Effects of Starch and Fat Concentrations in Starter Grain on Jersey Calf Performance

Honors Research Thesis

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ABSTRACT:

We investigated the nutritional needs of Jersey calves, focusing on meeting energy requirements by altering starch and fat concentrations in calf starters. Thirty-six female Jersey calves were grouped by BW and birth date and randomly assigned among 3 calf starters: 35% starch and 2% fat (HST), 20% starch and 2% fat (LST), and 35% starch and 4% fat (HST-F). The fat supplement for HST-F consisted of 20% coconut oil, 45% lard, 15% flaxseed oil, and 20% soybean oil. Calves were fed 4 L of colostrum at birth. All calves were fed the same milk replacer at 4.4 L/d during week one, 5.2 L/d during wk 2 to 7, and 2.6 L/d during wk 8 prior to weaning. Intake was measured daily and wither heights (WH) and BW were measured weekly. One week after weaning, fecal and feed samples were collected daily for 3 d. Using acid insoluble ash, apparent digestibility of dry matter (DM), neutral detergent fiber (NDF), and crude protein (CP) were determined. Neither starter (0.54, 0.52, and 0.56 kg/d, respectively for LST, HST, and HST-F) nor total DM intakes (1.05, 0.99, and 1.08 kg/d, respectively) differed among treatments. Average daily gains from birth through wk 10 were similar among groups (0.534, 0.586, and 0.550 kg/d, respectively), thus BW and WH were similar across weeks. Digestibilities of DM (66.0, 73.4, and 70.2%, respectively), NDF (50.2, 41.6, and 41.4%, respectively), and CP (65.1, 67.6, and 62.6%, respectively) were similar among treatments. Fecal scoring was evaluated on a 1-6 scale. For the first 4 weeks, there were no differences among treatments for average fecal scores and days with fecal scores of 1 to 4. Starch and fat concentrations in the starters appeared to not affect calf performance which can provide flexibility in formulation of starters based on ingredient costs.

INTRODUCTION:

The development of replacement heifers is important for maintaining herd size and financial efficiency of dairy farms. In recent years, there has been a trend towards maximizing milk production by breeding heifers younger. This may lead to reduced longevity at the farm, thus it is important that proper heifer replacements are available (Knaus, 2009). Therefore, research has been conducted on the feed intake of calves, specifically the nutrient content of the milk replacer and calf starters (Kertz, 2017). However, much of today's research has been conducted using Holstein calves, and as a result, this project focuses on determining Jersey specific nutrient requirements (Kertz, 2017).

Current research focuses on the content and process of feeding milk to calves, thereby leading to formulas of milk replacer specific to Jersey calves with high levels of fat and protein needed to meet nutrient requirements for their growth (Bowen Yoho et. al., 2013). Despite this development of the milk replacer, growth rates often decline during weaning. Furthermore, the average age at which Jersey heifers calve has been significantly reduced from previous years (Knaus, 2009). The average currently is 22 months, down from the typical of 24 months. Due to this young age, it is important that we provide the correct nutrition to allow efficient growth in order for the heifer to reach the appropriate size and frame to be able to freshen at 22 months of age. This requires minimizing the decline in development that may occur during weaning.

Research has focused on two strategies to improve growth rates in calves: the amount of feed provided and the concentration of the nutrients within the feed. Studies showed that calves provided larger amounts of feed had increased growth rates (Kertz, 2017). Though a possible solution to increase development, it would require farms to purchase more milk replacer and grain, making it a costly burden upon the farm. To further counter this argument, Bach et. al.

(2013) found during the pre-weaning period that the calves receiving more milk replacer did grow faster than those receiving less. However, when they transitioned to weaning, the calves receiving less milk replacer grew faster, eventually leading to no differences in body weight between the two groups. In addition to growth rate improvement, other research showed the effect of the preweaning diet on a cows first lactation performance (Gelsinger et. al., 2015). Although Gelsinger et. al. (2015) found that improved growth rate and nutrition led to a larger milk production, it was concluded that the influence was minimum and that other management practices had a greater impact on the cows' production.

