingredients and nutrients composition of the feedstuff used were not the same, limiting the comparability of the results.

Cumulative starter consumption (CSC) was measured within both the whole period of pre-weaning and single intervals: the CSC measured in Te group was slightly lower than CSC measured in the Pellet group, until 44 days after birth.

Results regarding feed intake are presented in Table 4. Globally, treatments did not differ in CSC, starter DMI and total CPI; however, it was observed that CSC values were slightly lower in Te group than in Pellet group, with a tendency (\(p = 0.089\)) only in the 2nd week of treatment.

Our results appeared in contrast with findings of Mirzaei et al. (2016), who showed higher consumption of texturized feed in animals offered corn silage as fibers source. On the other hand, according to our results, Terré et al. (2015) reported that the absence of differences between DMI and total DMI could be attributed to the physical form of the starter feedstuff. It should be stressed that our results refer to calves from 2 to 44 days of age, and that different observation could be obtained for older animals, as demonstrated by Pazoki et al. (2017).
Table 2  Morphometric measurements of pelleted (Pellet) and texturised (Te) feedstuff supplied to pre-weaned calves observed from 2 to 44 days of age

| Trait        | Treatment | Weeks | overall | SEM  | p-value |
|--------------|-----------|-------|---------|------|---------|
| BW (kg)      | Pellet    | 42.3  | 43.6    | 46.7 | 50.4    | 53.6    | 57.1    | 49.0 | 0.83 | 0.847 ≤0.001 | 0.108 |
|              | Te        | 40.8  | 42.2    | 46.1 | 51.3    | 55.3    | 60.3    | 49.3 |
|              | SEM       | 1.12  | 1.27    | 1.15 | 1.42    | 1.21    | 1.26    |      |
|              | P-value   | 0.175 | 0.426   | 0.781 | 0.753  | 0.512   | 0.241   |      |
|              | Pellet    | 78.1  | 79.4    | 80.4 | 81.4    | 82.8    | 84.4    | 81.1 | 0.16 | 0.977 0.515 0.998 |
|              | Te        | 78.0  | 79.1    | 80.2 | 81.5    | 82.9    | 84.7    | 81.1 |
|              | SEM       | 0.76  | 0.87    | 0.72 | 0.56    | 0.53    | 0.50    |      |
|              | P-value   | 0.954 | 0.844   | 0.859 | 0.886  | 0.891   | 0.820   |      |
| HW (cm)      | Pellet    | 82.2  | 83.4    | 83.3 | 86.4    | 87.5    | 89.1    | 85.3 | 0.36 | 0.624 0.032 0.839 |
|              | Te        | 82.7  | 82.8    | 83.3 | 85.1    | 87.1    | 88.8    | 85.0 |
|              | SEM       | 0.70  | 0.65    | 0.77 | 0.67    | 0.61    | 0.55    |      |
|              | P-value   | 0.678 | 0.557   | 0.964 | 0.205  | 0.776   | 0.787   |      |
| HR (cm)      | Pellet    | 18.0  | 18.4    | 18.9 | 19.9    | 20.3    | 21.3    | 19.5 | 0.37 | 0.503 0.291 0.971 |
|              | Te        | 17.9  | 18.2    | 18.6 | 19.5    | 20.0    | 21.0    | 19.2 |
|              | SEM       | 0.17  | 0.23    | 0.20 | 0.30    | 0.26    | 0.42    |      |
|              | P-value   | 0.711 | 0.745   | 0.518 | 0.594  | 0.595   | 0.682   |      |
| RW (cm)      | Pellet    | 78.5  | 79.2    | 82.6 | 85.7    | 85.9    | 89.2    | 83.5 | 0.57 | 0.787 0.003 0.570 |
|              | Te        | 76.9  | 78.7    | 83.2 | 84.4    | 86.8    | 89.5    | 83.2 |
|              | SEM       | 0.83  | 0.90    | 1.10 | 1.02    | 0.66    | 0.78    |      |
|              | P-value   | 0.135 | 0.606   | 0.751 | 0.512  | 0.551   | 0.874   |      |
| CRF (cm)     | Pellet    | 78.5  | 79.2    | 82.6 | 85.7    | 85.9    | 89.2    | 83.5 | 0.57 | 0.787 0.003 0.570 |
|              | Te        | 76.9  | 78.7    | 83.2 | 84.4    | 86.8    | 89.5    | 83.2 |
|              | SEM       | 0.83  | 0.90    | 1.10 | 1.02    | 0.66    | 0.78    |      |
|              | P-value   | 0.135 | 0.606   | 0.751 | 0.512  | 0.551   | 0.874   |      |

T - treatment; W - week; T*W - interaction treatment per week; BW - body weight; HW - height at withers; HR - height at rump; RW - rump width; CRF - heart girth circumference.
Data were covaried as follows: BW=40.33 kg, HW=76.33 cm, HR=79.89 cm, RW=17.59 cm, CRF=76.36 cm

