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Alfalfa Protein Concentrate as a Less Ruminally Degradable Protein Source for High-Producing Dairy Cows

C.D. Lu[1] and N.A. Jorgensen[2]

[1]College of Agriculture, Sultan Qaboos University, P.O. Box 34. Al-Khod 123, Sultanate of Oman and [2]College of Agriculture and Life Sciences, University of Wisconsin, Madison, WI 53706, U.S.A.

إستخدام مركز بروتين البرسيم كمصدر للبروتين بطئ التحلل في الكرش لتغذية أبقار الحليب ذات الإدرار العالي

سي. دي. لو و إن. أي. يورجينيسن

خلاصة: استخدمت عشر أبقار هولستين عديدة الولادات في تجربة تغذية لمدة ١٠٥ أيام متواصلة لمقارنة تأثير كسب فول الصويا وبروتين البرسيم المركز كمصدر بروتين إضافي لتغذية أبقار الحليب ذات الإنتاج العالي. تم وضع الأبقار ذات متوسط إنتاج قدره ٣٥,٢ كجم في اليوم في أزواج عشوائيا في أحد المجموعات. تم استخدام الأنموذج التجاربي المقلوب مرتين لفترة ٣٥ يوما. تمت المقارنة بين المجموعات خلال فترة ال٢١ يوما الأخيرة من كل المدة. ثم تركيب الغذاء التجريبي الذي يحوي على ٦٠٪ من سيلاج الذرة و١٠٪ من دريس البرسيم بحيث يحتوي على نفس نسبة النيتروجين والطاقة (١٥,٦٪ بروتين خام، ١,٦٠ ميقاكالوري/كجم مادة جافة طاقة نهائية للإدرار). ثم توفر خمسين بالمائة من النيتروجين الغذائي من بروتين الإختبار و تم تقديم الغذاء للحيوانات أربع مرات في اليوم. كما تم استخدام كبسولات أكسيد الكروم (بمعدل٥٠ جرام في اليوم) لتقدير معاملات الهضم، وكانت معدلات تحلل البروتين في الكرش داخل جسم الحيوان ٥٦,٨، ٦٨,٣٪ وخارجه ٤٧,٣، ٣٥,٣٪ لكسب فول الصويا ومركز بروتين البرسيم، على التوالي. وكان معدل تناول المادة الجافة (كجم في اليوم) ١٩,١ و١٨,٦ للأبقار التي تغذت على كسب فول الصويا ومركز بروتين البرسيم على التوالي. كانت معدلات بيانات الكرش في الأبقار المغذاة على كسب فول الصويا مقارنة بتلك المغذاة على مركز بروتين البرسيم كالآتي: الرقم الهيدروجيني ٦,٦ مقابل ٦,٧، نيتروجين الأمونيا (مجم/يوم) ١٠,٨ مقابل ٦,٢ (فرق معنوي عند ١٪)، مجموع الأحماض الدهنية المتطايرة (ميكروميقا) ٨٦,٣ مقابل ٨٤,٦ (فرق معنوي عند ٥٪)، الأسيتيت ٥٠,٨ مقابل ٦٤,٩٪ (فرق معنوي عند ١٪)، البروبيونيت ٢٤,٨ مقابل ١٩,٦٪ (فرق معنوي عند ١٪) البيوتاريت ١٠,٧ مقابل ١١,٥٪. كان معامل الهضم في الأبقار المغذاة على كسب فول الصويا مقابل المغذاة على مركز بروتين البرسيم كالآتي: المادة الجافة ٦٥,٣ مقابل ٦١,٨، البروتين الخام ٦٧,٦ مقابل ٦١,١٪ (فرق معنوي عند ٥٪)، الألياف المحايدة ٥١,١ مقابل ٥٢,٥ ٪، ألياف الحمض المحايدة ٤٧,٧ مقابل ٤٩٪. أنتجت الأبقار المغذاة على مركز بروتين البرسيم كمية أعلى قليلا من الحليب (٢٨,٦ ± ٣,٥ مقابل ٢٨,٢ ± ٣,٨ كجم في اليوم). أسهم كل جرام إضافي من البروتين غير المتحلل من مركز بروتين البرسيم في زيادة إنتاج الحليب المعدل لنسبة دهن ٤٪ بمقدار ٥ جرام.

