The effects of partial replacement of soybean meal by xylose-treated soybean meal in the starter concentrate on performance, health status, and blood metabolites of Holstein calves

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Abstract

The objective was to study the effects of partial replacement of soybean meal (SBM) with xylose-treated SBM (XSBM) as a source of rumen undegradable protein (RUP) in the starter concentrate of calves on performance, health status and selected blood metabolites. Twenty-one female Holstein dairy calves (body weight=39.6±2.3 kg) were randomly assigned to 3 groups (n=7 each): i) starter concentrate with 25% SBM [control (CTR)]; ii) starter concentrate with 17.5% SBM +7.5% XSBM (7.5XSBM); and iii) starter concentrate with 12.5% SBM+12.5% XSBM (12.5XSBM). Calves received 2 L of milk twice daily, with ad libitum access to starter concentrates from d 4 until weaning (d 56). Performance and health status were recorded throughout the experiment. Blood samples collected on d 4, 35 and 56 were assayed for concentrations of glucose, total protein (TP), and plasma urea nitrogen (PUN). Starter intake (560, 400, and 420 g/d for CTR, 7.5XSBM, and 12.5XSBM, respectively), average daily gain (0.67, 0.6 and 0.57 kg/d), and feed to gain ratio (0.83, 0.67, and 0.74) were affected by treatments (P<0.05). Heattirth, height at withers, body length, rectal temperature, faecal score, and respiratory score did not differ among treatments. Mean plasma glucose and TP were not affected by treatments, whereas PUN in the 12.5XSBM group was lower than in the other groups (P<0.05). In conclusion, the present results showed that partial replacement of SBM by XSBM may improve efficiency of dietary protein utilisation in pre-weaned calves, which warrants further studies.

Introduction

The dairy National Research Council (2001) recommends 20% crude protein (CP) as dry matter basis in calf starter. Data on the effects of protein level in starter concentrate on calves’ performance have been contradictory (Stobo et al., 1967; Gardner, 1968; Leibholz and Kang, 1973). Most of previous studies have mainly focused on level of CP in calf starter and there is limited data available concerning inclusion of rumen undegradable protein (RUP) sources in pre-weaned calves’ starters (Sahoo et al., 2005; Sissell, 2007). In the pre-weaned calves, the rumen and its microbial population are not fully developed which may explain the lack of studies concerning using RUP sources in the calf starters during the pre-weaning period. Furthermore, no recommendation has been made regarding RUP requirement of pre-weaned calves. However, providing RUP sources with high quality amino acid (AA) profiles that reach the small intestine may help to achieve high pre-weaning growth rates.

Animal protein sources such as blood meal, and meat and bone meal have been mainly used as RUP sources in previous animal studies (Tolinson et al., 1997). Meat and bone meal is a good source of RUP, but problems such as bovine spongiform encephalopathy, high level of fat, and other probable contaminants (Deydier et al., 2007) as well as deficiency in methionine as a limiting AA for growing ruminants should be concerned in diet formulating for calves starters (Klemesrude et al., 2000). Feather meal and blood meal other excellent sources of RUP, may be deficient in sulfur AAs or imbalance AAs (Goedecken et al., 1990; Bohnert et al., 1999).

Soybean meal may be the most common protein source in ruminant feeding (Baker, 2000). It has been extensively used as intact (Abdelgadir et al., 1996a), roasted (Abdelgadir et al., 1996a, 1996b; Reddy et al., 1993) or fermented (Kim et al., 2010) forms in calves starter. It is also included in milk replacer for neonatal calves (Dawson et al., 1988). Heat treatment is the most common and probably the most feasible processing methods of feed-stuffs such as SBM. However, during heat treatment of protein-reach feeds, temperature and duration of heating must be under careful control in order to optimise the content of digestible RUP (Schwab, 1995). Treatment of SBM with xylose which was first introduced by Cleale et al. (1986) reduced degradation of SBM protein in rumen and consequently increased the proportion of RUP in SBM. Jahani-Moghadam et al. (2009) demonstrated that replacing SBM with XSBM had positive effects on efficiency of lactating dairy cows. In addition, replacing SBM with XSBM in diets of Awassi ewes improved milk yield (Obeidat et al., 2010). However, to our knowledge, the question of whether replacing SBM with XSBM affects growth performance, health status, and metabolic indicators in calves has not been addressed. The current study was designed to determine whether partial replacement of SBM with XSBM influences feed intake,
Materials and methods

Animals, housing and diets

This study was conducted at the calf-raising facilities of Ebyaei Dairy Facilities (Hamadan, Iran). Twenty-one Holstein female calves (BW=39.6±2.3 kg; mean±SD) were randomly assigned to 3 groups, each consisting of 7 animals: i) starter concentrate with 25% SBM (control (CTR)); ii) starter concentrate with 17.5% SBM+7.5% XSBM (7.5XSBM); and iii) starter concentrate with 12.5% SBM+12.5% XSBM (12.5XSBM). On treatments 2 and 3 equal amounts of SBM was replaced with XSBM. Ingredients and chemical composition of treatments are presented in Table 1. The SBM and XSBM used in the present study were provided by the same company (Yasmino Max; Yasna Mehr Co., Tehran, Iran). Calves received 2 L of milk twice daily, with ad libitum access to starter concentrates from d 4 of life until weaning (d 56). At the commencement of the study, 200 g/d of starter was provided for each calf. The animals were kept in individual hutches and had free access to fresh water. Amounts of starter concentrate offered and orts were recorded daily for individual calves, and daily starter intake was determined.

