International Journal of Agronomy and Agricultural Research
ISSN: 2223-7054 (Print); 2225-3610 (Online) | IJAAR |
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RESEARCH PAPER
Vol. 28, Issue: 1, 2026
OPEN ACCESS

Effects of partial replacement of calf starter with whole cottonseed on growth performance of preweaned dairy calves

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DOI: https://dx.doi.org/10.12692/ijaar/28.1.1-5

ARTICLE INFORMATION

RESEARCH PAPER

Vol. 28, Issue: 1, p. 1-5, 2026

Int. J. Agron. Agri. Res.

Altinso

ACCEPTED: 30 December, **2025**

PUBLISHED: 05 January, **2026**

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ABSTRACT

Whole cottonseed (WCS) is commonly used in adult ruminant nutrition due to its combined fiber, energy, and protein content; however, information on its use in preweaned dairy calves remains limited. This study evaluated the effects of partial replacement of calf starter with whole cottonseed on growth performance and feed intake of preweaned Holstein calves. A total of 36 calves were randomly assigned to one of three dietary treatments: a control diet without WCS, a diet containing 10% WCS, and a diet containing 20% WCS on a dry matter basis. Calves were monitored throughout the preweaning period for body weight, average daily gain (ADG), dry matter intake (DMI), and feed efficiency. Partial replacement of calf starter with whole cottonseed did not significantly affect final body weight, ADG, DMI, or feed efficiency ($p > 0.05$). Growth performance was comparable among all dietary treatments. Increasing levels of whole cottonseed reduced *in vitro* gas production and estimated dietary energy values; however, these changes were not associated with differences in *in vivo* growth or feed utilization. The results indicate that whole cottonseed can be included in calf starter diets at levels up to 20% without adverse effects on preweaning growth performance. Under controlled management conditions, whole cottonseed may be considered a viable alternative feed ingredient in calf starter formulations. Further studies are warranted to evaluate long-term effects on rumen development and postweaning performance.

Key words: Dairy calves, Whole cottonseed, Calf starter, Growth performance, Preweaning nutrition, Feed intake

INTRODUCTION

Early-life nutrition is critical for the growth, health, and future productivity of dairy calves, with the preweaning period playing a key role in rumen development. During this stage, the composition of calf starter diets strongly influences rumen fermentation patterns and overall growth performance. Identifying alternative feed ingredients that support rumen development while maintaining performance and reducing feeding costs is therefore of practical importance in dairy production systems.

In recent years, whether forage should be offered to calves during the preweaning period has become a subject of debate (Phillips, 2004; Suarez *et al.*, 2007; Castells *et al.*, 2012). Feeding calves only calf starter in addition to milk or milk replacer increases ruminal production of butyric and propionic acids, with butyric acid being the most effective volatile fatty acid for stimulating rumen papilla development (Warner, 1991). However, excessive accumulation of these acids may reduce rumen pH (Beharka *et al.*, 1998), leading to impaired rumen motility (Clarke and Reid, 1974), keratinization of rumen papillae, and reduced nutrient absorption (Castells *et al.*, 2012). Conversely, forage inclusion has been reported to improve rumen fermentation, stimulate rumen mucosa, support rumination, and improve rumen health, although inconsistent effects on intake and growth have been observed, particularly during the first weeks of life when cellulolytic activity is limited (Tamate *et al.*, 1962; Nocek and Kesler, 1980; Coverdale *et al.*, 2004).

Whole cottonseed (WCS) is widely used in diets of adult ruminants due to its combined fiber, energy, and protein content, yet its use in calf nutrition remains limited and poorly documented. Concerns related to fiber digestibility and gossypol content have restricted its application, despite evidence that moderate inclusion of fibrous ingredients may be tolerated by young calves when diets are properly balanced. Therefore, the objective of this short communication was to evaluate the effects of partial replacement of calf starter with whole cottonseed on growth performance and feed intake of preweaned Holstein calves under field conditions.

MATERIALS AND METHODS

Experimental site and animals

The experiment was conducted on a commercial dairy farm located in the Karacabey region of Türkiye. A total of 36 female Holstein calves, born from second-lactation cows, were used in the study. Calves were separated from their dams immediately after birth and received high-quality colostrum within the first 2 h of life to ensure adequate passive immunity transfer. All calves were housed individually under identical management conditions and had free access to clean drinking water throughout the experimental period.

