Use of cotton plant byproducts as a source of fiber in feedlot diets

ABSTRACT

Cotton fibre co-products available in northern Argentina are a source of effective fiber to replace high cost roughage (e.g., alfalfa hay or silage or grasses) in finishing diets. This experiment was conducted to evaluate the effect of replacing roughage sources (alfalfa hay) by cotton plant byproduct (SPA) on average daily gain (ADG), dry matter intake (DMI) and feed efficiency (DMI/ADG) in feedlot diets. One hundred and four (220 ± 4 kg LW) were assigned to 12 pens (8 or 9 animals/per pen) for 68 days on feed. The experiment was divided in two feeding periods: adaptation (days 0 to 19) and finishing (days 20 to 68). Treatments consisted of replacing the roughage portion of the diet (alfalfa hay: 12.9% CP, 65.5% NDF) by SPA (7.2% CP, 71.4% NDF): 100% alfalfa (SPA0); 66% alfalfa: 33% SPA (SPA33); 33% alfalfa: 66% SPA (SPA67); and 100% SPA (SPA100). Initial (day 0; P = 0.92), adaptation (day 19; P = 0.26) and final (day 68; P = 0.37) average live weight did not significantly differ among treatments. Moreover, ADG (P > 0.43), DMI (P > 0.23) and DMI/ADG (P > 0.50) were not affected by treatments for both feeding periods. Results show that total or partial replacement of alfalfa roughage by SPA in high concentrate diets (>89%) do not adversely affect live weight gain and feed efficiency.

Keywords: feedlot, effective fiber, cotton byproduct, concentrate, feed efficiency, beef cattle.

INTRODUCTION

Usually, feedlots use grain-rich finishing diets to maximize animal conversion and productivity. However, several studies (Shain et al., 1999; Galyean and Defoor, 2003; Pritchard et al., 2003) point out to the need to include minimum levels of bulky or “long fiber” (LF) forage in rations with a high content of grains to prevent ruminal acidosis and stimulate energy consumption.

Krekemeier et al. (1990) and Shain et al. (1999) reported increases from 5 to 10% in dry matter (DM) consumption before including LF in the diet, and between 10 and 15% when compared to totally concentrated diets. However, excessive consumption of LF in finishing rations leads to a reduction in energy density, consumption, and animal productivity (Mertens, 1997). Galyean and Gleghorn (2001) and Galyean and Defoor (2003) suggest that the LF requirements to maximize animal productivity range between 3 and 15% of the diet (dry base).

The effectiveness of voluminous forages as a source of LF - to stabilize ruminal pH and stimulate energy consumption depends on their physical and chemical properties, neutral detergent fiber concentration (NDF), volumetric density, and buffer capacity (Defoor et al., 2002). The main factor associated with the effectiveness of voluminous forage for concentrated diets is the NDF content and the particle size.

Swingle (1986) reported that replacing alfalfa hay with wheat straw in steer’s growing (65 and 80% concentrate) and finishing (90% concentrate) diets did not affect the productive response. The authors speculated that wheat straw could have affected fermentation kinetics and the passage...
rate of other components of the rumen diet, changing the site and extent of digestion. In a subsequent trial, Moore et al. (1990) showed that substitution of alfalfa hay by wheat straw or cotton husk, used as fodder in mixed diets, differentially affected the rate of passage and digestion of sorghum grain.

Wheat straw stimulated the rumination and digestibility of alfalfa fiber and sorghum, and were not affected by cotton husk. Theurer et al. (1999) compared alfalfa hay, cotton husk, and wheat straw as sources of bulky forage in finishing diets. The authors concluded that low quality forage sources - cotton husk and wheat straw - exert a greater "fiber" effect than higher quality forages (alfalfa), which was attributed to differences in the NDF content.