Experimental procedures and chemical analyses

The starter concentrates were sampled weekly. The samples were dried at 60°C for 48 h, ground using a Wiley mill to pass a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA), and stored at -20°C until analyses. The starter samples were analysed for CP, ether extract (EE), ash, and organic matter (AOAC, 2000; Table 1). The RUP was calculated using the data reported by Jahani-Moghadam et al. (2009) who used the same source of SBM and XSBM in their study on dairy cows.

Feed to gain ratio (F:G) was calculated as kg of starter intake divided by kg of body weight gain. Body weight, body length (distance between the points of shoulder and hip), withers height, and heart girth (Lesmeister and Heinrichs, 2005) were measured every 10 days during the course of the study.

Respiration rate (by visual observation, for 3 separate min) and rectal temperature were recorded at 1300 h, 3 times a week, during the experimental period. Faecal scoring was recorded 3 times a week on a scale of 1 to 5, with 1 being normal, 2 being soft to loose, 3 being loose to watery, 4 being watery, mucous and slightly bloody, and 5 being watery, mucous and bloody (Heinrichs et al., 2003).

Blood samples were taken 4 h after the morning feeding from the jugular vein using heparinised Vacutainer tubes on d 4, 35, and 56. All tubes were immediately placed in wet ice and centrifuged at 4°C at 3000 g for 15 min. The plasma was obtained and frozen at -20°C.

Table 1. Ingredients and chemical composition of starter concentrates.

| Ingredients, % | CTR | 7.5XSBM | 12.5XSBM |
|----------------|-----|---------|----------|
| Corn grain     | 40  | 40      | 40       |
| Barley grain   | 20  | 20      | 20       |
| Soybean meal   | 25  | 17.5    | 12.5     |
| Xylose-treated soybean meal | 0  | 7.5    | 12.5     |
| Molasses       | 5   | 5       | 5        |
| Wheat bran     | 4   | 4       | 4        |
| Alfalfa meal   | 2.5 | 2.5     | 2.5      |
| Fat            | 1   | 1       | 1        |
| Di-Calcium phosphate | 1 | 1     | 1        |
| NaCl           | 0.5 | 0.5     | 0.5      |
| Vit.-min. mix° | 1   | 1       | 1        |

Chemical composition

| Ingredient               | CTR | 7.5XSBM | 12.5XSBM |
|--------------------------|-----|---------|----------|
| NEg, Mcal/kg             | 1.3 | 1.3     | 1.3      |
| NDF, %DM                 | 16.7| 16.7    | 16.7     |
| CP, %DM                  | 19.2| 19.3    | 19.3     |
| RUP, %CP#                | 37  | 38.2    | 40       |
| EE, %DM                  | 2.8 | 2.8     | 2.8      |
| Ca, %DM                  | 0.7 | 0.7     | 0.7      |
| P, %DM                   | 0.4 | 0.4     | 0.4      |

Table 2. Least square means for feed intake, performance, body measurements and health parameters in calves fed experimental diets.

| Item                      | CTR | 7.5 XSBM | 12.5 XSBM | SE  | P    |
|---------------------------|-----|----------|-----------|-----|-----|
| Intake and performance    |     |          |           |     |     |
| Starter intake, kg/d      | 0.56| 0.49     | 0.42      | 0.04| 0.0003|
| Daily gain, kg/d          | 0.67| 0.60     | 0.57      | 0.04| 0.0001|
| F:G°                      | 0.83| 0.67     | 0.74      | 0.09| 0.02|
| Body measurements         |     |          |           |     |     |
| Heart girth, cm           | 81.9| 81.3     | 81.8      | 3.23| 0.84|
| Wither height, cm         | 81.4| 80.6     | 81.6      | 3.07| 0.43|
| Body length, cm           | 78.7| 76.9     | 77.5      | 3.43| 0.24|
| Health parameters         |     |          |           |     |     |
| Respiration rate, min⁻¹   | 52.3| 53.6     | 53.9      | 2.45| 0.35|
| Rectal temperature, °C    | 38.8| 38.6     | 38.7      | 0.34| 0.72|
| Faecal scoring            | 2.6 | 2.4      | 2.5       | 0.27| 0.73|

