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EFFECT OF PHYSICAL FORM OF STARTER FEED ON INTAKE, GROWTH RATE, BEHAVIOR AND HEALTH STATUS OF FEMALE DAIRY CALVES

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Abstract

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The aim of the experiment was to compare the effect of physical form of starter feed on growth and development of dairy calves until 70 days of age. Forty female Black and White calves at one day of age and average live weight (LW) of 39.2 kg are divided in four equal groups with respect to date of birth and LW. Calves were kept in individual hutches with straw bedding. Treatments were four physical forms of starter feed: a) Whole maize grain plus pelleted protein concentrate (WMP); b) Pelleted starter feed (PSF); c) Starter in meal form with coarsely grounded maize (MSF); and d) 95% MSF + 5% Nutrilait (contains 35% whey powder) (MSN). The ingredient and nutrient composition of the four starter feeds were similar, except for replacing 5% of dry distiller's grain with soluble with Nutrilait in the starter feed for the fourth group. The calves from the 4 groups received per feeding 2 L colostrum the first two days, gradually increasing the quantity of milk until 6 days of age, and 4 L per feeding unmarketable pasteurized whole milk afterwards until 56 days of age. First three days liquid feed was provided three times a day, from 4 to 35 days of age twice, and from 36 to 56 days of age once per day. From 35 days of age all calves were provided alfalfa hay *ad libitum*. Intake of milk, starter feed, and hay was recorded every day. Live weight and frame size (withers heights and heart girth) were measured at birth, on 35, 56 and 70 days of age. Health status, fecal score, beginning of eating dry feed and rumination, time spent eating and ruminating and behavior of calves were observed and recorded. There were no significant differences in the intake of different starters, both pre- and post-weaning. Live weight gain, frame size gain and feed efficiency of calves receiving different starters feed were practically similar. There were no differences in health status and fecal scoring of calves from the four groups. Results showed that starter with whole maize grain and pelleted starter allowed similar intake, performance and health status to those of calves fed starters with coarsely ground maize. Inclusion of Nutrilait (whey) into the starter didn't affect the intake of starter and average daily gain of calves. There was a tendency for earlier initiation of rumination in calves receiving whole maize grain or pelleted starter, than in calves fed starters in meal form. Eating time was significantly longer, and there was a tendency for increasing rumination time, when calves received whole maize grain, compared to other starters. Starter of whole maize and pelleted supplement (protein, mineral and vitamin), and starter in meal form were cheaper than pelleted starter and starter with dry whey supplementation for improving palatability. In conclusion, the starter with equal ingredient and nutrient composition in coarsely ground or pelleted form, and starter of whole maize plus pelleted protein concentrate ensured equal gain, feed efficiency and health of calves. Chewing of feed was longer when whole maize was offered to calves.

Key words: calves, physical form of feed, whole grain, pellet, ground, intake, growth, size of body, health, fecal score

Abbreviations: CP – crude protein; DDGS – dry distillers grain with solubles; DM – dry mater; LW – live weight; FUG – feed units for growth; MSF – meal starter feed; MSN – meal starter with Nutrilait (whey); PSF – pelleted starter feed; WMP – whole maize grain plus pelleted protein concentrate

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Introduction

Calves generally do not like finely ground (meal) feeds, and palatability and intake are usually lower than other types of feeds. Long time ago, Lassiter et al. (1955) found that calves consume more pelleted starter, compared to meal starter feed. Recently textured calf starters with corn flakes and pelleted supplements, which have increased volume and palatability compared to meal and pelleted starters became popular (Franklin et al., 2003; Ghassemi Nejad et al., 2012). Some researchers also used successfully whole corn grains plus pelleted protein concentrate (Chester-Jones et al., 1991; Owens et al., 1997; Bateman II et al., 2009; Terré et al., 2015).

Results from experiments about intake and performance of calves receiving starters in different physical forms are inconsistent. Some authors reported higher intake and LW gain when ground starters were replaced with pelleted (Ghassemi Nejad et al., 2012) or textured (steam-flaked) starter (Owens at al., 1997; Ghassemi Nejad et al., 2012). However, Porter et al. (2007) found that calves consumed more coarsely ground than pelleted starter. Franklin et al. (2003) reported higher intake and average daily gain of calves fed textured starter than calves fed pelleted starter.