Similar results were reported by Defoor et al. (2002) in a study conducted with finishing heifers using cotton husk (DM 2.5, 5.9, and 12.5%) and a control with 12.5% alfalfa hay. Another aspect that influences the effectiveness of voluminous forages is volumetric density (g/L), the lower the volumetric density, the greater the effectiveness of the forage source. For example, the Sudanese sorghum silo (base DM) has approximately twice the density of alfalfa hay. In turn, cotton husk has a volumetric density similar to alfalfa hay (140 g/L and 142 g/L, respectively). These results indicate that LF, like cotton husk, should be included in high energy rations, in lower concentrations when compared to diets that have a high quality fiber source as a fibrous fraction.

The cultivation of cotton generates a high amount of potentially useable by-products in ruminant feed, which has recently increased due to the increasing use of sowing in narrow furrows. The cotton plant by-product (SPA) is the one that increases the most ton plant by-product (SPA) is the one that increases the most ton husk. Theurer et al. (1999) compared alfalfa hay, cotton husk, and wheat straw as sources of bulky forage in finishing diets. The authors concluded that low quality forage sources - cotton husk and wheat straw - exert a greater "fiber" effect than higher quality forages (alfalfa), which was attributed to differences in the NDF content.

The treatments were generated by replacing medium quality alfalfa hay as a source of long fiber by cotton plant byproduct (SPA): 10.44% Alfalfa (SPA0), 6.93% Alfalfa: 3.41% SPA (SPA33); 3.41% Alfalfa: 6.93% SPA (SPA67); and 10.35% SPA (SPA100). Table 1 shows the chemical composition of the ingredients used in the four rations.

The diets were formulated to be isoenergetic, isoproteic and with similar contents of fibrous fraction, according to the nutritional requirements established by the NRC (1996) of bovine meat (Table 2).

The rations were supplied twice a day at 9:00 AM and 2:00 PM. The SPA was provided unprocessed, while the alfalfa hay was ground using a hammer mill (5 cm sieve diameter).

Animals underwent a 19-days adaptation period to the diet. From the beginning of the adaptation period, we started supplying the concentrated rations (c.a., 10% long fiber), but with controlled supply. The daily supply was gradually increased until day 19, and adjusted by feeder reading until the end of the trial (day 68). The rejections of the ration were quantified using the daily feeder reading, adjusted with a weekly weighing of the remainder.

A weekly portion of the rejects (per pen) was dried in a forced air oven at 55 °C. We made a composite sample using the rejections collected weekly, which was later used for chemical analysis in the laboratory. The daily dry matter intake (DMI) and nutrients was quantified by the difference between the daily supply and the rejections, both corrected on the DM content and nutrients.

The initial and final live weight was recorded after 24 h of fasting prior to weighing, with the exception of the adapta-

### MATERIALS AND METHODS

**Description of the study**

The work was conducted in the Experimental Field “La María” (INTA EEA Santiago del Estero, Argentina). For this study, 52 steers and 52 heifers (Braford crossbred) were used. They were distributed in 12 pens, balanced by sex (eg, 50% males: 50% females within each pen) and grouped into three groups of similar initial weight (4 pens per group): high= 242.8 ± 4.1 kg LW, medium= 229.5 ± 2.4 kg LW, and low= 187.6 ± 1.4 kg LW (± standard deviation). The trial was conducted during 68 days, divided into two phases of evaluation: adaptation phase (day 0 to 19) and finishing phase (day 20 to 68). Before starting the trial, the animals were treated with antiparasitics and vitamins A, D, and E (Ivermectin 3.15%, Vetanco S.A., Vicente López, Buenos Aires). A mineral complex (Yodacalcico B12-D, Chinfeld S.A.) was also injected.

The treatments were generated by replacing medium quality alfalfa hay as a source of long fiber by cotton plant byproduct (SPA): 10.44% Alfalfa (SPA0), 6.93% Alfalfa: 3.41% SPA (SPA33); 3.41% Alfalfa: 6.93% SPA (SPA67); and 10.35% SPA (SPA100). Table 1 shows the chemical composition of the ingredients used in the four rations.

The diets were formulated to be isoenergetic, isoproteic and with similar contents of fibrous fraction, according to the nutritional requirements established by the NRC (1996) of bovine meat (Table 2).

