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Precutting round alfalfa and cornstalk bales decreases time and fuel required for bale breakup in a vertical mixer

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Precutting Round Alfalfa and Cornstalk Bales Decreases Time and Fuel Required for Bale Breakup in a Vertical Mixer[1]

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Introduction

Properly mixing and distributing nutrients throughout a ration can be equally as important as including them in the formulation. Many factors, including forage type, particle length, and mixer type, affect the homogeneity of total mixed rations. Particle size plays an important role in digestion and animal performance and, therefore, is an important consideration from harvest through feeding. An increase in particle size results in a less uniform distribution of nutrients throughout the total mixed ration. Typically, diets with a high proportion of forages have the lowest uniformity of nutrients in individual batches of complete feed.

Many operations reduce particle length of forages by placing whole round bales in vertical mixers to break apart the bale prior to adding the remaining ingredients to the total mixed ration. This approach can be time consuming but is rationalized as a necessary step in improving forage utilization and ration homogeneity. Because diet preparation time and energy use affect productivity and profitability of many operations, alternatives that decrease total feed preparation time may save money through decreased fuel usage and opportunity costs. Typically, alfalfa hay or cornstalks are cut by various types of machines and baled in full particle length. This method generally requires that producers further process bales into shorter particle lengths before using the forage in a total mixed ration by either tub grinding or placing bales into a vertical mixer. A baler has been developed that cuts stems prior to bale wrapping to reduce overall particle length, potentially eliminating the need to further process the forage before using it in a total mixed ration. Objectives of this study were to determine the effects of precut and conventional alfalfa and cornstalk bales on (1) mixing time in a vertical mixer, (2) influence of initial field cut method of cornstalks on mixing time, and (3) tractor fuel usage while mixing.

Experimental Procedures

The conventional baling method used a round baler that fed alfalfa through the header and carried it by packer fingers into a baling chamber without further processing. The precut baling method used a round baler that fed alfalfa through a header equipped with serrated knives that cut the alfalfa stems into 3- to 8-in. sections as packer fingers moved the sections from the header to the baling chamber. Because there were no knives on the outer 6 in. of each side, the perimeter of the bale was composed of alfalfa that was of full stem length, which maintained bale structure for hauling or handling.

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[2] John Deere, Ottumwa, IA.

Experiment 1

One field of alfalfa in northeast Kansas was swathed and raked in mid-July. A total of 31 alfalfa round bales were used to evaluate differences in mixing time of alfalfa baled with different techniques (precut vs. conventional) and in different bale sizes (5 × 4 ft vs. 6 × 4 ft). Treatments were: 5 × 4 ft precut bales, 5 × 4 ft conventional bales, 6 × 4 ft precut bales, and 6 × 4 ft conventional bales. There were eight replicates per treatment, with the exception of the 6 × 4 ft conventional alfalfa bales, which had seven replicates. Core samples were taken from each bale, composited by treatment, and chemically analyzed.

Each bale was raised to 16 ft by a loader tractor and dropped into a 425 ft^3 vertical double-screw mixer (Vertical Express; Roto-Mix, Dodge City, KS) that had the power engaged. The power take-off speed was set at 540 revolutions per minute during the mixing process. Mixing time was measured as the time from when the bale entered the mixer until the bale core was completely broken apart. Fuel usage was determined with the factory-installed on-board computer display in the tractor. Fuel usage rate (gal/hour) was recorded every 20 seconds of mixing time and averaged by bale, and then fuel usage was calculated.

Experiment 2

A total of 46 cornstalk round bales were used to evaluate differences in mixing time of cornstalks baled with different techniques (precut vs. conventional) and harvested with various field cutting methods. In mid-October, portions of one field of cornstalks in northeast Kansas were prepared with three field cutting methods: New Holland 116 swather (swathed), Model John Deere 27 flail shredder (shredded), and Model HX 15 batwing mower (brush hog). After each cutting method was used, cornstalks were raked using a Darf 17-wheel v-hay rake and then baled as precut or conventional. All bales were 5 × 4 ft. Treatments were: (1) conventionally baled, brush hog; (2) precut baled, brush hog; (3) conventionally baled, flail shredded; (4) precut baled, flail shredded; (5) conventionally baled, swathed, and (6) precut baled, swathed. Core samples were taken from each bale to make a composite sample of each treatment and chemically analyzed. Bales were loaded into the mixer, and data were collected by using the same procedures as in experiment 1.

Data from both experiments were analyzed with the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Individual bales were the experimental unit. Differences between main effects were declared significant at $P<0.05$ and regarded as tendencies when $P<0.10$. Contrasts comparing bale size and type were evaluated.