CTR, starter concentrate with 25% SBM (control); SBM, soybean meal; 7.5XSBM, starter concentrate with 17.5% SBM+7.5% XSBM; XSBM, xylose-treated SBM; 12.5XSBM, starter concentrate with 12.5% SBM+12.5% XSBM. °Contained per kg of supplement: vitamin A, 250,000 IU; vitamin D, 50,000 IU; vitamin E, 1500 IU; Mn, 2.25 g; Ca, 120 g; Zn, 7.7 g; P, 20 g; Mg, 20.5 g; Na, 186 g; Fe, 1.25 g; S, 3 g; Co, 14 mg; Cu, 1.25 g; I, 56 mg; Se, 18 mg. *Calculated using the data reported by Jahani-Moghadam et al. (2009).
until analyses. Plasma concentrations of glucose (Abdelgadir et al., 1996a), TP (Lesmeister and Heinrichs, 2005), and PUN (Kohn et al., 2005) were measured.

Statistical analysis
The data were analysed using the MIXED procedure of SAS (1999-2000), using repeated measures. The model included the fixed effects of treatment, time, and the interaction of treatment and time; calf was considered the random effect. Differences between least square means were considered significant at P<0.05 and differences were considered to indicate a trend towards significance at 0.05<P<0.10.

Results
Performance, rectal temperature, faecal consistency, and respiration rate
Starter intake and performance data are given in Table 2. The results indicated that starter intake, daily gain and feed to gain ratio (F:G) differed between treatments (P<0.05). The greatest starter intake and the greatest daily gain were observed for CTR. Starter intake was decreased in calves fed XSBM compared to CTR animals, whereas F:G ratio was improved in calves fed XSBM (Figure 1; P=0.02). The growth parameters did not show any difference among different treatments (P>0.05; Table 2). Respiration rate, rectal temperature, and faecal score values were not affected by treatments (P>0.05).

Blood metabolites
The effects of experimental starter concentrates on plasma glucose, TP, and PUN are presented in Table 3. A significant treatment effect was observed for plasma glucose concentrations on d 35, which was increased for calves in the 7.5XSBM group compared to the other groups. Mean plasma glucose concentration did not differ among treatments (P>0.05). Plasma concentrations of TP were not affected by treatments (P>0.05). Plasma concentrations of PUN on d 56 were affected by treatments (P=0.006). Furthermore, mean plasma PUN was lowest in the 12.5XSBM, followed by 7.5XSBM, and the highest in CTR (P=0.02).

Discussion
It is known that not only the level of RUP sources, but also their quality must be careful-
starter intake compared with those in the CTR group; however, calves in the 7.5XSBM and 12.5XSBM groups had lower F:G ratio than did calves in the CTR group, suggesting probably a more efficient tissue accretion in calves. The greater starter intake and the higher F:G ratio for calves in the 12.5XSBM group than for those in the 7.5XSBM group may show slightly impaired efficiency in tissue accretion with high replacement levels that warrant further investigation.

In the current study, calves were generally healthy, with no mortality during the study. Furthermore, the health status data were all in the normal ranges. Soybean meal contains a number of anti-nutritional compounds including trypsin inhibitors, lectins, flatulence producing compounds, and many other allergenic proteins which may limit use of SBM in diet of young animals (Kim and Baker, 2003; Baker, 2000). Faecal consistency in the current study did not change with the treatments. Furthermore, we did not observe impaired gastrointestinal tract function and calf well-being with using SBM or XSBM in the starter concentrates. Therefore, these data may show possible replacement of XSBM as a RUP source in pre-weaned calves’ starters.

Levels of TP and albumin in blood could be used as long-term indicators of AA and immune states, whereas blood urea nitrogen may reflect short-term dietary effects on production of ammonia in rumen and liver nitrogen turnover (National Research Council, 2001; Kohn et al., 2005; Jahani-Moghadam et al., 2009). In the present study, plasma TP did not differ among treatments, but calves in the 7.5XSBM and 12.5XSBM groups had lower PUN concentrations compared with those in the CTR group. This may probably reflect a more efficient use of dietary protein in the 7.5XSBM and 12.5XSBM groups. The treatments in the current study contained the same level of CP. Thus, the observed improvement in F:G ratio and minimal reduction in PUN with replacement of SBM by XSBM can probably be explained by greater intestinal AA availability, and AA delivery to the target tissues.

Conclusions

The data indicate beneficial effects of partial replacement of SBM by XSBM in the starter concentrate to improve efficiency of dietary protein utilisation in calves during the pre-weaning period, as reflected by improved F:G ratio and minimal decreased PUN level. Therefore, supplementing pre-weaned calves with high quality RUP sources may increase the flow of nitrogen and AAs to the small intestine, which may consequently improve growth performance. Further studies are needed to confirm these findings and better define the effects of different high quality RUP sources in the starter concentrates of pre-weaned calves.

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