The rations were supplied twice a day at 9:00 AM and 2:00 PM. The SPA was provided unprocessed, while the alfalfa hay was ground using a hammer mill (5 cm sieve diameter).

Animals underwent a 19-days adaptation period to the diet. From the beginning of the adaptation period, we started supplying the concentrated rations (c.a., 10% long fiber), but with controlled supply. The daily supply was gradually increased until day 19, and adjusted by feeder reading until the end of the trial (day 68). The rejections of the ration were quantified using the daily feeder reading, adjusted with a weekly weighing of the remainder.

A weekly portion of the rejects (per pen) was dried in a forced air oven at 55 °C. We made a composite sample using the rejections collected weekly, which was later used for chemical analysis in the laboratory. The daily dry matter intake (DMI) and nutrients was quantified by the difference between the daily supply and the rejections, both corrected on the DM content and nutrients.

The initial and final live weight was recorded after 24 h of fasting prior to weighing, with the exception of the adapta-

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>DM</th>
<th>CP¹</th>
<th>NDF²</th>
<th>FAD³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton seed</td>
<td>895</td>
<td>247</td>
<td>520</td>
<td>289</td>
</tr>
<tr>
<td>Cotton plant byproduct</td>
<td>868</td>
<td>72</td>
<td>714</td>
<td>530</td>
</tr>
<tr>
<td>Broken maize</td>
<td>867</td>
<td>100</td>
<td>135</td>
<td>37</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>871</td>
<td>129</td>
<td>655</td>
<td>395</td>
</tr>
<tr>
<td>Urea</td>
<td>990</td>
<td>2810</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Chemical composition of the ingredients of the diet (g/kg dry matter, DM).

¹Crude protein. ²Neutral Detergent Fiber. ³Acid Detergent Fiber.
Use of cotton plant byproducts as a source of fiber in feedlot diets

We calculated the conversion (DMI/ADG) over the DMI (kg) divided by ADG using the intake records corrected for dry matter (DMI) and live weight gain.

Laboratory analysis

We determined the chemical composition of each ingredient of the diet using standardized procedures used in forage laboratories. The samples of offered and rejected food were dried in an oven with forced ventilation (55 °C) to determine DM. Then they were ground to 1 mm (mill number 4 Wiley, Thomas Scientific, Swedesboro, N.J.), and subsequently dried for 24 h at 105 °C to calculate the percentage of final DM. We used the Kjeldahl procedure described by the AOAC (1980) to determine crude protein (total N). The fiber content (neutral detergent fiber, NDF; acid detergent fiber, ADF) of the components of the diet and the composite samples of remnants per pen was determined with the 220-ANKOM fiber analyzer (ANKOM Technology, Fairport, NY) using the procedure reported by Komarek (1993).

The metabolizable energy content (ME, Mcal/kg DM) for each ration was estimated using the equation adjusted to high-concentrate mixes in concentrates of Menke and Steingass (1988): 

\[ \text{ME (Mcal/kg DM)} = 3.5 - 0.035 \times \% \text{ADF} \]

In turn, the net energy for weight gain (ENg, Mcal/kg DM) was determined from the ME using the equation suggested by NRC of bovine meat (1996):

\[ \text{ENg (Mcal/kg)} = 1.42 \times \text{ME} - 0.174 \times \text{ME}^2 + 0.0122 \times \text{ME}^3 - 1.65 \]

Statistic analysis

The experimental design was in blocks (3), and the experimental unit was the pen. Intake, live weight, average daily gain, and feed conversion were analyzed using the SAS Mixed processor (SAS Inst. Inc., Cary, NC, USA). For the statistical analysis of the diet’s parameters of nutritional