To improve efficiency in calf growth, some studies have investigated the concentrations of proteins, fat, and starch in the milk replacer and calf starters. Diaz et. al. (2001) demonstrated that concentrations of nutrients in these feeds affected body composition of calves. Therefore, altering the concentration of protein, fat, and starch influences the growth of the calf. Some studies showed that the nutrient requirements for Jersey calves was immensely underestimated, leading to less growth (Bascom et. al., 2007; Diaz et. al., 2001). Hill et. al. (2011) showed an increase in growth with the calves that received a fat supplement consisting of butyric acid, coconut oil, and flaxseed oil in their milk replacer. However, another study using coconut oil in varying amounts did not see differences in comparison to including lard in the milk replacer (Bowen Yoho et. al., 2013). These studies led to the conclusion that further investigation into short-chain fatty acids and different combinations of medium chain fatty acids was needed.

Bascom et. al. (2007) showed that the protein and fat composition within milk replacer can impact growth as well as body composition of calves. Other research shows the effect of grain consumed by pre-weaning calves and its relation to digestibility and nutrient absorption in the calves (Suarez-Mena et. al., 2011; Hill et. al., 2015). Some of that research showed the differences between high and low starch concentration, concluding with higher growth rates occurred from those that ate grain with high starch concentration (Dennis et. al., 2016). Although this research shows an improvement, these studies have been done with Holstein calves and with extreme differences between starch concentrations. Research on fat in milk replacer has included the addition of lauric and myristic fatty acids to the milk because of the higher concentration of these fatty acids found in Jersey cows' milk compared to milk from Holstein cows (Bowen Yoho et. al., 2013). This study found that there was no difference in the growth rate when comparing those fed with fatty acid fortified milk replacer and those fed with pasteurized whole milk from Jersey cows or milk replacer with low concentrations of the medium chain fatty acids. Nevertheless, they did find that those fed the fortified milk went fewer days with a fecal score over 2, which may be important since scours is one the major health problem of pre-weaned calves. Another study on fat concentration looked at the addition of butyric, lauric, myristic, and linolenic acids into the grain given to calves. It resulted in an increase of digestibility and body weight gain in comparison to calves not supplemented with these fatty acids (Hill et. al., 2016).

Today's research shows the need to further study the nutritional requirements of Jersey calves. The current Nutrient Requirement of Dairy Cattle (NRC) was published in 2001 and holds many insufficiencies (Bascom et. al., 2007). It is expected that the new NRC will be published within the next year, adding additional tools to better understand the data being collected. As a result, this project built upon current research and investigated a calf starter that may meet calves' nutritional needs by altering starch and fat concentrations to improve growth rate. The study looked at the cost of feeds and determined the flexibility dairy farmers have with ingredient purchasing. It emphasized the importance of minimizing feed cost whilst meeting nutrient needs of the calves.

The objectives of this research project focus on three key growth periods: pre-weaning, weaning, and post-weaning. Based on the study's concept, we have drawn two hypotheses: 1) calves that consume the higher starch and fat concentration in their calf starter will have higher pre-weaning growth which will continue into the weaning period and 2) calves with the higher starch and fat content will have fecal scores >2 for fewer days.

METHODS AND MATERIALS:

All animal procedures were approved by The Ohio State University IACUC committee. The feed trial was conducted using Waterman Dairy Farm's facilities from September 2018 to February 2019.

Animals and Treatments

Thirty-six Jersey heifer calves were grouped by body weight (BW) and birth date and randomly assigned to one of three treatment groups. Each treatment group was assigned a specific calf starter (Table 2). Calves on the low starch treatment (LST) diet received 20% starch and 2% fat, calves on the high starch treatment (HST) diet (control) received 35% starch and 2% fat , and calves on the HST diet with fat (HST-F) diet received 35% starch and 4% fat (Table 1). HST was indicative of a standard calf starter formulation. Corn and oats were used as the starch in the diet. The fat supplement for HST-F consisted of 20% coconut oil, 45% lard, 15% flaxseed oil, and 20% soybean oil to reach a targeted fatty acid profile (Table 1). The fat supplement specifically targeted concentrations of lauric, myristic, and linolenic fatty acids similar to Hill et. al., 2016. All ingredients were pelleted except for the corn (steam flaked), oats (whole), and molasses. The later ingredients were mixed with the pellets to form a textured feed. Water was added as needed to make the molasses sticky and allow for proper mixture. The fat supplement was mixed prior to being pelleted. All diets were formulated on a DM basis and mixed at the

Ohio Agricultural Research and Development Center in Wooster, Ohio.