Feeding management and experimental design

Following the colostrum period, calves were fed milk replacer according to the standard feeding protocol of the farm until weaning at 56 days of age. From 7 days of age onward, calves were randomly assigned to one of three dietary treatments (n = 12 calves per treatment):

Control: calf starter without whole cottonseed
WCS10: calf starter partially replaced with 10% whole cottonseed
WCS20: calf starter partially replaced with 20% whole cottonseed

Whole cottonseed replaced an equivalent proportion of calf starter on a dry matter basis. No forage was offered during the experimental period to avoid confounding effects on rumen development and intake. Experimental diets were offered ad libitum, and feed refusals were recorded daily.

Growth performance and feed intake measurements

Calves were weighed at the beginning of the experiment and subsequently at weekly intervals to determine body weight changes. Average daily gain (ADG) was calculated as the difference between final and initial body weight divided by the duration of the preweaning period. Daily feed intake was recorded by measuring feed offered and refusals, and dry matter intake (DMI) was calculated accordingly. Feed efficiency was calculated as the ratio of ADG to DMI.

Chemical analysis of feeds

Representative samples of experimental diets were collected and analyzed for chemical composition. Dry matter, crude protein, ether extract, and ash contents were determined according to standard procedures described by the Association of Official Analytical Chemists (AOAC, 1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) fractions were analyzed following the methods of Van Soest *et al.* (1991).

***In vitro* gas production and energy estimation**

In vitro gas production of the experimental diets was measured using the gas production technique described by Menke and Steingass (1988). Gas production values were used to estimate digestible organic matter, metabolizable energy, and net energy values of the diets according to established equations.

Statistical Analysis

All data were analyzed using analysis of variance (ANOVA) to evaluate the effects of dietary treatment. The experimental unit was the individual calf. Differences among treatment means were considered statistically significant at $p<0.05$. Results are presented as means with the standard error of the mean (SEM).

RESULTS

Growth performance and feed intake parameters of preweaned Holstein calves fed different levels of whole cottonseed (WCS) are summarized in Table 1. Initial body weight did not differ among dietary treatments and averaged approximately 38 kg across groups ($p> 0.05$). Similarly, final body weight at weaning was comparable among calves fed the control, WCS10, and WCS20 diets ($p> 0.05$).

Average daily gain (ADG) during the preweaning period was not affected by partial replacement of calf starter with whole cottonseed. Mean ADG values ranged from 530 to 535 g/day, with no statistically significant differences among treatments ($p> 0.05$). Dry matter intake (DMI) was also similar across all dietary groups, averaging approximately 990 g/day throughout the experimental period ($p> 0.05$).

Feed efficiency, expressed as the ratio of weight gain to dry matter intake, did not differ among treatments and remained consistent regardless of whole cottonseed inclusion level ($p> 0.05$).

In vitro fermentation characteristics of the experimental diets showed a decline in gas production with increasing levels of whole cottonseed. Correspondingly, estimated digestible organic matter, metabolizable energy, and net energy values decreased as whole cottonseed inclusion increased. However, these changes in *in vitro* estimates were not associated with measurable differences in in vivo growth performance or feed utilization during the preweaning period.

Table 1. Growth performance and feed intake of preweaned calves fed different levels of whole cottonseed

Parameter	Control	WCS10	WCS20	SEM	*p*-value
Initial body weight (kg)	37.76	37.76	37.91	1.41	>0.05
Final body weight (kg)	67.88	68.13	67.87	1.85	>0.05
ADG (g/day)	535.27	534.52	530.36	22.63	>0.05
DMI (g/day)	990.17	990.71	989.28	34.87	>0.05
Feed efficiency	0.541	0.540	0.536	0.003	>0.05

DISCUSSION

The present study evaluated the effects of partially replacing calf starter with whole cottonseed (WCS) on growth performance and feed intake of preweaned Holstein calves. The results demonstrate that inclusion of WCS at levels up to 20% of the starter diet did not adversely affect body weight gain, dry matter intake, or feed efficiency during the preweaning period. These findings suggest that moderate inclusion of WCS can be nutritionally tolerated by young calves when diets are properly formulated.