ABSTRACT : Ten multiparous Holstein cows were used in a 105-day continuous feeding trial to compare soybean meal (SBM) and alfalfa protein concentrate (APC) as supplemental protein sources for high-producing dairy cows. Dairy cows with an average milk production of 35.2 kg/day were paired and randomly assigned to one of the treatments. A double reversal design was employed with 35 days per period. The comparison between treatments was made during the last 21 days of each period. Experimental diets, containing 60% corn silage and 10% alfalfa hay, were formulated to be isonitrogenous and isoenergetic (crude protein, 15.6%; net energy for lactation, 1.60 Mcal/kg DM). Fifty percent of dietary nitrogen was provided by test proteins. Animals were fed four times daily. Chromic oxide boluses, 50 g/day were used to estimate digestion coefficients. Ruminal protein degradability *in vivo* (%) and *in situ* (%) were 56.8, 68.3 and 47.3, 35.3 for SBM and APC, respectively. Dry matter intake (kg/day) was 19.1 and 18.6 for cows fed SBM and APC, respectively. Ruminal parameters of cows fed SBM *vs* APC were: pH, 6.6 vs 6.7; ammonia nitrogen (mg/dl), 10.8 *vs* 6.2 ($P < 0.01$); total volatile fatty acids (mM), 86.3 *vs* 84.6 ($P < 0.05$); acetate (%), 50.8 *vs* 64.9 ($P < 0.01$); propionate (%), 24.8 *vs* 19.6 ($P < 0.01$); butyrate (%), 10.7 *vs* 11.5. Digestion coefficients (%) in cows fed SBM *vs* APC were: dry matter, 65.3 *vs* 61.8; crude protein, 67.6 *vs* 61.1 ($P < 0.05$); neutral detergent fiber, 51.1 *vs* 52.5; acid detergent fiber, 47.7 *vs* 49.0. A slightly higher ($P > 0.05$) amount of milk was produced by cows fed APC (28.6 ± 3.5 *vs* 28.2 ± 3.8 kg/day). Each additional gram of undegradable intake protein provided by APC contributed to a 5-gram increase in 4% fat-corrected milk production.

Plant fractionation process (PFP, Figure 1) has been considered as a novel approach to producing plant protein from forage crops. One of the resulting products, alfalfa protein concentrate (APC) can be utilized by ruminants, monogastric animals and humans. Compared with the conventional harvest system, PFP is less weather dependent, better in control of the stage of maturity at harvest, and has a higher recovery of nutrients from the field. While cell maceration and pressure fractionation improved the utilization of pressed fiber by ruminants (Lu *et al.*, 1979, 1980), heat coagulation and dehydration

[1]Corresponding Author.

a.m.-p.m. composite milk samples. *In situ* protein degradability was determined using the polyester bag technique and in vivo protein degradability was determined using dairy cows fitted with ruminal and intestinal cannulae (Lu *et al.*, 1988).

Data were calculated as $D = Y_1 - 2Y_2 + Y_3$ where D is the transformed response variable; Y_1, Y_2 and Y_3 are the performance variables in Period 1, 2 and 3, respectively (Cochran and Cox, 1957). Data were subjected to analysis of variance using the general linear models procedure of the Statistical Analysis System (SAS, 1988).

Results and Discussion

When ruminal components were analyzed (Table 3), the value for NH_3-N was higher for SBM than that for APC ($P < 0.01$). The values, 10.8 *vs.* 6.2 mg/dl were approximately 5 percentage units lower than the previous study (Lu *et al.*, 1988). However, the differences between treatments were similar in both studies. A lower ruminal NH_3-N in cows fed APC suggested lower extent of protein, peptides or amino acids degradation, because both diets were isonitrogeneous. The value of total VFA was higher ($P < 0.05$) in cows fed SBM than the APC diet. Lower total VFA concentrations in cows fed APC could be attributed to lower digestion of organic matter in the stomach. In a previous study (Lu *et al.*, 1988), cows fed APC also had a lower ($P < 0.05$) VFA concentration in the rumen. When the individual VFA percentages were compared, cows fed APC had higher ($P < 0.01$) acetate and lower ($P < 0.01$) propionate levels than those fed SBM. The reason for the difference in individual VFA is not clear. However, it can be assumed that the feeding of APC could be beneficial for milk fat synthesis, because acetic acid is a precursor of milk fat. In the previous *in vivo* study (Lu, *et al.*, 1988) differences were not observed in the individual VFA distribution between APC and SBM. The pH and butyrate values for the two treatments were essentially the same.

TABLE 2

Chemical composition of soybean meal (SBM) and afalfa protein concentrate (APC)

Item	SBM	APC[a]
Dry matter, %	89.0	50.6
Crude protein, %[b]	51.8	56.9
Protein degradability, %		
In situ[c]	68.3	35.3
In vivo	56.8	47.3
Gross energy, Kcal/gDM	4.8	4.9
Acid detergent fiber, %[b]	11.9	11.6

[a]Preserved with 2.5% (W/W) Moldex (containing 35% propionic, 10% acetic, 10% benzoic, and 3% sorbic acids).
[b]Dry matter basis.
[c]Calculated as Kd/Kr+Kd; Kd, rate of disappearance in the rumen; Kr, ruminal turn over rate.