Table 1: *Ingredient composition of starter grains fed [LST = low starch, HST = high starch (typical starter), and HST-F = with fat].*

Ingredient	LST (%)	HST (%)	HST-F (%)
Corn, steam flaked	14.20	38.28	38.93
Oats, whole	14.89	14.79	14.85
Molasses	5.73	5.70	5.72
Soybean meal	17.97	21.82	23.39
Soybean hulls	27.12	8.79	5.88
Wheat middlings	16.97	7.21	4.16
Min. & Vit. supplements	3.07	3.36	3.46
Bovatec 91	0.05	0.05	0.05
Coconut oil	0.00	0.00	0.71
Lard	0.00	0.00	1.60
Flaxseed oil	0.00	0.00	0.54
Soybean oil	0.00	0.00	0.71

Calves were fed 4 L of colostrum via nipple at birth. All calves were fed the same milk replacer at 4.4 L/d during week one, 5.2 L/d during wk 2 to 7, and 2.6 L/d during wk 8 prior to weaning. They were weaned at 8 wk of age. Calves were fed grain starting at 3 d of age. They were grain and water ad libitum. Feed intake was measured by recording feed offered and feed refused each day at 1700 h. Orts were collected, weighed, and fed to breeding-age heifers. Calves initially received 225 g/d, and feed offered was increased by multiples of 225 g/d as calf's consumption increased. Observations in feed intake were recorded every day. Anytime at which calves did not consumed allotted milk, it also was recorded.

The calves were housed in individual hutches outdoors through weaning. They remained in the hutches till 10 wk of age. At 10 wk of age, they were moved to group housing. Calf feed intake was monitored whilst the calves remained in the hutches.

Calves 768, 782, and 787 were removed from the study. 768 died at 7 d of age due to bloating. She was replaced by 773. 782 had a birth weight significantly smaller than the other calves in her block. She was replaced by 785. 787 was euthanized due to limited circulation in her leg. We were unable to replace her because a new calf would have a birth date much later than the others in block 12.

Table 2. *Treatment assignments of the 36 Jersey calves used for the trial*

Calf	DOB	Block	Sequence	Treatment	Wean date	Day 60
749	9/5/2018	1	312	HST-F	10/31/2018	11/4/2018
750	9/5/2018	1		HST	10/31/2018	11/4/2018
751	9/5/2018	1		LST	10/31/2018	11/4/2018
752	9/7/2018	2	231	LST	11/2/2018	11/6/2018
753	9/8/2018	2		HST-F	11/3/2018	11/7/2018
754	9/11/2018	2		HST	11/6/2018	11/10/2018
755	9/18/2018	3	213	LST	11/13/2018	11/17/2018
756	9/25/2018	3		HST	11/20/2018	11/24/2018
757	9/26/2018	3		HST-F	11/21/2018	11/25/2018
758	9/28/2018	4	123	HST	11/23/2018	11/27/2018
759	9/29/2018	4		LST	11/24/2018	11/28/2018
760	10/7/2018	4		HST-F	12/2/2018	12/6/2018
761	10/11/2018	5	231	LST	12/6/2018	12/10/2018
762	10/19/2018	5		HST-F	12/13/2018	12/17/2018
763	10/21/2018	5		HST	12/16/2018	12/20/2018
764	10/23/2018	6	213	LST	12/18/2018	12/22/2018
765	10/23/2018	6		HST	12/18/2018	12/22/2018
766	10/25/2018	6		HST-F	12/20/2018	12/24/2018
767	10/27/2018	7	321	HST-F	12/22/2018	12/26/2018
773[a]	11/14/2018	7		LST	1/9/2018	1/13/2018
769	10/31/2018	7		HST	12/26/2018	12/30/2018
770[b]	11/2/2018	8	321	HST-F	12/28/2018	1/1/2018
771	11/4/2018	8		LST	12/30/2018	1/3/2018
772	11/5/2018	8		HST	12/31/2018	1/4/2018
774	11/18/2018	9	312	HST-F	1/13/2019	1/17/2019
775	11/19/2018	9		HST	1/14/2019	1/18/2019
776	11/19/2018	9		LST	1/14/2019	1/18/2019
777	11/27/2018	10	321	HST-F	1/22/2019	1/26/2019
778	12/2/2018	10		LST	1/27/2019	1/31/2019
779	12/3/2018	10		HST	1/28/2019	2/1/2019
780	12/9/2018	11	132	HST	2/3/2019	2/7/2019
781	12/10/2018	11		HST-F	2/4/2019	2/8/2019
785[c]	12/22/2018	11		LST	2/16/2019	2/20/2019
783	12/14/2018	12	231	LST	2/8/2019	2/12/2019
784	12/18/2018	12		HST-F	2/12/2019	2/16/2018
787[d]	1/5/2019	12		HST	3/2/2019	3/6/2019