### Table 2. Proportion of ingredients and chemical composition of the diets.

<table>
<thead>
<tr>
<th>Source of Long Fiber in the diet¹</th>
<th>SPA₀</th>
<th>SPA₃₃</th>
<th>SPA₆₇</th>
<th>SPA₁₀₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA₀</td>
<td>10.44% Alfalfa, SPA₃₃= 6.93% Alfalfa: 3.41% SPA; SPA₆₇= 3.41% Alfalfa: 6.93% SPA; and SPA₁₀₀ = 10.35% DM SPA.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPA₃₃</td>
<td>6.93% Alfalfa: 3.41% SPA; and SPA₁₀₀ = 10.35% DM SPA.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPA₆₇</td>
<td>3.41% Alfalfa: 6.93% SPA; and SPA₁₀₀ = 10.35% DM SPA.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPA₁₀₀</td>
<td>10.35% DM SPA.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Source of Long Fiber (SPA= cotton plant byproduct), % in the diet: SPA₀= 10,44% Alfalfa, SPA₃₃= 6,93% Alfalfa: 3,41% SPA; SPA₆₇= 3,41% Alfalfa: 6,93% SPA; and SPA₁₀₀ = 10,35% DM SPA.

₂Hydrated lime (calcium hydroxide).

³Vitamin-mineral core (composition: copper sulphate 2.20%, calcium iodate 0.06%, cobalt carbonate 0.021%, manganese oxide 10%, zinc sulfate 10.8%, sodium selenite 0.021%, ferrous sulfate 5.82%, calcium carbonate 4%, monensin 10%).

⁴Estimated using the equation of Menke and Steingass (1988); ME (Mcal/kg DM)= 3.5 - 0.035 x %FAD).

⁵SNEg = net energy for live weight gain estimated by NRC (1996).

---

Use of cotton plant byproducts as a source of fiber in feedlot diets
value, repeated measures were used in time (phase 0-19 days vs. phase 20-68 days) using proc. Mixed of SAS. The means of treatments were compared using the test of least significant differences (LSD).

RESULTS

The initial average weight (day 0, P= 0.92) at the end of the adaptation stage (day 19, P= 0.26) and at the end of the trial (day 68, P = 0.37) did not differ significantly between treatments (Table 3). Similarly, the ADG during the adaptation phase (day 0 to 19= 968 ± 274, P= 0.51), finishing phase (day 19 to 68= 1255 ± 149, P= 0.67), and average of the trial (day 0 to 68= 1176 ± 144, P= 0.43) were not affected by the treatments.

The interaction diet x day of feeding did not affect the DMI nor the conversion (DMI/ ADG). Therefore, the average results are reported by diet and stage of the study (day 0 to 19, day 19 to 68, and day 0 to 68, Table 3). The DMI did not differ during the cycle of the trial (P= 0.87), the stages of day 0 to 19 (P= 0.23) and of days 19 to 68 (P= 0.53) among the four evaluated treatments. The mean consumption expressed as % of the LW was 1.97 ± 0.32, 3.07 ± 0.19, 2.74 ± 0.20 (± SEM) for the adaptation stage, finishing stage, and the complete fattening cycle, respectively.

Similar to what happened with the DMI and the ADG, the DMI/ADG conversion did not differ significantly between treatments at any stage and the complete test cycle (P>0.50). The mean conversions of the adaptation stage (day 0 to 19), finishing stage (day 19 to 68), and the complete cycle (day 0 to 68) were 5.59 ± 2.04, 6.26 ± 0.72, and 5.99 ± 0.83, respectively.

The interaction stage × diet was not statistically significant for any quality parameter of the diet. The CP and NDF content did not differ statistically between treatments (P>0.23, Table 4) in any of the studied feeding stages. However, the average CP content (two stages) tended to be higher in SPA0 than in SPA33 and SPA67 (P= 0.07), while SPA100 presented intermediate values.

In contrast, the FAD content increased, and the net energy of weight gain (NEg) decreased in response to the replacement of alfalfa by cotton plant byproduct (from SPA0 to SPA100, P<0.05, Table 4). A similar trend was observed in the percentage of NDF contributed by the voluminous (NDFv) and the metabolizable energy (ME) content of the diet (P= 0.08).

