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Effects of Four Diet Structure and Two Protein Percentage Content on Growth Performance and Biometric Measurements of Holstein Calves

Research Article

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ABSTRACT

This study was conducted to evaluate the effects of different diet structure and protein levels on the growth performance and biometric measurements of male Holstein calves during starter period (from 1 to 60 days of age). In this experiment, 56 Holstein male calves were randomly divided into a 4 × 2 factorial experimental design with 4 levels of diet structure (grinding, nutty, pelleted and grain) and 2 levels of protein (22 and 24%) in a completely randomized design with 8 treatments and 7 replications. The measured traits were: body weight gain, average daily feed intake, body temperature, biometric measurements (height, chest girth, length and width), blood parameters (glucose and beta hydroxyl butyrate), fecal score and rumen fatty acids. The results showed that average feed intake, body weight and glucose and beta-hydroxyl butyric acid concentration in the blood at two levels of protein, had no differences. But the structure of feed mostly influenced traits. Nutty diet showed higher feed intake and body weight. The grinding diet increased volatile fatty acids in rumen of valves. The structure of diet affected biometric measurements, grain and nutty diets increased the body height and chest girth. The fecal score and concentration of volatile fatty acids was variable in different diet structures but the difference was not meaningful. In terms of body temperature, nutty and pelleted diets containing 22% protein increased body temperature spite of the grinding diet that decreased the temperature up to 0.25 ˚C, it is mentioned that changing the structure of diet may be a useful way for controlling heat stress. The findings of this study indicated that nutty starter increased feed intake and significant weight gain compared to grinding, grain and pelleted diets, it is suggested to use nutty starter to increase the growth performance of the production period of calves.

KEY WORDS biometric measurements, diet structure, growth performance, protein, starter.

INTRODUCTION

Nutrition is an important part of animal husbandry and is the main tool in economic production. The period from birth to weaning, when calves are fully prepared for the weaning, is the step in the rearing of calves intended to be stressful, because in this period there is the maximum risk of death and outbreaks, besides feed costs and labor costs are high. In current production systems, optimizing calf growth, especially at early stages of life when feed conversion efficiency is greatest, is a key objective for any profitable heifer-raising operation. It is commonly believed that texturized or coarse starters lead to better performance than finely ground starters (Bach *et al.* 2007). Individual care and feeding of calves before weaning period is essential, so feeding the young calves is of a great importance in calves' profitability of milk production (Schwartzkopf-Genswiein *et al.* 2004). Transporting from one-gastrin to a fully ruminant is essential for the growth and health of calves. The rumen improvement and increased performance is affected by feed intake and feed composition during the starter period. Physical and metabolic development of the reticulorumen is important both for easing the transition from preruminant to mature ruminant state and improving calf health (Drackley, 2008). Processing and physical form of starter feed can affect its palatability and intake by dairy calves (Terré *et al.* 2013), which is critical for the physical and metabolic rumen development (Baldwin *et al*. 2004). It is commonly known that textured forms (containing steam-flaked grains combined with a pelleted supplement) lead to better performance than finely ground starter feed (Hill *et al*. 2012). Pelleted starters may result in lower dry feed consumption compared with multiparticle starters, but because final body weight (BW) was similar in both treatments, feed efficiency of calves consuming pelleted starters may be greater than that of calves consuming multiparticle starters. Therefore, when feeding a starter with similar nutrient composition to the one used in this study, there seems to be an economic advantage associated with feeding the starter in a pelleted form compared with a multiparticle form (Bach *et al*. 2007). Baldwin *et al*. (2004) stated that the process of transferring from milk feeding to solid feeding is economically important for producers. As a result of this transition, side metabolites for growth would increase because glucose of milk transforms to short chain fatty acids in tissue which are considered as the primary source of energy becomes (Swan *et al*. 2006) reported that feed intake during pre-weaning period, especially high-carbohydrate diets, it stimulates the proliferation of microbes in the rumen and the production of volatile fatty acids, is followed by early development of the rumen. Baldwin *et al*. (2004) reported results showed that feeding with solid feed and to adequately, stimulates the development of the final production of microbial rumen epithelial. The physical structure of feed has been proved to have influence on the feed digestibility and efficiency (Daneshvar *et al*. 2017). Different feed structures are provided by processing methods. Bannink *et al*. (2006) reported that different processing of corn would affect performance during the starter period. Other studies reported that the processing of cereals could improve palatability, digestibility, nutritional value and feed intake that were the result of altering chemical and physical structure of feed (Boyles *et al*. 2004; Hill *et al*. 2012). Svihus *et al*. (2005) suggested that pelleting of grain reduced particle size and increased the available surface. It also increased the degradability of starch in the grain pelleted, may be due to the effects of pressure and fragmentation.