There are publications showing better gain of calves receiving starter with whole grain, compared to ground starter (Owens et al., 1997), and starter with dry rolled grain (Chester-Jones et al., 1991). On the contrary, other authors found better results with pelleted starters (Khan et al., 2007) or with ground starter (Beharka et al., 1998) than when calves were fed whole grain.

Bittar et al. (2009) evaluated pelleted or coarsely ground starter, and have not identified the effect of the physical form on feed intake, body weight, and daily gain. Similar results reported Ghorbani et al. (2007) in feeding trials with finely ground or the pelleted form of similarly formulated starters. In a number of trials, the physical form of calf starter did not affect intake and performance (Bateman II et al., 2009; Bagheri et al., 2005; Zhang et al., 2010; Terré et al., 2015).

Crocker et al. (1998) reported that starch digestibility was the highest in steam-flaked grains, followed by finely ground, and then dry-rolled grains, and was the lowest in whole grains. Zhang et al. (2010) found that stem flaking improved feed efficiency compared to that of calves consuming other form of starter. Bach et al. (2007) reported better feed efficiency for pelleted starter, compared to multiparticle (textured) starter.

Lesmeister and Heinrichs (2004) reported that rumen development, blood volatile fatty acids concentrations, and ruminal propionate production were enhanced by incorporation of steam-flaked corn into the calf starter, but the intake, feed efficiency, and growth were negatively influenced. However, the optimal combination of feedstuffs required for optimal rumen development remains unclear.

It is important that young calves start early to consume starter to support rapid rumen development and to enable early weaning. Some researchers found a positive effect of inclusion of ingredients improving taste, as milk products (Mareu et al., 2013), vanilla (Fathi Nasri et al., 2009), or sucrose (Montoro et al., 2009), and other substances in calf starters.

The objective of this experiment was to compare the effects of coarsely ground starter, pelleted starter, and starter with whole maize plus pelleted supplement on intake, growth, feed efficiency, health and behavior in female dairy calves. The second objective was to estimate the effect of adding dry whey to ground starter on its palatability, and the intake and performance of calves.

Materials and Methods

Forty female one day old calves of Black and White Breed were assigned in four experimental groups (10 calves each) equalized by weight at birth, and parity of dam (first or second and next calving). The trial was carried out in a large dairy farm (in Popovitsa village, Plovdiv Province) with 2300 dairy cows artificially inseminated with female sexed semen. The calves included in the trial were born within one-week interval. All calves were housed in individual hutches (100 x 150 cm) bedded with straw.

All calves received 2 L colostrum in three feedings (total 6 L/day) in the first two days after birth. The first day, high quality (above 50 g immunoglobulin per/L) colostrum from their mother or refrigerator-stored was used. The second day calves received 2 L available colostrum in three feedings, usually medium or low quality colostrum, from second and third milking after calving of cows. On the third day of life, calves were fed 6 L transition milk in 3 feedings.

From the fourth day of age whole pasteurized unmarketable milk was provided. Pasteurization was at 60^0C for 30 minutes. The calves were offered milk twice a day from 4 to 35 days of age at the following quantity: 4^{th} day 2.5 L, 5^{th} day 3 L, 6^{th} day 3.5 L and from 7^{th} to 35^{th} days 4 L. From 36 to 56 days of age calves received 4 L once a day to stimulate dry feed consumption. After weaning at 57 days of age calves remained in the hutches for a fortnight to control the effect of weaning on their gain, development and behavior. Total intake of colostrum and milk from one calf was 352 L or 44.25 kg milk DM. The scheme of feeding of individual calves depended on their age.

Average data from weekly analyses of pasteurized milk by Milkoscan FT-120 (Foss, Denmark) were 12.38% DM,

3.76% fat and 3.30% protein content. According to Todorov et al. (2007) 1 kg milk and colostrum dry matter has 2.327 feed units for growth (FUG).

Experimental treatments were feeding starter with similar ingredients and nutrients content, and differed only in their physical form: a) starter composed of whole maize grain plus pelleted protein concentrate (WMP); b) Pelleted starter feed (PSF); c) Starter in meal form with coarsely ground maize (MSF); and d) 95% MSF + 5% Nutrilait (contains 35% whey powder) (MSN). Nutrilait (Uclab industry, France) contains micronized soy meal, dry whey, wheat meal and rapeseed oil. One kilogram Nutrilait has 1.25 feed units for growth (FUG), 285 g crude protein, 15 g crude fiber, 40 g crude fat, 5.5 g calcium and 3.3 g phosphorus.