In the adaptation stage, the NDF, NDFv and FAD content of the diet was greater than in the finishing stage (P<0.01, Table 4), although the level of bulky forage was not significantly higher than that of the finishing diet. In contrast, ME and NEg were higher in the finishing stage. The CP concentration was not statistically different between stages.

The consumption of NDFv and NEg was similar between treatments (Table 4), although the concentration of FAD

<table>
<thead>
<tr>
<th>Source of long fibre in the diet</th>
<th>SPA0</th>
<th>SPA33</th>
<th>SPA67</th>
<th>SPA100</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0 (beginning)</td>
<td>220.7</td>
<td>219.0</td>
<td>219.7</td>
<td>220.7</td>
<td>3.48</td>
<td>0.92</td>
</tr>
<tr>
<td>Day 19 to 68 (end)</td>
<td>241.0</td>
<td>234.0</td>
<td>237.0</td>
<td>242.0</td>
<td>4.8</td>
<td>0.26</td>
</tr>
<tr>
<td>Day 68 (end)</td>
<td>305.3</td>
<td>291.3</td>
<td>297.7</td>
<td>305.3</td>
<td>10.5</td>
<td>0.37</td>
</tr>
<tr>
<td>Average daily increase, g/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0 to 19</td>
<td>1060</td>
<td>793</td>
<td>907</td>
<td>1113</td>
<td>274</td>
<td>0.51</td>
</tr>
<tr>
<td>Day 20 to 68</td>
<td>1317</td>
<td>1173</td>
<td>1237</td>
<td>1293</td>
<td>149</td>
<td>0.67</td>
</tr>
<tr>
<td>Day 0 to 68</td>
<td>1247</td>
<td>1067</td>
<td>1147</td>
<td>1243</td>
<td>144</td>
<td>0.43</td>
</tr>
<tr>
<td>DM intake, % LW/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0 to 19</td>
<td>1.87</td>
<td>2.07</td>
<td>2.00</td>
<td>1.92</td>
<td>0.32</td>
<td>0.87</td>
</tr>
<tr>
<td>Day 20 to 68</td>
<td>3.15</td>
<td>2.89</td>
<td>3.25</td>
<td>3.00</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>Day 0 to 68</td>
<td>2.77</td>
<td>2.64</td>
<td>2.88</td>
<td>2.68</td>
<td>0.20</td>
<td>0.53</td>
</tr>
<tr>
<td>Conversion, kg/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 0 to 19</td>
<td>4.86</td>
<td>7.05</td>
<td>5.78</td>
<td>4.67</td>
<td>2.04</td>
<td>0.51</td>
</tr>
<tr>
<td>Day 20 to 68</td>
<td>6.12</td>
<td>6.26</td>
<td>6.71</td>
<td>5.93</td>
<td>0.72</td>
<td>0.61</td>
</tr>
<tr>
<td>Day 0 to 68</td>
<td>5.69</td>
<td>6.28</td>
<td>6.46</td>
<td>5.52</td>
<td>0.83</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Table 3. Efecto de la sustitución de heno de alfalfa por subproducto de planta de algodón (SPA) sobre la productividad animal y la conversión de la dieta.

1Source of long fibre (SPA= cotton plant byproduct), % in base diet DM: SPA0= 10,44% Alfalfa, SPA33= 6,93%, Alfalfa= 3,41% SPA; SPA67= 3,41%, Alfalfa: 6,93% SPA; and SPA100= 10,35% DM SPA.
and NDFv increased in response to the increase in the inclusion of SPA in the voluminous fraction of the diet, and that the NEg decreased. We only observed differences in the consumption of NDFv and NEg between the adaptation and finishing stages.