The aim of this study was to investigate the effect of different types of feed structure and protein % age on the growth performance and body biometric measurements of male Holstein calves during the starter period.

MATERIALS AND METHODS

Calves, location, management and experimental diets

This study was conducted in Typical Heifer Incorporation, located in Shahriar, Alborz province, Iran, 2015. 56 male Holstein calves were examined from the day 30th to 60th of rearing period. Calves were borne in the same institute and nourished by the similar base diet until day 30. After that they were fed similar base diet (NRC, 2001) and 8 experimental diets as follows: 1) grinding diet with 22% protein content; 2) grinding diet with 24% protein content; 3) pelleted diet with 22% protein content; 4) pelleted diet with 24% protein content; 5) nutty diet with 22% protein content; 6) nutty diet with 24% protein content; 7) grain diet with 22% protein content and 8) grain diet with 24% protein content. Calves were fed colostrum (10% of body weight) in 2 equal meals, during the first 12 hours of birth. The starter diet offered at the end of the first week of age and the water was *ad libitum*. Experimental diets were analyzed using Spartan nrc program. The diet ingredients are shown in Table 1.

Body weight, body biometric measurements and fecal score

In order to determine body weight changes, calves were weighted at birth (before feeding the colostrum) and it as repeated at days 25, 43, 50 and 60 of the experimental period. The starter diet was offered at the end of the first week of age. Body height and chest girth were measured using Coliseum also Fecal Consistency Measurement were determined by method explained by Harrison *et al*. (1960).

Blood parameters and body temperature

In order to determine blood parameters, 5 blood samples were randomly collected at day 60 of age, from each treatment by the vacuum tubes containing the anticoagulant. Body temperature was measured during the period.

Rumen fatty acids

In order to determine volatile fatty acids in the rumen such as acetic acid, propionic acid and butyric acid, which represents metabolic activity of the rumen, at day 60, 5 samples of rumen fluid were taken using a pump vacuum and sulfuric acid was added, then volatile fatty acid concentrations determined by gas chromatography.

Statistical analysis

Data collected in this study were analyzed in a completely randomized base design with a 4 × 2 factorial design (8 treatments and 7 replicates). The statistical model used was as follows:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$$

Where:
Y_{ijk}: observations of the i-th A and B factors.
μ: overall mean.
A_i: i-th level of factor A.
B_j: j-th level of factor B.
AB_{ij}: the interaction of factors A and B.
e_{ijk}: the experimental error.

The data analyzed by SAS (2002) and least square means were compared with Tukey procedure.

RESULTS AND DISCUSSION

Feed intake and blood parameters

Least-squares means and standard errors of feed intake, weight gain and blood parameters of Holstein male calves fed starter diets containing two different levels of protein and four types of diet structure are shown in Table 1. The protein % age had no significant effect on feed intake, but feed structure had effect on feed intake (P<0.05). Nutty feed significantly increased feed intake in comparison with grinding, pelleted and grain diets. The interaction between feed structure and protein % age, confirmed the higher feed intake with 22% protein nutty feed than other feed structures (P<0.05). Weight gain was not different in two protein levels, but nutty feed had the most weight gain (P<0.05).