[a] Replaced 768
[b] Leg wrapped, lived in freestall barn
[c] Replaced 782
[d] Euthanized before trial ended

Data Collection

The first 36 calves born, starting in September 2018, were used in the trial. Newborn calves were weighed and wither height (WH) immediately after birth and/or before afternoon feeding to guarantee accurate birth weights. BW and WH were then measured weekly through wk 9 of age. Rectal temperatures were measured for the first six days to ensure the health of the calves. Blood was collected from the calves within 48 h of birth in a green top tube (contained heparin as an anticoagulant). The blood was centrifuged and the resulting plasma was pipetted into a 5 ml test tube. A refractometer was used to measure total protein levels (g/100 ml) in the calves' blood. This was to ensure proper IgG absorption and overall calf health.

From birth to wk 10, fecal and respiratory scores were collected daily for each individual calf. Feces were scored on a 1 to 6 scale (Figure 1). Respiratory scores were based on a 1 to 6 scale (Figure 2). Observations of calf health were recorded daily. These included decreased milk consumption, scours, medication consumed, electrolytes added to water, disease/injuries, etc.

Figure 1. *Scale used to measure feces quality of the calves*

Fecal Scoring System

1 = Runny: liquid consistency, splatters on impact
2 = Very loose: spreads readily but may pile slightly, moderate splattering
3 = Moderately loose: limited spattering, spreads moderately on impact and setting but holds form
4 = Very soft: spreads slightly on impact and settling, very moist
5 = Moderately soft: Does not spread on impact and settling but appears moist
6 Hard: dry appearance, original form not distorted on impact and settling

(Modified based on J. Dairy Sci. 76:1074-1082)

Figure 2. *Scale used to assess calf health*

Respiratory Scoring System

1 = normal
2 = runny nose
3 = heavy breathing
4 = cough–moist
5 = cough–dry
6 = fever

(Diaz et al., JDS, 84:830-842)

Feed and Fecal Sampling

One week after weaning, fecal samples were collected over the course of 3 d at varying times of the day (6 am, 10 am, 12 pm, 2 pm, 6 pm, 10 pm) and composited to mimic a 24 h day. These fecal samples were used to determine digestibility of the feed by the calves. Feed refused from the three days was weighed and stored in a freezer for later processing. A 250 g sample of the feed offered was collected once during the three days for each diet. It was stored in a freezer for further processing.

Laboratory Analysis

Before laboratory analysis, the feed refused collected throughout the 3day digestibility period were combined for each calf. An equal amount from each day was combined and mixed. The amount used was dependent on the smallest refusal weight. Feed offered was composited in a similar manner based on the treatment color. 250 g from each period were then combined and mixed. This represented a collective sample of the feed offered throughout the trial. To avoid feed spoilage, feed was mixed at various points of the trial when needed. Therefore, ingredient quality could have differed amongst dates, altering nutrient concentrations. A collective sample was created to minimize this effect. Following mixing of both feed refusal and offered, all samples were ground to fine particles to ensure equal distribution of ingredients when conducting lab work.

Fecal samples from the digestibility days were composited in a similar manner to feed refused. However, before compositing, all samples were placed in a freeze dryer for 3 to 4 d to remove excess moisture. An equal sample from each collection time was combined and mixed to represent a 24 h period. Like the feed, the feces were ground to fine particles to ensure even distribution.

Starter composition was represented by selecting one period at the beginning of the feed trial (November), one in the middle (January) and one at the end (February). DM of feed offered was determined by placing 250 g of the feed offered in an oven at 55 degrees Celsius for 48 h. It was weighed and the dry matter was calculated by dividing the weight after drying by the weight before drying. This sample was used to perform nutrient analysis for feed offered. Dry matter of milk replacer underwent a similar process. Three replicates of 100 g of milk replacer were placed in an oven at 55 degrees Celsius and dried for 48 h. The ending weight was divided by the beginning weight and multiplied by 100 to determine percent DM.