**DISCUSSION AND CONCLUSIONS**

In this experiment the partial or total substitution of alfalfa hay by cotton plant byproduct did not affect the animal performance, consumption (DM, NDFv, and NEg) and the efficiency of use of the diet with a ration of 89% of concentrated. However, the literature show different results in terms of animal performance in response to the inclusion of SPA as a source of fiber in concentrated diets (Bartle et al., 1994; Gill et al., 1981; Defoor et al., 2002; McCartor et al., 1972; Theurer et al., 1999). The inconstancy in the response to the inclusion of SPA is due to the fact that the productive performance and the efficiency not only depend on the type of fiber source, but also on its level of inclusion in the diet. The content of voluminous forage recommended for concentrated diets ranges between 4.5 and 13.5% (Galyean and Glegehorn, 2001), although it is more related to the content of NDF contributed by the volume to the total diet than with the inclusion level of voluminous forage per se (Galyean and Defoor, 2003).

In this study, the ADG equivalent between treatments coincides with previous results obtained in a similar study conducted by Bartle et al. (1994) in high energy diets. Defoor et al., (2002) noted that consumption and efficiency were similar when replacing alfalfa hay by cotton husk. However, in contrast to our results and those of Defoor et al. (2002), Bartle et al. (1994) observed that higher consumption and lower efficiency of use of the diet in lots where the source of long fiber of the ration was SPA when compared to those that used alfalfa as a source of long fiber.

Guthrie et al. (1996) replaced alfalfa hay with cotton husk or sorghum-sudan hay at 7.5% and 15%. The results showed that, on average, alfalfa hay treatments consumed less and gained less weight per day than those where cotton husk or sorghum-sudan hay were offered. The authors suggest that bulky, more fibrous forages may have a greater ability to stimulate energy consumption and reduce acidosis than alfalfa hay.

In contrast to the response in DNI observed in our work, studies on substitution of alfalfa hay or other source of good quality long fiber by cotton husk shows mostly an increase in DMI (Defoor et al., 2002; Theurer et al., 1999; Bartle et al., 1994). Unlike the previously cited works, the present trial differs in that the NDF content of the husk was only 5.9 points higher than that of alfalfa and generated practically similar diets in terms of NDF content (concentration range of NDF in offered diets= 19.34 - 19.89%, Table 2).

The small difference in fiber content in bulky forages plus - possibly - the selection of the diet by the animals in the feeder, resulted diets with very similar NDF content (NDF concentration range in diets consumed= 18.1 - 19.2%, Table 4). On the one hand, the concentration of metabolizable energy of the diets in the four treatments was close to the lower limit of the optimal range (ME= 3.16 to 3.45) to maximize ADG and feed conversion (Krehbiel et al., 2006). On the other hand, the consumption of NEg is congruent with levels observed in other studies (Defoor et al., 2002, Xiong et al., 1990).

Defoor et al. (2002) suggest that the DMI and NEg increase due to the increase in the NDF content of the diet and NDFv increased in response to the increase in the inclusion of SPA in the voluminous fraction of the diet, and that the NEg decreased. We only observed differences in the consumption of NDFv and NEg between the adaptation and finishing stages.

**Table 4.** Effect on the nutritional value of the diet consumed of alfalfa replacement by cotton plant byproduct (SPA).

<table>
<thead>
<tr>
<th>Source of long fibre in the diet1</th>
<th>Phase</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SPA0</td>
<td>SPA33</td>
</tr>
<tr>
<td>CP2, g/kg DM</td>
<td>124a7</td>
<td>120b</td>
</tr>
<tr>
<td>NDF3, g/kg DM</td>
<td>191</td>
<td>181</td>
</tr>
<tr>
<td>NDFv4, g/kg DM</td>
<td>87b</td>
<td>93ab</td>
</tr>
<tr>
<td>FAD5, g/kg DM</td>
<td>88b</td>
<td>93ab</td>
</tr>
<tr>
<td>ME6, Mcal/kg DM</td>
<td>3,19a</td>
<td>3,18ab</td>
</tr>
<tr>
<td>NEg7, Mcal/kg SM</td>
<td>1,51a</td>
<td>1,50ab</td>
</tr>
</tbody>
</table>