The grain diet showed similar performance with nutty feed, in spite of grinding and pelleted feed, they had significant lower weight gain than nutty diet (P<0.05). the interaction of protein and feed structure showed higher weight gain of nutty feed in both 22 and 24 protein % age (P<0.05).

Higher feed intake in nutty diet was likely the cause of the more weight gain at the end of the period. The increased blood glucose in nutty diet was affected by increased feed intake and the increased propionic acid in rumen. Porter *et al.* (2007) reported nutty and pelleted diets increased daily weight gain.

Grinding diet significantly decreased blood glucose and beta hydroxyl butyrate. It has been reported that diet composition of starter, processing and change of diet particle size had effect on productivity and performance. Many previous studies also showed that the use of diets with very fine and soft particle size reduced the consumption of starter.

Other studies have linked to starter particle size and its impact on growth performance and beef dry matter intake (Bach *et al.* 2007; Coverdale *et al.* 2004; Franklin *et al.* 2003; Porter *et al.* 2007).

Feeding a pelleted diet increased dry matter intake and daily weight gain, although the starters were not identical in terms of nutrient composition. Bach *et al.* (2007) fed pelleted diet to calves and showed that weight gain was more with pelleted diet but feed intake was less than grinding diet. Porter *et al.* (2007) showed that feeding a course diet increased weight gain in comparison with pelleted diet.

Coverdale *et al.* (2004) have shown that weight gain in calves fed the course starter was more effective than smooth starter. Franklin *et al.* (2003) mentioned that total dry matter intake in nutty diets was significantly higher than grinding and pelleted diets, they concluded that these differences were likely due to the earlier weaning of calves fed nutty diet. Porter *et al.* (2007) found that newly born calves fed processed course meals for starter, had higher feed intake, they did not measure feed efficiency but Coverdale *et al.* (2004) and Sua´ rez *et al.* (2006) in agreement with the Porter *et al.* (2007) demonstrated that structure influenced feed efficiency of calves fed course starter. The digestibility of nutrients in the present study was not measured, probably one of the reasons for the improvement in consumption and growth in processed diets were in association with improved digestibility, nutty diet with 22% protein content increased growth performance and feed intake.

In this connection, Kertz (2007) showed that dry matter digestibility in calves fed grinding starter was significantly lower than the nutty starter. The digestibility of crude protein and organic matter in pelleted and nutty starter was significantly greater than grinding diet. Processing cereals often increases the digestibility of starch and other nutrients. Soft grinding increases the surface area and increases the effect of enzymes and microbes on that position (Beauchemin *et al.* 2001).

Fecal consistency measurement and volatile fatty acids concentration of rumen

The least square means and standard errors of feed protein content and structure of starter on fecal score and the concentration of volatile fatty acids of rumen are shown in Table 2.

Protein content, diet structure and the interactions between these two factors had no significant effect on fecal scores. Despite the variability observed between the concentrations of volatile fatty acids of rumen, the effect of diet protein content on the concentration of valeric acid, isovaleric acid, iso-butiric acid and propionic, butyric and acetic acid combination was not significant. The iso-valeric and iso-butiric acids concentration was not affected by diet structure.

Table 1 The ingredients of the experimental diets

Ingredients (g/kg)	22% protein	24% protein
Corn seed	40	40
Barley seed	10	10
Soybean meal	38	41.6
Gluten	0	2
Wheat bran	8.3	3
Bayon payp	0.05	0.05
Salt	0.5	0.5
Sodiyom bicarbonate	0.5	0.5
Calcum phosphate	0.5	0.5
Bentonite	0.3	0.3
Minerals	0.45	0.45
Vitimins	0.5	0.5
Total	100	100

Table 2 Least square means and standard errors of feed intake, weight gain, blood glucose, blood beta hydroxyl butyrate, body weight, fecal score, and volatile fatty acids of rumen of Holstein calves