Grinding of maize was rough with 4 mm sieve in hammer mill and there was not a significant amount of fines. Pellets were medium hard and there were no fine particles in the feeds. The starter feed was pelleted at 4 mm of diameter and 12 mm in length. All starter feeds were offered *ad libitum*, but the remaining feed was removed every morning and new feed was provided. Ingredients and chemical composition of experimental starters are shown in Table 1.

Alfalfa hay was provided to calves after 35 days of age *ad libitum*. One kilogram hay has 85% DM, 0.61 FUG and 153 g CP or 0.72 FUG and 180 g CP in 1 kg DM. Clean water was offered in bucket from the 4th day of age, and was changed with fresh water every morning.

Offered milk, starter feed and alfalfa hay, and also refusals were measured daily, and intake calculated daily on an individual basis. Feed units for growth (FUG, equivalent to 6 MJ net energy for growth) according to Bulgarian energy evaluation system were estimated in daily calf rations using published data (Todorov et al., 2007). Total feed and milk DM and FUG per 1 kg live weight gain were calculated for different experimental periods and groups.

Live weight (LW) of calves and size growths (withers height and heart girth) were measured at birth, 35, 56 and 70 days of age.

Table 1
Composition of experimental starters

Items	WMP♣	PSF♣	MSF♣	MSN♣
Ingredients	%	%	%	%
Maize, different form	50	50	50	50
Protein concentrate	50			
Sunflower meal	10.0*	10	10	10
DDGS from maize	20.0*	20	20	15
Canola meal	18.55*	18.55	18.55	18.55
Nutrilait (35% whey)	0	0	0	5
Limestone	1.2*	1.2	1.2	1.2
TMV premix♦	0.25*	0.25	0.25	0.25
Total	100	100	100	100
Energy and nutrients in 1 kg				
Dry matter, g	858	860	876	876
FUG**	1.27	1.28	1.3	1.3
Crude protein, g	195	195	199	200
Crude fiber, g	66.3	66.5	67.7	63.9
Ether extracts, g	38.8	38.9	39.6	37.9
Calcium, g	6.39	6.4	6.52	6.61
Phosphorus, g	5.35	5.36	5.46	5.47

* As a component of pelleted protein concentrate
** Feed units for growth according to Todorov et al. (1995)
♦ Trace mineral-vitamin premix contains per 1 kg: 6 000 000 IU vitamin A, 800 000 IU vitamin D_3, 25 000 mg vitamin E, 60 000 mg manganese, 12 000 mg copper, 60 000 mg zinc, 240 mg cobalt, 780 mg iodine, 240 mg selenium
♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter wit Nutrilait

Fecal output was scored daily throughout the trial for consistency (1 = normal, firm, 2 = soft, spreads easily, 3 = very soft or runny, 4 = watery, liquid consistency and mucus or trace of blood), and for odor (1 = normal, 2 = slightly offensive, 3 = offensive, and 4 = highly offensive). The beginning of eating, beginning of rumination, and vocalizing (bellowing) was observed for 2 hours each day 4 h after morning milk feeding from 4 to 35 days of age. Incidence and duration of health disorders and treatments were observed and recorded every day during the experiment. Duration of eating, rumination, and non-feeding oral behavior, as nose licking, movement of jaw without regurgitating etc. was recorded on 5 calves per group in 4 consecutive days for 6 h from 6:00 – 12:00, 12:00 – 18:00, 18:00 – 24:00 and 24:00 – 6:00 h during 67 – 70 days of calves' age.

DM, crude protein, crude fiber, ether extract, calcium and phosphorus in feeds are determined according the methods described by AOAC international (2007).

Data were analyzed for statistical significance of differences using the mixed procedure of SAS (2003).

Results and Discussion

Intake of dry feeds was practically equal during the different periods of the trial in spite of methods of processing grain and physical form of starters (Table 2). There was a slight tendency for consuming more starters with whole maize grain plus pelleted protein concentrate, and pelleted starter feed between 36 to 56 days of age, compared to starters in meal (ground) form, but this was not the case after weaning of calves.