TABLE 3

Ruminal components of high- producing dairy cows fed isonitrogenous and isoenergetic diets containing soybean meal (SBM) or alfalfa protein concentrate (APC)

Item	SBM	APC	SE	Significance
pH	6.6	6.7	0.1	NS
Ammonia N, mg/dl	10.8	6.2	1.5	$P < 0.01$
Total VFA, mM/l	86.3	84.6	3.8	$P < 0.05$
Individual VFA, %				
Acetate	59.8	64.9	1.0	$P < 0.01$
Propionate	24.8	19.6	2.0	$P < 0.01$
Butyrate	10.7	11.5	1.8	NS

Dry matter intake by cows was not different between treatments, 19.1 vs 18.6 kg/day (Table 4). Digestion coefficients of dry matter, NDF and ADF were similar in cows fed APC or SBM. Slightly higher fiber digestibilities might have contributed to higher acetic acid concentration in cows fed APC. Crude protein digestibility was lower ($P < 0.05$) in cows fed APC. This could be attributed to a lower protein degradation in the rumen. Feed protein degraded in the stomach was slightly lower in cows fed APC, but apparent nitrogen digestion in the small intestine was slightly higher in cows fed APC (Lu *et al.*, 1988). In the previous study, apparent nitrogen digestibility in the total tract was 3 percentage units lower in cows fed APC. In the present study, the difference was 8 percentage units. It is apparent that APC is more resistant to ruminal degradation than SBM, and resulted in a lower total tract digestion. There was no difference in fecal dry matter output between treatments.

Milk production was numerically higher in cows fed APC. The results were less than expected. Previous studies suggested that approximately 44% of protein in APC escaped microbial degradation in the rumen (Lu *et al.*, 1982a) and approximately 72% of the amino acids reaching the duodenum was absorbed (Lu *et al.*, 1983). There is little doubt that APC is relatively resistant to microbial degradation in the rumen.

Undegradable intake protein contributed by APC was calculated to be 736 g/day compared to SBM of 641 g/day. Numerically, the 95 g/day difference in

TABLE 4

Dry matter intake and nutrient digestibilities and milk production of high producing cows fed isonitrogenous and isonergetic diets containing soybean meal (SBM) or alfalfa protein concentrate (APC)

Item	SBM	APC	SE	Significance
Dry matter intake, kg/day	19.1	18.6	1.0	NS
Digestibility, %				
Dry Matter	65.3	61.8	3.1	NS
Crude protein	62.6	54.1	4.5	$P < 0.05$
Neutral detergent fiber	51.1	52.5	2.4	NS
Acid detergent fiber	47.7	49.0	4.9	NS
Fecal dry matter,kg/day	6.6	7.1	0.8	NS
Milk Production				NS
Milk,kg/day	28.2	28.2	3.1	NS
Fat, %	3.6	3.6	0.2	NS
4% FCM[a], kg/day	26.5	27.0	2.9	NS
Protein, %	3.7	3.7	0.3	NS

[a]FCM, fat-corrected milk.

UIP contributed to a 500 g/day difference in 4% fat-corrected milk (FCM) production in favor of APC. For each additional gram of UIP, contributed to a 5-gram increase in 4% FCM.

In order to achieve a significant difference in milk production, perhaps more APC should have been incorporated in the total ration. To accomplish this, diets containing higher dietary protein concentration will have to be fed to higher producing dairy cows than those used in this experiment. Both milk fat and milk protein contents were identical in both treatments.

Lactation curves of cows fed SBM or APC diets are presented in Figure 2. These curves are typical for cows in mid-lactation. At the end of week 5 and 10, experimental diets were switched according to the design. With the exception of week 8 to 10, milk production was essentially the same between treatments. Nevertheless, cows fed the APC diet produced a numerically higher amount of milk at the end of each period (week 5, 10 and 15).

Conclusions

As evidenced by lower ammonia N and total VFA concentrations in the rumen. APC can be considered a dietary protein source which is more resistant than SBM to microbial degration in the rumen. Numerical calculation suggests that for each additional gram to UIP provided by APC, an increase of 5 g of 4% FCM was produced. If the PFP is to be considered as an on-the-farm and one-pass system, all three end products (pressed fiber, brown juice, and protein concentrate) should be efficiently utilized. Being less weather dependent and having higher yield due to more cuts of forage per season, PFP allows dairy farmers to increase their herd size without subjected to land limitation.

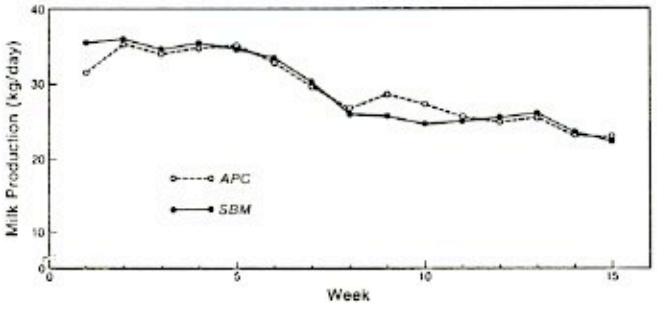

Figure 2. Milk Production curves of dairy cows fed diets containg alfalfa protein concentrate (APC) or soybean meal (SBM)

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