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Textured vs pelleted feed impact on dairy heifers pre-weaning

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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

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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[1] (% DM)	Starter feedstuff[2]
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

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

[2]Feedstuff 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 $p \leq 0.05$.

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.

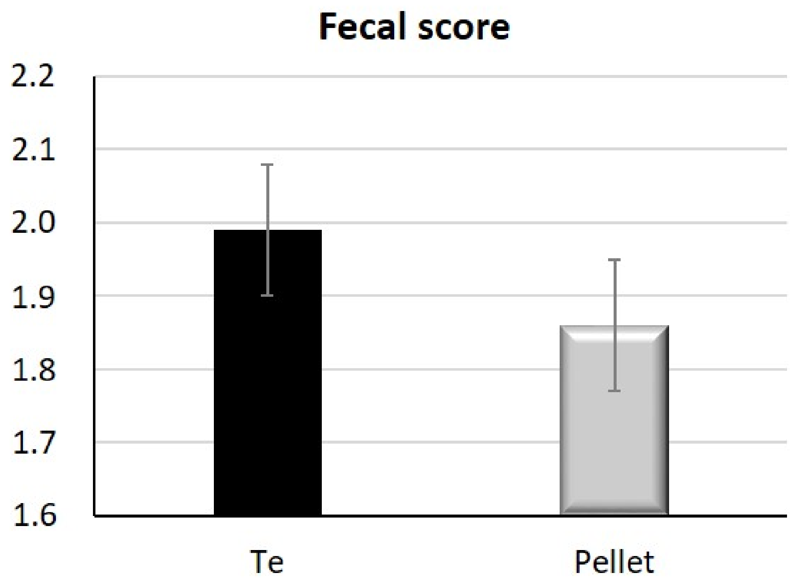

Figure 1 Influence of feedstuff physical form, pelleted (Pe) and texturized (Te), on feces quality, observed from 2 to 44 days of age. Mean Fecal score values for the entire treatment period are represented. Error bars represent standard error of the mean

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 2^{nd} 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		
		1	2	3	4	5	6			T	W	T*W
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					
HW (cm)	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					
HR (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					
RW (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					
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 pelletted (Pellet) and texturised (Te) starter feedstuff observed from 2 to 44 days of age

Trait	Treatment	Weeks						overall	SEM	*p*-value		
		1	2	3	4	5	6			T	W	T*W
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 increment (kg)	Pellet	2.01	3.24	6.40	10.07	12.12	16.81	8.44	0.842	0.670	≤0.001	0.013
	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	*p*-value		
		1	2	3	4	5	6			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	*p*-value		
		1	2	3	4	5	6			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.

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References

Bach, A. et al. (2007) Effects of physical form of a starter for dairy replacement calves on feed intake and performance. *Journal of Dairy Science.* 90, 3028–3033. doi:https://doi.org/10.3168/jds.2006-761

Baldwin, R. L. VI et al. (2004) Rumen development, intestinal growth and hepatic metabolism in the pre- and post-weaning ruminant. *Journal of Dairy Science.* 87(E Suppl.): E55–E65. doi: https://doi.org/10.3168/jds.S0022-0302(04)70061-2

Boulton, A. C. et al. (2015) A study of dairy heifer rearing practices from birth to weaning and their associated costs on UK dairy farms. *Open Journal of Animal Sciences* 5, 185–197.

Boulton, A. C. et al. (2017) An empirical analysis of the cost of rearing dairy heifers from birth to first calving and the time taken to repay these costs. *Animal*. doi: https://doi.org/10.1017/S1751731117000064

Drackley, J. K. (2008) Calf nutrition from birth to breeding. *Veterinary Clinics of North America: Food Animal Practice Special.* 24, 55–86. doi: https://doi.org/10.1016/j.cvfa.2008.01.001

Franklin, S.T. et al. (2003) Health and performance of Holstein calves that suckled or were hand-fed colostrum and were fed one of three physical forms of starter. *Journal of Dairy Science.* 86, 2145–2153.