Published experiments are equivocal about intake of ground, pelleted and texturized calf starters. Bagheri et al. (2005), Ghorbani et al. (2007) and Bittar et al. (2009) did not find differences in the intake of pelleted and ground starter, while Bateman II et al. (2009) reported reduced intake of starter by 6% with significant amount of fines and decreased average daily gain by 11%, compared to textured or dry rolled starter. Owens et al. (1997) found lower intake of finely ground starter than starter with whole grain or texturized starters. Ghassemi Nejad et al. (2012) also reported low-

Table 2
Consumption of starter, alfalfa hay, total dry matter and feed units for growth (FUG) of calves at different age in days (d)♦

Items	WMP♣	PSF♣	MSF♣	MSN♣
Starter DM intake, kg				
Birth to 35 d	6.01	5.49	5.65	5.98
36 to 56 d	18.53	18.25	17.39	17.78
57 to 70 d	28.9	29.98	30.11	29.07
Birth to 70 d	53.44	53.72	53.15	52.83
Hay DM intake, kg				
36 to 56 d	2.8	3.1	3.3	2.9
57 to 70 d	3	3.3	3.5	3.2
36 to 70 d	5.8	6.4	6.8	6.1
Total DM intake, kg*				
Birth to 35 d	39.86	39.34	39.5	39.83
36 to 56 d	31.73	31.75	31.09	31.08
57 to 70 d	31.9	33.28	33.61	32.27
Birth to 70 d	103.49	104.37	104.2	103.18
Total FUG intake**				
Birth to 35 d	87.66	86.94	87.15	87.64
36 to 56 d	53.64	53.6	52.38	52.67
57 to 70 d	44.94	47	47.2	45.44
Birth to 70 d	186.24	187.54	186.73	185.75

♦ Differences between groups were not significant (P>0.05)
♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter with Nutrilait (whey)
* Sum of colostrum (18%DM), milk, starter feed and hay
** Feed units for growth (FUG) according to data of Todorov et al. (2007). One FUG is equal to 6 MJ net energy for growth

er intake of ground starter than pelleted or texturized starter. Evidently the intake of ground starter depends too much on the method of grinding and amount of fines. When maize was coarsely ground, without much fine particles, consumption of starter by young calves was not decreased, compared to pelleted, texturized or other forms of starter.

Starter composed of whole grains plus pelleted protein concentrate (WMP group) was consumed as well as pelleted (PSF) and ground starters (MSF and MSN group) (Table 2). Therefore our results don't agree with Beharka et al. (1998) which observed lower intake of starter with whole grains than starter with ground grain. They attributed the decreased intake to increased time of rumination and decreased rumen liquid flow rate.

In contrast to the present study, other studies (Franklin et al., 2003; Bach et al., 2007; Porter et al., 2007) reported that calves offered meal, multiparticle or texturized starter feeds consumed more concentrate than calves fed a pelleted starter feed.

Strusińska et al. (2009) found that during the first 30 days of life, feed intake and daily gain were higher when calves were fed a diet containing ground cereal components, than whole grains. Khan et al. (2007) showed that calves fed pelleted starter with maize consumed more feed and gained greater LW than those fed starter with whole barley, oat, and wheat during pre- and post- weaning period. However, when coarsely ground starter was fed, Coverdale et al. (2004) showed that calves consumed more dry matter and the LW gain was higher, compared to calves fed finely ground starter.

It seems that controversial experimental results depended on fineness of grinding of grain, because differences related to processing were not so substantial. In spite of the effect on intake the particle size of the ration determines the abrasive value of the feedstuff rather than chemical composition, thus explaining the impact on papillae development and health.

We did not found increased intake when milk product (dry whey) was included in starter (MSN) in meal form (Table 2).

Different physical forms of starters did not affect alfalfa hay consumption by calves. Because of the abundantly offered milk, the intake of starter feed and hay was relatively small, especially pre-weaning. Similar intake of milk, starter and hay lead to similar consumption of DM and net energy (FUG) by calves (Table 2).