Item	ADG[2] (during 10 days)	IFT[2] (g)	BW[2] (kg)	Glucose (mg/dL)	BHB[2] (m*M*/mL)	FS[2] (5-1)	Valerate (m*M*/mL)	Iso-valerate (m*M*/mL)	Iso-butirate (m*M*/mL)	Propionate + butirate (m*M*/mL)	Acetate (m*M*/mL)
Protein											
22%	5806	29031	65.24	77.25	0.58	2.67	2.95	0.31	17.07	56.03	68.00
24%	6062	30311	65.55	83.37	0.54	2.82	2.22	0.30	15.30	62.73	56.81
SEM	191	1468	0.69	2.47	0.07	0.02	0.02	0.03	1.16	5.26	5.38
Structure											
Nutty	7130^{a}	30565^{a}	69.07^{a}	84.00^{a}	0.58^{a}	2.81^{a}	1.37^{a}	0.22^{a}	8.65^{c}	60.80^{a}	59.32^{a}
Grinding	5446^{b}	27231^{b}	63.44^{b}	59.00^{b}	0.44^{b}	2.78^{a}	5.47^{b}	0.35^{a}	19.15^{ab}	64.50^{a}	71.97^{b}
Grain	5593^{b}	27967^{ab}	65.91^{ab}	87.25^{a}	0.62^{a}	2.75^{a}	2.60^{a}	0.30^{a}	14.72^{b}	50.67^{b}	57.59^{a}
Pelleted	5556^{b}	27833^{b}	63.15^{b}	91.00^{a}	0.60^{a}	2.83^{a}	4.90^{b}	0.35^{a}	22.22^{a}	61.57^{a}	60.37^{a}
SEM	270	2077	0.98	3.49	0.098	0.03	0.035	0.05	1.57	7.44	7.62
Prot. × Struc.											
22% × Nutty	6458^{a}	38290^{a}	70.91^{a}	84.50^{a}	0.64^{a}	2.82^{a}	0.55^{c}	0.20^{b}	6.30^{d}	57.35	57.15
22% × grinding	5718^{bc}	28590^{bcd}	63.62^{bc}	53.00^{b}	0.43^{b}	2.77^{ab}	9.15^{a}	0.30^{ab}	26.70^{a}	54.45	71.76
22% × grain	5469^{bc}	27349^{bcd}	66.31^{ab}	85.00^{a}	0.75^{a}	2.68^{b}	1.80^{c}	0.25^{ab}	11.70^{cd}	46.30	67.40
22% × pelleted	4379^{c}	21897^{d}	60.11^{c}	86.00^{a}	0.51^{a}	2.77^{ab}	8.30^{ab}	0.50^{a}	23.60^{ab}	66.05	75.85
24% × nutty	6603^{ab}	33016^{abc}	67.22^{ab}	83.00^{a}	0.52^{a}	2.80^{ab}	2.20^{bc}	0.25^{ab}	11.00^{cd}	64.25	61.50
24% × grinding	5174^{bc}	25871^{cd}	63.25^{bc}	65.00^{b}	0.45^{a}	2.80^{ab}	1.80^{c}	0.40^{ab}	11.60^{cd}	74.55	72.35
24% × grain	5717^{bc}	28583^{bcd}	65.51^{abc}	89.50^{a}	0.49^{a}	2.81^{ab}	3.40^{abc}	0.35^{ab}	17.75^{bc}	55.05	48.50
24% × pelleted	6054^{ab}	33770^{ab}	66.20^{ab}	95.00^{a}	0.69^{a}	2.90^{a}	1.50^{c}	0.20^{b}	20.85^{ab}	57.10	44.90
SEM	382	2937	1.39	4.94	0.14	0.05	1.19	0.08	2.23	10.53	10.77

ADG: average daily gain; IFT: total feed intake; BW: body weight; BHB: beta hydroxyl butyrate and FS: fecal score.
The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Also, the interaction of dietary protein content and diet structure significantly affected the concentration of these fatty acids except for iso-valeric acid (P<0.05). In overall, grinding diet increased the amount of fatty acids in the rumen, which may be due to more feed surface provided for rumen microbes (P<0.05).