1Source of long fibre (SPA = cotton plant byproduct), % in base diet DM: SPA0= 10.44% Alfalfa, SPA33= 6.93%, Alfalfa= 3.41% SPA; SPA67= 3.41% Alfalfa; 6.93% SPA; and SPA100 = 10.35% DM SPA.
2Crude protein.
3Neutral detergent fiber.
4Neutral detergent fiber provided by the volume.
5Acid detergent fiber.
6Metabolizable energy.
7Net energy of live weight gain.
8Means with different letters between columns for diet and phase differ from each other according to LSD (P <0.05).
as a consequence of the substitution of alfalfa for husk. In this present study we observed an increase of NDFv and FAD in the consumed diet in response to the total or partial substitution of alfalfa for husk. Although the increase of the FAD in the diet reduced the concentration of dietary NEg, a lower consumption of NEg was not reflected. Many factors influence the consumption of NEg: for instance different sources of voluminous forage play an important role in concentrated diets. Defoor et al. (2002) suggest that an important point to value a long fiber source is, in addition to its ability to reduce the problems of digestive disorders, its ability to stimulate the consumption of NEg. Thus, sources with higher NDF content are more effective in optimizing NEg consumption.

The NEg consumption increases in response to the contribution of NDF from voluminous forage. Despite the dilution of the energy concentration of the diet, this seems to be compensated or overcompensated. Therefore, in diets where consumption is not limited by physical regulation (filling), the animal has the possibility of consuming additional energy by adding basal levels of bulky forage fiber before the chemo-static mechanisms limit consumption (Owens et al., 1998). Accordingly, we observed in this study that, although the concentration of NEg decreased and the NDFv increased by the substitution of alfalfa for SPA, the DMI remained similar. What was described by Owens et al. (1998) explains in some way these results.

An important aspect associated with the fiber source is that the increase or maintenance in the NEg consumption, when compared to dilutions of the diet, is mostly associated with an increase in the passage rate (NRC, 1996). In this sense, changes in the passage rate of the dietary components alter the magnitude of digestion in the different compartments of the digestive tract (Owens et al., 1998). Moore et al. (1990) evaluated the passage rate in fistulated rumen steers fed with 65% concentrate (sorghum grain base) diets containing three treatments of differential bulky fiber: 35% alfalfa hay, 35% alfalfa with cotton husk (50% alfalfa: 50% husk), or 35% alfalfa with wheat straw (50% alfalfa: 50% wheat straw). The replacement of alfalfa by cotton husk increased the DMI and tended to increase the passage rate of grain.

Therefore, small amounts of voluminous forages in concentrated diets increase the passage rate of grain and ruminal fluid (Goetsch and Owens, 1986), although the effect can be the inverse when the level is excessive (> 50%, increases the retention time).

The NDF of the forage reduces the retention time of the grain, and reduces its digestion at the ruminal level, which translates into lower production and lower concentration of ruminal volatile fatty acids. As it is known, volatile fatty acids (VFA) play a major role in the regulation of consumption in ruminants (Baile and Forbes, 1974). Propionate stands out as one of the most important VFAs in the regulation of consumption. The change of the digestion site increases the availability of starch in the small intestine and reduces the concentration of VFA in the rumen. This would partially disrupt or delay the regulation of consumption by reducing the ruminal concentration of VFA, and would allow a greater energy consumption than a fully concentrated diet.

Finally, a usually disregarded aspect that may also influence the digestion site of the diet is that the cotton husk contains tannins and gossypol, in lower concentrations than in the seed (Blasi and Drouillard, 2002). Secondary compounds such as tannins and gossypol can alter fermentation via a direct effect on ruminal microorganisms or via the formation of complexes with carbohydrates or proteins (Molan et al., 2001). It is speculated that certain levels of secondary compounds in the forage source would reduce the production of volatile fatty acids, and thus stimulate the consumption of NEg in concentrated diets.

We conclude, from the results obtained in this experiment, that the total or partial replacement of alfalfa hay by fibrous cotton byproducts as a source of long fiber in concentrated diets (>89%) does not influence the weight gain and efficiency use of the ration.

**REFERENCES**


Use of cotton plant byproducts as a source of fiber in feedlot diets