Very small differences in DM and FUG intake by the four groups of calves resulted in similar live weight of calves and average daily gain during the different periods of the trial (Table 3). Feed and net energy efficiency also did not differ significantly. Unexpectedly, the ratio of net energy (FUG) to live weight gain was lower from 36 to 56 days of age (when calves received half of milk, compared to the previous period) than before 36 days of age. The average for four groups' expenditure of FUG per 1 kg LW gain was 3.65 until 35 days, and 3.46 from 36 to 56 days of age. Differences were probably connected with higher fat content of diet with 8 L whole milk containing 3.76% fat, and deposition in the body of calves of more fat than after decreasing twice the milk. The higher average daily gain during 36 – 56 days of age may also play some role in decreasing FUG to LW gain ratio. However it was not known if gut fill was not greater at 56 days than on 35 days of age, because calves consumed much more dry feeds with lower digestibility than milk, predominating feed before 35 days of age. During the milk feeding period, ratios of FUG to LW gain were almost equal in the four groups, but this was expected because of equal milk consumption and very small difference in starter and hay intake between the groups.

Similar LW gain of calves receiving pelleted or ground starter was reported also by Bagheri et al. (2005), and Bittar et al. (2009), while Ghassemi Nejad et al. (2012) concluded that the calves receiving pelleted starter, had significant higher average daily gain than those receiving ground starter.

Khan et al. (2007) showed that calves fed pelleted starter consumed more feed and gained greater LW than those fed starter with whole grains during pre- and post- weaning period. However Terre et al. (2015) found that calves receiving whole corn plus protein supplement have the same gain with calves fed pelleted starter.

Whole corn in starter ensures better rumen parameters. Jarrah et al. (2013) compared coarse ground, whole, steam-rolled and roasted barley as components of calf starter and did not detect any effect on DM intake, average daily gain, feed efficiency, skeletal growth, health and rumen pH. Similar performance and starter intake were reported when calves were fed textured, coarsely ground starters, or pelleted starters (Franklin et al., 2003).

Offering rolled and whole grains as compared to a finely ground starter improved feed efficiency, growth, and body weight of dairy calves (Coverdale et al., 2004).

Frame (skeletal) size growth of calves fed starter in different physical forms was very similar (Table 4). There was a slight tendency towards higher growth in calves fed whole maize starter and pelleted starter.

No differences were observed in health status of calves and consistency and odor of faeces (Table 5).

Calves receiving starter with dry whey (MSN group) tended to start eating about two days earlier compared to calves receiving starter in the same physical form, but without milk

Table 3
Live weight (LW), live weight gain and feed efficiency at different age in days (d)*

Items	WMP♣	PSF♣	MSF♣	MSN♣
Live weight, kg				
at birth	38.9	39.2	39.4	38.8
on 35 d	62.8	62.9	63.2	63.1
on 56 d	78.3	78.4	78.2	78.4
on 70 d	91	91.6	90.4	90.4
LW gain, kg				
Birth to 35 d	23.9	23.7	23.8	24.3
36 to 56 d	15.5	15.5	15	15.3
57 to 70 d	12.7	13.2	12.2	12
Birth to 70 d	52.1	52.4	51	51.6
LW gain, g/day				
Birth to 35 d	683	677	680	694
36 to 56 d	738	738	714	729
57 to 70 d	907	943	871	857
Birth to 70 d	744	749	729	737
DM♦/LW gain				
Birth to 35 d	1.64	1.64	1.64	1.62
36 to 56 d	2.05	2.05	2.07	2.03
57 to 70 d	2.51	2.52	2.77	2.69
Birth to 70 d	1.98	1.98	2.03	1.99
FUG♦♦/LW gain				
Birth to 35 d	3.67	3.67	3.66	3.61
36 to 56 d	3.46	3.46	3.49	3.44
57 to 70 d	3.54	3.56	3.87	3.79
Birth to 70 d	3.57	3.58	3.66	3.6

♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter wit Nutrilait
* Differences between groups were not significant (P>0.05)
♦ Sum of colostrum, milk, starter feed and hay
♦♦ Feed units for growth (FUG)

Table 4
Withers height and heart girth in calves at different days (d) of age*

Items	WMP♣	PSF♣	MSF♣	MSN♣
Withers height, cm				
at birth	77.39	77.9	77.94	77.02
on 35 d	84.5	84.9	84.82	84.09
on 56 d	89.8	90.31	89.52	89.17
on 70 d	91.7	91.89	91.04	90.6
Heart girth, cm				
at birth	83.5	83.7	83.9	83
on 35 d	91	91.9	92.3	91.1
on 56 d	97.9	98.4	98.5	98
on 70 d	101.9	102.8	102.5	102.1

♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter wit Nutrilait
* Differences between groups were not significant (P>0.05)

products (MSF group) (Table 6). However later, the difference in intake of starter between the two groups although in favor of MSN group was insignificant (Table 2).