The pelleted and grain diets was also showed increase in the level of fatty acids in the rumen (P<0.05), but taking into account the interaction of different dietary protein levels and diet structure, had variable effects. The concentrations of butyric acid found in the rumen of calves fed nutty diet with 22% protein content was significantly less, and it was the highest in calves fed pelleted diet with 22% protein content. Given that previous studies have shown increased butyrate acid that can be increased in these reasons: increasing metabolism in rumen villi and increasing the energy production through the absorption.

Feeding pelleted or grinding diets with 22% protein content would be followed by stimulated development of rumen. Also, the change in the production of fatty acids in rumen have been reported in previous studies, for example Porter *et al.* (2007) showed that feeding diets containing different structure, meaningfully changed rumen pH, so that feeding pelleted and nutty diet reduced rumen pH significantly from day 60 to 90 after the starter. These results were in agreement with the findings of this study. The great particle size increases chewing and increases the flow of saliva to the rumen; this will increase the liberalization of salivary urea and ammonium of rumen raises (Beauchemin *et al.* 2001). Change of fatty acids in the rumen and thus change in the pH of the rumen in calves fed grinding diets are reported by Porter *et al.* (2007). Similar results of increased butyric acid and iso-butyric acid in grinding diet with 22% protein content was also observed in this study. The rate of changes was mostly lower in nutty diets or diets with larger particles that may be because larger size diets has a greater buffering effect. It is common that there are different levels of processing corn in commercial calves' starters. However, adult ruminants, especially in dairy cattle that often have hay or buffer feed, the effect of cereal processing is covered. Kertz (2017) and Franklin *et al.* (2003) reported that this could affect the volatile fatty acids and pH of rumen.

Body temperature and body biometric measurements

Least square means and standard errors of body temperature and biometric measurements including body height, chest girth and body length are shown in Table 3. Body temperature, height, chest girth and body length of calves were not affected by dietary protein %age, but starter diet containing 22 protein %, significantly increased body height in comparison with 24 protein % age ($P<0.05$). Nutty and pelleted diets increased body temperature rather than grinding diet ($P<0.05$). Calves fed by 24% protein pelleted diet and 22% protein grinding diet had the highest and the lowest body temperature, respectively ($P<0.05$). Chest girth of calves fed nutty and grain diets was higher ($P<0.05$) than the pelleted diet. Feeding 22% protein nutty diet significantly increased chest girth of calves. Feeding grinding diet decreased body temperature up to 0.25 ˚C in comparison with nutty and grain diets ($P<0.05$). This means that probably changing feed structure during the hat seasons would be a useful way to control the body temperature and also heat stress. In overall, feeding grinding diet decreased body biometric measurements ($P<0.05$). Calves fed 22% protein pelleted diet had the lowest chest girth ($P<0.05$).