Nutrient analyses were conducted on feed refused, feed offered, and fecal samples. Percent DM of each sample was determined by drying 2 g at 55 degrees Celsius overnight in replicates of two. A third or fourth replicate was performed if the covariance was not less than 10. Samples were weighed before and after to determine the moisture loss. The samples were then ashed at 500 degrees Celsius overnight. The ash was weighed and used to determine organic matter in the feed. Acid insoluble ash (AIA) was used as a marker of digestibility. The ashed samples were mixed with 100 ml of 2 N HCl and boiled for 5 minutes. Then, the samples were filtered and dried at 105 degrees Celsius overnight. The samples were weighed and the percent AIA was calculated. A third or fourth replicate was performed if the covariance was above 15.

CP was determined via the kjeldahl method. 0.5 grams of each sample was weighed and mixed with 15 ml of concentrated HSO4 and one kjeldahl tab. It was heated at 216 degrees Celsius for 1 hour and 30 minutes. They were cooled for 15 minutes and 30 ml of water were added to cool the reaction. The samples were placed in the kjeldahl machine for 4 minutes and the nitrogen was collected in an Erlenmeyer flask filled with 25 ml of boric acid and indicator. The samples were titrated with H_2SO_4. The normality of the H_2SO_4 was determined by titrating it with concentrated NaOH. The percent CP was calculated by multiplying the percent nitrogen by 6.25. This was performed in replicates of two. A third or fourth replicate was performed if the covariance was above 10.

NDF was determined by weighing 0.5 g of each sample and mixing it with 50 ml of NDF solution. It was boiled for one hour. Alpha amylase was added 5 min into the boiling process. After an hour, it was filtered and washed with acetone. It was heated at 105 degrees Celsius overnight. The next morning it was weighed and the percent NDF was calculated. Before filtering, the filter papers were dried overnight at 105 degrees Celsius. Data on starch and fat contents of diets and digestibilities are not available as of yet.

Feed Cost Calculations

The calf starters were mixed by Ohio Agricultural Research and Development Center and the cost to produce each feed was provided. These numbers were compared to determine which feed a farmer might purchase based on our study's results and the cost of the feed. It is important to note that feed availability and cost is dependent on region, season, and the current market.

Statistical Analysis

Experimental data are shown as mean ± standard error of the mean with $P < 0.05$ considered statistically significant. SAS Software version 9.4 was used to perform statistical analyses of the data using a randomized block design (SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION:

Feed Chemical Composition

Table 3 displays the chemical compositions of the feed offered to each treatment group. The three treatment groups were fed feed with similar CP and DM percentages. The LST diet had a higher concentration of NDF than the other two diets. These differences can be attributed to the lower levels of starch-based ingredients (i.e. steam flaked corn) and higher fiber-based ingredients (i.e. wheat middlings) in LST (Table 1). Even though HST appears to more digestible based on DM and NDF digestibility, the DM, CP, and NDF digestibilities were among the treatments.

Table 3: *Percentage of nutrient components in starter offered and their apparent digestibility as determined through laboratory analysis*

Composition	**LST**	**HST**	**HST-F**
DM (%)	89.8	90.9	90.3
CP (%)	17.0	17.2	16.9
NDF (%)	38.9	20.3	23.2
Ash (%)	7.5	6.6	6.2
AIA (%)	0.2	0.2	0.2
Apparent Digestiblity			
DM (%)	66.0	73.4	70.2
CP (%)	65.1	67.6	62.6
NDF (%)	50.2	41.6	41.4

Body Weight, Wither Height, and Average Daily Gain

Figures 3 and 4 illustrate the average growth of the calves for each treatment group. When comparing the three treatments, there were no differences in either WH or BW as the calves aged. Furthermore, Table 4 provides the averages for BW and WH across all 9 weeks of the trial. When compared to one another, the treatment groups were not statistically different ($P > 0.05$). WH for HST did lag at the beginning but could be attributed to their lower average birth weight. In addition, Table 4 shows the ADG of the calves across the entire trial. When compared to one another, there was statistical significance for the HST group compared to LST and HST-F ($P > 0.05$). This treatment group appeared to gain more mass throughout the weeks than the other two. We would have expected to see significant differences in BW and WH to complement the ADG differences. The apparent better gain could be a result of the apparent increased digestibility of HST compared to LST and HST-F as seen in Table 5. With additional experimental units, these results may become significant. Moreover, the calves on HST began at lower BW (Figure 4) and continued through 5 wk of age before increasing and becoming comparable to LST and HST-F. Since Table 4 is a representative sample of all 9 weeks, the dramatic increase during 4 and 5 wk of age could be influencing the end result. These results should be further investigated and analyzed in future research.