Greenwood, R. H. et al. (1997) A new method of measuring diet abrasion and its effect on the development of the forestomach. *Journal of Dairy Science.* 80, 2534–2541. doi: https://doi.org/10.3168/jds.S0022-0302(97)76207-6

Khan, M. A. et al. (2011) Invited Review: Effects of milk ration on solid feed intake, weaning and performance in dairy heifers. *Journal of Dairy Science.* 94, 1071–1081. doi: https://doi.org/10.3168/jds.2010-3733

Khan et al. (2016) Invited review: Transitioning from milk to solid feed in dairy heifers. *Journal of Dairy Science.* 9, 885–902*.* doi*:* https://doi.org/10.3168/jds.2015-9975

Larson, L. L. et al. (1977) Guidelines toward more uniformity in measuring and reporting calf experimental data. *Journal of Dairy Science.* 60, 989–991.

Lassiter, C.A. et al. (1955) The nutritional merits of pelleting calf starters. *Journal of Dairy Science.* 38, 1242-1245.

Mirzaei, M. et al. (2016) Interactions between the physical form of starter (mashed versus textured) and corn silage provision on performance, rumen fermentation, and structural growth of Holstein calves. *Journal of Animal Science*. 94(2):678-686. doi: https://doi.org/10.2527/jas.2015-9670

Newman P.E. and Savage E.S. (1938) Use of Yeast in Calf Meals and Pellets. *Journal of Dairy Science.* 21: 161-167.

Olynk. N. J. and Wolf, C. A.(2008) Economic analysis of reproductive management strategies on US commercial dairy farms. *Journal of Dairy Science.* 91, 4082–4091. doi: https://doi.org/10.3168/jds.2007-0858

Pazoki, A, et al. (2017) Growth Performance, Nutrient Digestibility, Ruminal Fermentation, and Rumen Development of Calves During Transition From Liquid to Solid Feed: Effects of Physical Form of Starter Feed and Forage Provision. *Animal feed science and technology*, 234, 173-185. doi: https://doi.org/10.1016/j.anifeedsci.2017.06.004

Porter, J. C. et al. (2007) Effect of fiber level and physical form of starter on growth and development of dairy calves fed no forage. *Professional Animal Scientist.* 23, 395–400. doi:https://doi.org/10.15232/S1080-7446(15)30994-3

Quigley, J. D., et al. (2018). Effects of feeding milk replacer at 2 rates with pelleted, low-starch or texturized, high-starch starters on calf performance and digestion. *Journal of Dairy Science*. 101(7), 5937-5948.

Ragionieri, L, et al. (2016) Annals of Anatomy Effect of the supplementation with a blend containing short and medium chain fatty acid monoglycerides in milk replacer on rumen papillae development in weaning calves. *Annals of Anatomy* 207:97–108.

Righi, F.et al. (2016). Feeding a free choice energetic mineral-vitamin supplement to dry and transition cows: Effects on health and early lactation performance. *Large Animal Review.* 22(4), 161–170.

Sutton, J. D. et al. (1963) Functional development of rumen mucosa. I. Absorptive ability. *Journal of Dairy Science*. 46, 426–436.

Tamate, H. et al. (1962) Effect of various dietaries on the anatomical development of the stomach in the calf. *Journal of Dairy Science*, 45, 408–420. doi: https://doi.org/10.3168/jds.S0022-0302(62)89406-5

Terré, M. et al. (2015) Interaction between the physical form of the starter feed and straw provision on growth performance of Holstein calves, *Journal of Dairy Science,* 98(2), 1101-1109. doi: https://doi.org/10.3168/jds.2014-8151

von Keyserlingk, M. A. G. et al. (1998) A comparison of textured versus pelleted concentrates on rumen degradability, dry matter intake, milk yield and composition in lactating Holstein cows. *Canadian Journal of Animal Science.* 78(2), 219-224.