Nutty diet increased body length and 22% protein nutty diets and 24% protein grinding diet had the highest and the lowest body length, respectively. Feeding a starter diet containing 22% protein increased height significantly rather than the 24% protein. Results of biometric measurements as well as rectal temperature as an indicator of body temperature, showed that feeding a diet containing 22% protein would improve measurements. The higher body temperature in the diet containing 24% protein may be the cause of the high protein the more catabolism to eliminate the extra protein and the heat is increased. However, because 24% protein of feed significantly decreased biometric measurements and protein is the most expensive part of the diet, the results indicates the benefits of using 22% compared to 24% of the protein. Porter *et al.* (2007) demonstrated that feed structure of starter had no effect on body biometric measurements, these results were in agreement with the findings of Bannink *et al.* (2006) which showed no difference between the hip width at days 0 to 28, 28 to 56 and 0 to 56 between calves fed Pelleted, nutty and grinding starters, but were not in consistence with the results of this study. Racial differences between calves (Brown Swiss and Holstein) as well as differences in the combination of starters used probably were the causes of the difference between the results. However, Lesmeister and Heinrich (2004) compared different methods for processing of corn and showed height of calves were different and resulted in higher height at the end of the period. Quigley (2004) studied calves fed corn grain and dry rolled corn, they reported faster growth during the last 2 weeks (5-6 weeks). This growth was due to more consumption of starter diet. Calves fed toasted corn or steam rolled corn had lower consumption and therefore growth was lower in the last 2 weeks. Changes in overall consistent growth, structural change, but overall growth were significantly lower. These results are in line with the findings of the present study suggests that diet structure and various processing can affect overall growth and development of organs. Part of the changes could be the result of earlier weaning and grazing of calves, for example Porter *et al.* (2007) showed that feeding pelleted starter diet caused earlier grazing in comparison with grinding diet. Also they reported the age of weaning calves fed pelleted and nutty diets decreased in comparison with other structure. Reducing weaning age has many benefits, including reduced milk consumption, reduced labor costs and costs related to feed. A large number of researches aimed at reducing weaning age. Weaning age is probably reduced by the physical structure of the diet such as pelleted or rolling, which increases dry matter intake and weight gain (Stamey *et al.* 2012).

Table 3 Least squares mean and standard error of body temperature and biometric measurements of Holstein male calves fed starter diets with different levels of protein and structure

Item	Body temperature (˚C)	Height (cm)	Chest girth (cm)	Body length (cm)
Protein				
22%	38.94[a]	87.94[a]	90.26[a]	97.85[a]
24%	39.03[a]	86.92[b]	90.11[a]	97.01[a]
SEM	0.04	0.25	0.36	0.38
Structure				
Nutty	39.05[a]	89.32[a]	92.08[a]	99.42[a]
Grinding	38.82[b]	85.66[b]	88.92[b]	96.33[b]
Grain	39.02[ab]	89.07[a]	90.94[ab]	97.64[a]
Pelleted	39.10[a]	85.69[b]	88.80[b]	96.33[b]
SEM	0.06	0.36	0.51	0.54
Prot. × Struc.				
22% × nutty	39.08[ab]	90.35[a]	93.07[a]	100.00[a]
22% × grinding	38.75[b]	86.39[ab]	89.50[bc]	97.28[abc]
22% × grain	39.10[ab]	89.25[a]	90.85[ab]	98.28[abc]
22% × pelleted	38.95[ab]	85.78[c]	87.64[c]	95.85[bc]
24% × nutty	39.03[ab]	88.28[ab]	91.10[ab]	98.85[ab]
24% × grinding	38.90[ab]	84.92[c]	88.35[bc]	95.39[c]
24% × grain	38.94[ab]	88.89[a]	91.03[ab]	97.00[abc]
24% × pelleted	39.25[b]	85.60[c]	89.96[ab]	96.82[abc]
SEM	0.08	0.51	0.72	0.77

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Franklin *et al*. (2003) showed that feeding nutty starter would decrease the weaning age but there was no significant differences between pelleted and grinding diets, but some reported that different diet structure had no significant effect on the weaning age (Coverdale *et al*. 2004), beside some mentioned feeding coarse diets in comparison with soft grinding pelleted diets, decreased the weaning age (Porter *et al*. 2007).

CONCLUSION

Nutty starter diet significantly affected feed intake and weight gain of the calves in comparison with grain, grinding and pelleted diets. It is likely due to the increased production of propionic acid and glucose in nutty diets. The increased feed intake during the starter resulted in increased weight gain and body weight at the end of this period. Feeding grain and nutty diet improved body biometric measurements such as body height and chest girth, it may influence on the reproduction performance of calves. Grinding diet significantly decreased body temperature and increased volatile fatty acids in rumen. Diets with 22% protein content, commonly, had effect on biometric measurements. 22% protein nutty and grinding diets increased chest girth rather than 24% protein. It is suggested that nutty structure could improve growth performance of Holstein calves.

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