***Figure** 3: Average WH of calves as they aged for each treatment group*

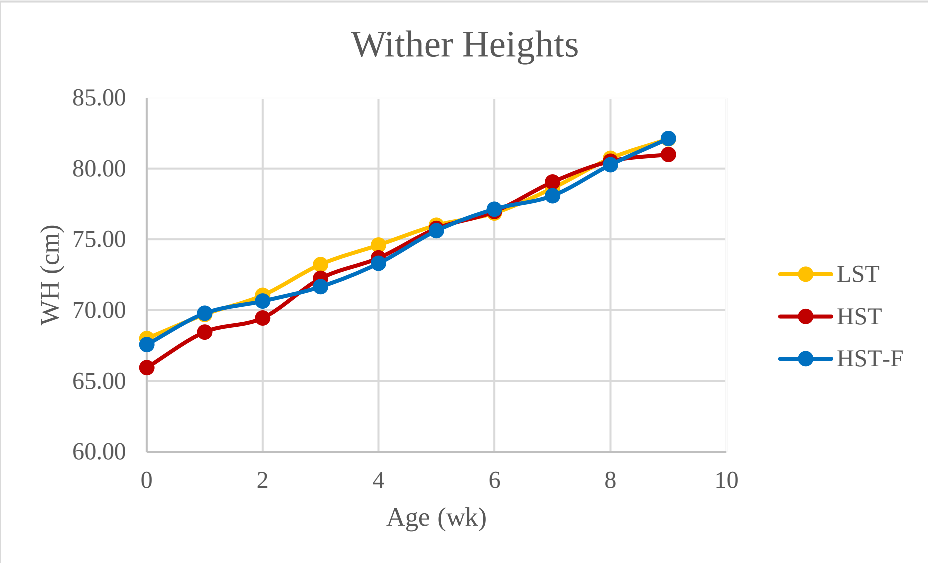


***Figure 4:** Average BW of calves as they aged for each treatment group*

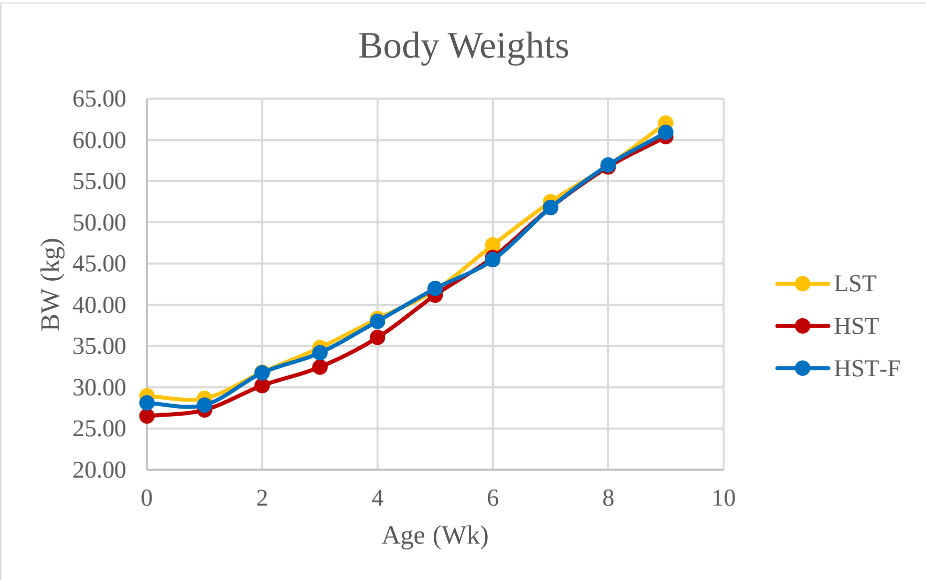


Table 4: *Average (+ SE) ADG, BW, and WH across all weeks of the trail for each treament group with their standard error.[a] Average starter and total DMI is through 9 wk of age for the calves in each treatment group. Standard error will be calculated at a later date.*