Growth performance parameters, including final body weight and average daily gain, were similar among dietary treatments. This indicates that replacing a portion of the calf starter with WCS did not compromise nutrient availability to an extent that limited growth. Comparable growth rates among treatments are

consistent with previous reports showing that moderate inclusion of fibrous ingredients does not necessarily impair calf performance, particularly when overall dietary energy and protein requirements are met (Coverdale *et al.*, 2004; Castells *et al.*, 2012). The absence of significant differences in dry matter intake further suggests that WCS did not negatively affect diet palatability or voluntary feed consumption, even at the 20% inclusion level.

The similarity in feed efficiency across treatments indicates that calves were able to convert consumed nutrients into body weight gain with comparable efficiency, regardless of WCS inclusion. This finding is important given concerns that increased dietary fiber or fat content may reduce nutrient utilization efficiency in young calves with immature rumen function. However, previous research has shown that calves can adapt to diets containing structural fiber, particularly when such diets avoid excessive fermentable carbohydrate loads that may depress rumen pH (Beharka *et al.*, 1998; Castells *et al.*, 2012).

In vitro gas production and estimated energy values of the experimental diets declined as WCS inclusion increased, reflecting the higher fiber and fat content of whole cottonseed. Reduced gas production is commonly associated with lower fermentability of fibrous feeds (Menke and Steingass, 1988). Despite these reductions in estimated digestible organic matter and metabolizable energy, *in vivo* growth performance was maintained. This discrepancy highlights the limitation of relying solely on *in vitro* fermentation estimates to predict animal performance, particularly in young calves whose rumen fermentation patterns are still developing (Tamate *et al.*, 1962; Warner, 1991).

The physical structure of WCS may have contributed to stable intake and performance by providing rumen stimulation without excessive production of volatile fatty acids. Diets consisting exclusively of highly fermentable starters have been shown to increase ruminal butyrate and propionate concentrations, which can promote rumen papilla development but may also predispose calves to ruminal acidosis and epithelial keratinization if rumen pH is excessively depressed (Warner, 1991; Beharka *et al.*, 1998). Inclusion of a fibrous ingredient such as WCS may help moderate fermentation intensity, supporting rumen health while maintaining growth.

Concerns regarding gossypol toxicity have historically limited the use of cottonseed products in young animals. However, the lack of negative effects observed in the present study suggests that WCS inclusion at the levels tested did not result in detrimental physiological responses. Similar observations have been reported in studies evaluating low to moderate inclusion of cottonseed products in ruminant diets, where gossypol exposure remained below harmful thresholds (Nocek and Kesler, 1980).

Overall, the findings of this study align with previous research indicating that strategic inclusion of fibrous feed components in calf starter diets can be achieved without compromising growth performance (Coverdale *et al.*, 2004; Suarez *et al.*, 2007). The results support the potential use of WCS as an alternative ingredient in calf starter formulations, particularly in production systems where feed cost reduction and ingredient availability are important considerations.

CONCLUSION

The present study demonstrated that partial replacement of calf starter with whole cottonseed at inclusion levels of 10% and 20% did not adversely affect growth performance, dry matter intake, or feed efficiency of preweaned Holstein calves during the preweaning period.

Calves fed diets containing whole cottonseed achieved comparable final body weights and average daily gains to those fed a conventional calf starter diet.

Although increasing whole cottonseed inclusion reduced *in vitro* gas production and estimated dietary energy values, these changes were not reflected in *in vivo* performance outcomes. This indicates that preweaned calves were able to maintain normal growth and feed utilization when whole cottonseed was

incorporated into the starter diet under controlled management conditions.

Overall, the findings suggest that whole cottonseed can be safely included in calf starter formulations at levels up to 20% without negative effects on preweaning growth performance. The use of whole cottonseed may therefore represent a practical alternative feed ingredient in calf nutrition programs, particularly in regions where it is readily available. Further research involving larger animal populations and postweaning follow-up is recommended to assess long-term effects on rumen development and subsequent productivity.

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