Significant differences existed in time spent by calves eating starter with whole grain compared to other starters (Table 6). Taking into account longer rumination time it was clear that calves made more chewing movements when consumed whole maize. This meant secretion of more saliva, and better buffering of rumen content. This fact is important because pH of rumen content of preweaned calves was usually very low (below 5.5) (Jarrah et al., 2013), which don't allow cellulolytic populations of bacteria to thrive. The calves receiving whole maize spent much shorter time for non-feeding behavior than calves in the other groups.

Initiation of rumination was 5 days earlier in calves receiving whole maize and 3 days earlier in calves fed pelleted starter, compared to calves receiving ground starter (Table 6). These tendencies were evidently connected with the physical form of dry feed, but not with quantity of consumed dry feed (see Table 2).

Lesmeister and Heinrichs (2004) reported that a texturized starter feed containing whole corn resulted in greater rumen pH in calves compared with those containing dried-rolled corn, roasted-rolled corn, or steamflaked corn, which would be consistent with whole corn requiring more chewing and saliva secretion than the other processed forms of corn.

There were significant differences in the cost of 1 ton starter and cost of starter per 1 kg LW gain in calves. The cheapest feeding was that with whole maize grain plus pelleted concentrate, followed by feeding the meal form of starter (Table 7). Pelleted starter cost was by 22% more, and starter with additive for increasing palatability (dry whey) by 21% more, than starter with whole grain. The order of cost of starter per 1 kg LW gain was approximately the same.

Table 5
Average fecal scores*

Items	WMP♣	PSF♣	MSF♣	MSN♣
Average fecal score				
Consistency	1.2	1.3	1.4	1.3
Odor	1.2	1.1	1.3	1.2
Fecal scores ≥3, sum for group, days				
Consistency, d	7	10	10	9
Odor, d	8	6	6	9

♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter wit Nutrilait
* Differences between groups were not significant (P>0.05)

Table 6
Initiation and time spent eating starter and rumination by calves

Items	WMP♣	PSF♣	MSF♣	MSN♣
Initiation of eating, days of age	7.2	7.5	8.5	6.8
Initiation of ruminating, days of age	18.9	20.6	24	23.8
Time spent eating at 67 – 70 days of age, min./24 h	83a	57b	66b	61b
Rumination at 67 – 70 days of age, min./24h	224	203	194	198
Time spent for non nutritive oral behaviour, min./24 h	121	138	142	135

♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter wit Nutrilait
ab Data in one row differ at P<0.05, if followed by different letter

Table 7
Cost of starters and starter per 1 kg live weight gain, Euro*

Items	WMP♣	PSF♣	MSF♣	MSN♣
One ton starter	227*	278	242	280
For 1 kg gain	0.271	0.331	0.288	0.327

♣ WMP – whole maize plus pelleted protein concentrate, PSF – pelleted starter feed, MSF – meal form of starter feed, MSN – meal form of starter with Nutrilait (whey)
* Maize grain was produced in the farm, other feeds were purchased from compound feed mill.

Conclusions

It seems that calves are good feed processors and when starters contained similar ingredients and nutrient contents, the physical form of starter feeds although important had no significant effect on dry feeds intake, live weight gain and feed to gain ratio. Whole corn plus pelleted protein concentrate, coarsely ground, and pelleted calf starters were similar with respect to intake, performance and feed efficiency. It seems that sizes of particles of ground grains, and amount of fines were important for calf starter. Inclusion of Nutrilait (whey) into the starter did not affect intake of starter and average daily gain of calves. There was a tendency for earlier initiation of rumination in calves receiving whole maize grain or pelleted starter, than starters in meal form. There were significantly longer times eating starter with whole maize, and tendency towards longer time spent ruminating, or totally longer chewing activities, which meant more saliva secretion and better buffering of rumen content. On the contrary, time of non feeding oral behavior tended to be shorter when calves received whole maize grain, compared to other starters. The starter with whole maize and pelleted supplements and starter in meal form were cheaper than pelleted starter and starter with dry whey supplementation for improving palatability.

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