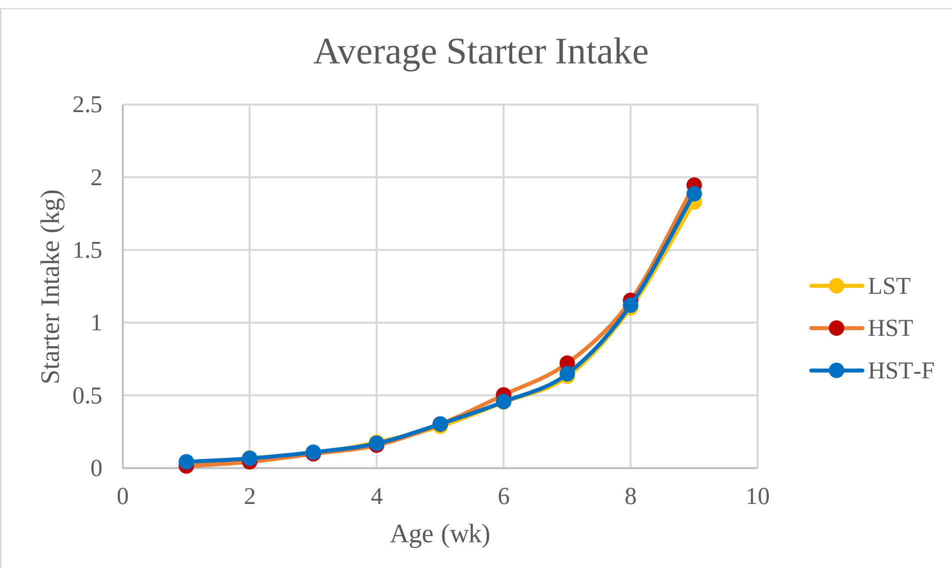
Treatment	**ADG (kg/d)**	**BW (kg)**	**WH (cm)**	**Starter DMI (kg/d)**	**Total DMI (kg/d)**
LST	0.52 ± 0.02	95.34 ± 1.41	29.83 ± 0.12	0.54	1.05
HST	0.59 ± 0.02	95.66 ± 1.49	29.74 ± 0.13	0.52	0.99
HST-F	0.53 ± 0.02	95.12 ± 1.39	29.63 ± 0.12	0.56	1.08

a Values for BW and WH are not statistically significant. HST for ADG differs from LST and HST-F ($P > 0.05$)

Nutrient Intake

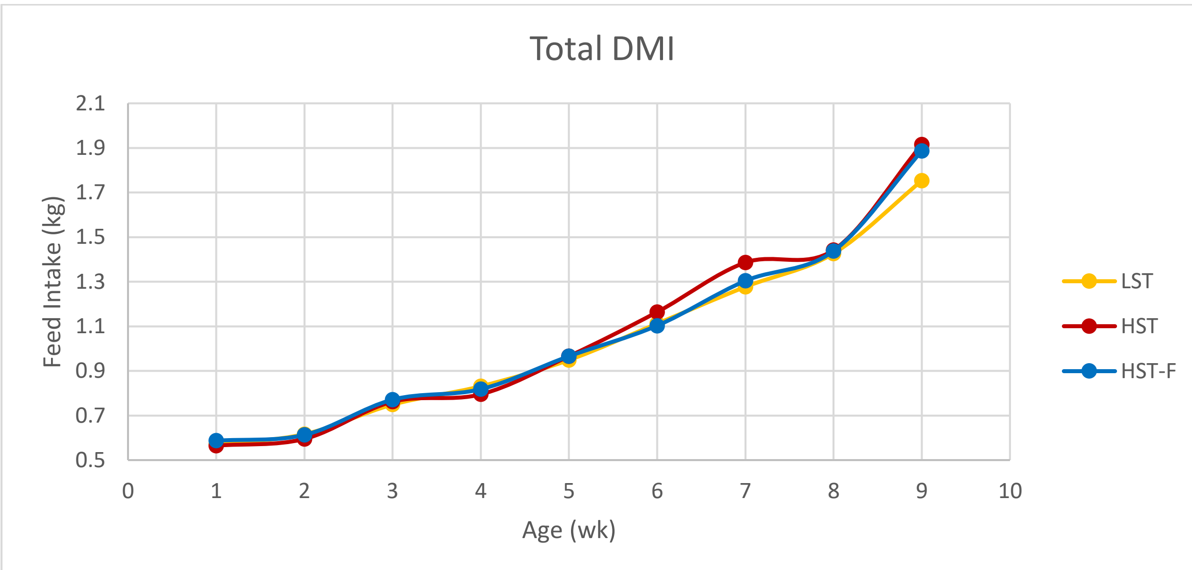
Figure 5 shows the average weekly starter intake of each treatment group. Figure 6 shows the total average DMI of each treatment group as they aged. There were no significant differences in feed consumption between the groups as the calves aged. Therefore, the calves had similar gain with similar intake.