Table 3  Average daily gain (ADG) and weight increments of calves fed pelleted (Pellet) and texturised (Te) starter feedstuff observed from 2 to 44 days of age

| Trait        | Treatment | Weeks | overall | SEM  | p-value |
|--------------|-----------|-------|---------|------|---------|
| ADG (kg d⁻¹) | Pellet    | 0.295 | 0.166   | 0.445 | 0.426   | 0.391   | 0.388   | 0.35 | 0.038 | 0.333 0.521 0.394 |
|              | Te        | 0.062 | 0.167   | 0.596 | 0.596   | 0.410   | 0.663   | 0.42 |
|              | SEM       | 0.078 | 0.074   | 0.086 | 0.064   | 0.104   | 0.099   |      |
|              | P-value   | 0.154 | 0.994   | 0.364 | 0.209   | 0.933   | 0.154   |      |
| Weight       | Pellet    | 2.01  | 3.24    | 6.40  | 10.07   | 12.12   | 16.81   | 8.44 | 0.842 | 0.670 ≤0.001 0.013 |
| increment (kg)| Te        | 0.48  | 1.83    | 5.80  | 10.97   | 14.68   | 21.48   | 9.20 |
|              | SEM       | 0.542 | 0.818   | 1.103 | 1.374   | 1.226   | 1.871   |      |
|              | P-value   | 0.175 | 0.426   | 0.781 | 0.753   | 0.242   | 0.108   |      |

T - treatment; W - week; T*W - interaction treatment per week.
Data covaried by initial BW at 40.33 kg
### Table 4  Cumulative starter consumption (CSC), weekly starter dry matter intake (Starter DMI) and total crude protein intake (Total CPI) of calves fed pelleted (Pellet) or texturized (Te) starter feedstuff observed from 2 to 44 days of age

| Trait                     | Treatment | Weeks          | overall | SEM | T  | W  | T*W |
|---------------------------|-----------|----------------|---------|-----|----|----|-----|
| CSC (kg)                  | Pellet    | 0.44 1.09 1.90 2.81 4.17 6.07 | 2.75 0.240 0.386 0.602 0.863 |
|                           | Te        | 0.25 0.59 1.38 2.37 3.63 5.73 | 2.32 |
|                           | SEM       | 0.089 0.161 0.210 0.260 0.366 0.526 |
|                           | P-value   | 0.272 0.089 0.232 0.420 0.501 0.765 |
| Starter DMI (kg week⁻¹)   | Pellet    | 0.44 0.55 0.81 0.92 1.36 1.91 | 1.00 0.091 0.809 0.662 0.843 |
|                           | Te        | 0.25 0.33 0.79 0.99 1.27 2.09 | 0.95 |
|                           | SEM       | 0.089 0.087 0.148 0.120 0.201 0.285 |
|                           | P-value   | 0.272 0.134 0.956 0.800 0.839 0.766 |
| Total CPI (g d⁻¹)         | Pellet    | 28.8 30.1 34.9 33.7 40.8 54.0 | 37.0 1.45 0.589 0.823 0.940 |
|                           | Te        | 25.5 26.4 34.4 35.0 39.5 51.9 | 35.5 |
|                           | SEM       | 1.63 1.38 2.31 1.74 3.09 4.94 |
|                           | P-value   | 0.348 0.162 0.909 0.726 0.853 0.844 |

T – treatment; W – week; T* - interaction treatment per week; Total CPI - total crude protein intake from milk and feedstuff.
Data covaried by initial BW at 40.33 kg

### Table 5  Effect of different feedstuff physical form, pelleted (Pe) and texturized (Te), on feed efficiency (FE) cumulative FE and crude protein (CP) efficiency in calves observed from 2 to 44 days of age

| Trait            | Treatment | Weeks          | overall | SEM | T  | W  | T*W |
|------------------|-----------|----------------|---------|-----|----|----|-----|
| FE               | Pellet    | 0.83 1.38 8.07 5.3 0.05 2.97 | 3.10 2.352 0.117 0.667 0.587 |
|                  | Te        | 23.43 14.86 11.64 6.12 4.41 | 5.61 11.08 |
|                  | SEM       | 13.327 5.567 3.379 0.868 2.438 | 1.026 |
|                  | P-value   | 0.422 0.222 0.650 0.980 0.389 | 0.385 |
| Cumulative FE    | Pellet    | -0.79 3.52 4.40 4.06 3.49 | 3.33 3.00 2.111 0.413 0.616 0.409 |
|                  | Te        | 23.40 6.00 5.68 5.79 4.95 | 4.82 7.34 |
|                  | SEM       | 13.310 3.240 1.020 0.685 0.487 | 0.530 |
|                  | P-value   | 0.388 0.912 0.912 0.462 0.257 | 0.327 |
| CP efficiency    | Pellet    | 9.65 4.72 14.19 13.15 8.96 | 9.70 10.06 1.234 0.226 0.039 0.497 |
|                  | Te        | 2.53 7.08 18.53 17.25 11.96 | 19.54 12.81 |
|                  | SEM       | 3.023 2.665 3.175 2.019 3.209 | 3.046 |
|                  | P-value   | 0.254 0.676 0.516 0.330 0.659 | 0.108 |

T – treatment; W – week; T*W - interaction treatment per week
As for other features, FE has been reported both in cumulative terms and in relation to week (Table 5). No differences between the two treatments were found, although numerically higher values of FE and cumulative FE were observed in Te group compared to the Pellet group. The CP efficiency was estimated (Table 5) and no difference between groups was observed. Despite the absence of significance, the results seem to indicate a better performance of the texturized feedstuff especially in terms of efficiency, thus supporting the weight increment. However, controlled studies involving a higher number of animals and including further indicators for the description and monitoring of the digestion process, as well as feeding behavior observation, should be addressed to obtain stronger evidences concerning feedstuff performance.

4 Conclusions

In conclusion, the use of a texturized feedstuff with a coarser physical form instead of pelleted feedstuff did not seem to affect growth performance or health status during pre-weaning period. However, some trends related to weight increment suggest a better performance for the Te group of calves compared to calves fed pelleted starter feedstuff.

Acknowledgments

We are indebted with Dr. Davide Polvere for data collection, and with Prof. Federico Righi for the technical supervision.

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