Figure 5: *Average starter DMI (kg/d) of calves for each treatment as they*



It is important to note that Table 4 showed ADG differences for HST when compared to LST and HST-F. In Figure 5, it appears, at around 5 wk of age, the calves on HST increased starter consumption. This could have contributed to the differences because more feed intake means more nutrients and energy available for the calf to grow. However, it is difficult to determine whether the slight increase in intake for HST is statistically different from LST and HST-F without further analysis, therefore it cannot be assumed that differing ADG is result of differing starter intake.

Figure 6: *Average total DMI (kg/d) for each treatment as they aged (starter and milk replacer)*



Serum Protein Levels

Within 48 hours of life, blood was collected from each of the calves to determine passive immunity transfer. This helped to determine overall health of the calves at birth. If IgG absorption was poor, this could affect the health of the calf and the results of the study. Calves with poor absorption capabilities would digest the calf starters poorly, therefore skewing the data because the poor growth would be a result of the calves' physiological characteristics rather than the diet characteristics. Calves with total serum protein of 5.5 g/100 mL were considered to have good IgG absorption. Average total serum protein for each of the treatment groups is provided in Table 5. All of the averages indicate successful passive transfer of immunity.

Table 5: *Total serum protein of each treatment group*

	LST	HST	HST-F
Total serum protein (g/100mL)	7.28	6.41	7.24

Fecal and Respiratory Scores

The fecal and respiratory scores were used as an indicator of the health of the calves (Table 6). They did not differ amongst the treatments. It can be concluded that a specific treatment group did not lead to poorer health in relation to the others. Furthermore, the average number of days with a fecal score below 4 did not differ among the groups, therefore one specific treatment did not cause more scours over another. Scours in calves is a costly disease for the cattle industry and has the greatest impact in the first few weeks of the calves' life (Anderson et. al., 2003). In addition, the number of days with a respiratory score above 3 did not differ among the groups, thus it can be concluded that one treatment did not cause an increase in respiratory disease compared to the other groups. In fact, only one calf during the first four weeks had a respiratory score above 3.

Table 6: *Average fecal and respiratory scores, days fecal scores under 4 and days respiratory scores were 3+ for each treatment group during the first four weeks*[a]

Treatment	Avg Fecal Score	Days Fecal Scores < 4	Avg Respiratory Score	Days Respiratory Score 3+
LST	4.4 ± 0.1	9.7 ± 1.0	1.1 ± 0.02	0.08 ± 0.05
HST	4.4 ± 0.1	8.3 ± 1.1	1.0 ± 0.02	0
HST-F	4.6 ± 0.1	9.3 ± 1.0	1.1 ± 0.02	0

a No values was deemed statistically different based on $P<0.05$

It is important to note that calves 770 and 767 developed foot issues. Both calves were on the HST-F diet. 770's leg was wrapped for most of the trial and spent part of her time in the free stall barn. 767 developed foot issues after the trial concluded. However, she recovered shortly after. Further studies should investigate whether the diet was a cause of the foot problems.

Ingredient Costs

Table 7 shows the cost of each feed on a per kg basis. LST was the cheapest diet to produce. This is most likely a result of the higher fiber content of the diet. The higher cost of HST-F was caused by the extra ingredients needed to increase the fat content of the diet. When the costs are broken down based on dollars per ADG, HST is more cost effective than HST-F and LST. Since the goal is to achieve efficient growth, to minimize costs whilst maximizing heifer growth rate a farmer would choose HST.

Table 7: *Cost of each diet*

Item	LST	HST	HST-F
Cost, $/kg	0.62	0.68	0.73
Cost, $/d	0.33	0.35	0.41
Cost, $/kg ADG	0.63	0.59	0.77

CONCLUSIONS:

Variations in fat and starch concentrations amongst the treatment groups did not result in significant differences in BW, ADG, and WH. Furthermore, fecal and respiratory scores were similar, concluding that overall calf health did not differ among the diets. Therefore, diets can be formulated based on ingredient costs and availability whilst achieving the same outcomes. Further research should be conducted in Jersey nutrition by looking at whether the source of the fat and starch effects the growth of the calves. In addition, deeper analysis of the proper concentration of starch and fat in the starter grain could include a wider span of concentrations and combinations. If the results hold, this could allow for more flexibility in feed purchasing. With feed being the number one cost of a dairy, it is important for dairy farmers to be able to cut costs without reducing production.

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