Results and Discussion

Experiment 1

The 5 × 4 ft alfalfa bales were lighter ($P<0.001$) than the 6 × 4 ft bales, as expected (Table 1). There was no difference in bale weight ($P>0.10$) between precut and conventionally processed bales. Bale mixing time was shorter ($P<0.05$) for precut bales than for conventional bales regardless of bale size (72 vs. 142 seconds for 5 × 4 ft and 110 vs. 237 seconds for 6 × 4 ft, respectively). The large bales had increased fuel usage on both a gallons-per-hour and gallons-per-bale basis ($P<0.001$). Fuel usage was lower ($P<0.05$) for the 5 × 4 ft precut bales than for the 5 × 4 ft conventional bales but similar between

bale types for the 6 × 4 ft bales. Precut alfalfa bales used less fuel (P<0.001) than conventional bales. Also, the 5 × 4 ft alfalfa bales used less fuel per bale (P<0.001) than the 6 × 4 ft bales.

Experiment 2

Cornstalk bale weights were similar (P>0.05) among treatments (Table 2). Bale mixing time was shorter (P<0.001) for precut bales than for conventional bales. Brush hog precut bale mixing time was decreased (P<0.05) compared with that for brush hog conventional bales (39.8 vs. 85.5 seconds, respectively). Mixing time for flail-shredded and swathed precut bales was less (P<0.001) than that for conventional bales. Brush hog and swathed bales had increased (P<0.02) mixing time compared with flail-shredded bales.

Fuel usage was similar (P=0.20) for precut and conventionally processed bales regardless of field cutting method. However, swathed bales had increased (P=0.04) fuel usage compared with brush hog bales and tended to have increased (P=0.06) fuel usage compared with flail-shredded bales. Brush hog bales had fuel usage similar (P=0.86) to that of flail-shredded bales. Precut bales used less (P<0.01) fuel per bale than conventionally processed bales for each field cutting method. Brush hog bales used more fuel per bale (P=0.02) than flail-shredded bales but showed similar (P=0.33) fuel usage per bale compared with swathed bales. Flail-shredded bales used less fuel per bale (P<0.002) than swathed bales.

Using the precut baling method reduced the time required for bale disassembly by approximately half and reduced fuel usage per bale during mixing, which may lead to increased on-farm time efficiency and could decrease the cost of mixing a total mixed ration.

The observed reduction in fuel usage was apparently due to the shorter particle length of the forage in precut bales, which required less time and power to break apart. Alfalfa stems are smaller in diameter and less fibrous than cornstalk stems. This allowed alfalfa bales to be baled tighter than cornstalk bales as indicated by their heavier weights compared with cornstalk bales of the same physical dimensions. Thus, bales of longer particle length require more time and fuel to achieve complete breakup.

Implications

Precut forage bales required less time to break up in a vertical mixer, which translated into less fuel required per bale.

Table 1. Effects of alfalfa bale type and size on mixing time and fuel usage[1]

	Bale size					Probability, P<	
	5 × 4 ft		6 × 4 ft				
Item	Precut	Conventional	Precut	Conventional	SEM	Precut vs. Conventional	5 × 4 ft vs. 6 × 4 ft
Weight[2], lb	1073^{a}	1080^{a}	1700^{b}	1700^{b}	18.1	0.64	0.001
Mix time, seconds	72^{a}	142^{b}	110^{ab}	237^{c}	19.5	0.001	0.003
Fuel usage							
Tractor, gal/hour	1.98^{a}	2.11^{b}	2.44^{c}	2.14^{c}	0.039	0.16	0.001
Bale, gal/bale	0.04^{a}	0.08^{b}	0.07^{b}	0.16^{c}	0.012	0.001	0.001

[1] n = 31 alfalfa bales (treatments 1-3, n = 8; treatment 4, n = 7).
[2] Bale weight on an as-is basis.
Means within a row without a common superscript letter differ (P<0.05).

Table 2. Effects of cornstalk field cutting type and bale type on mixing time and fuel usage[1]

	Bale type							Probability, P<			
	Brush hog		Shredded		Swathed						
Item	Precut	Conv[2]	Precut	Conv	Precut	Conv	SEM	Precut vs. Conv	Brush hog vs. Shredded	Brush hog vs. Swathed	Shredded vs. Swathed
Weight[3], lb	980^{b}	946^{ab}	973^{a}	923^{a}	955^{a}	963^{a}	25.9	0.09	0.41	0.81	0.56
Mix time, seconds	39.8^{a}	85.5^{c}	39.9^{a}	64.6^{b}	39.6^{a}	83.5^{c}	5.33	0.001	0.01	0.77	0.02
Fuel usage											
Tractor, gal/hour	2.9^{ab}	2.7^{b}	2.9^{ab}	2.8^{b}	3.1^{a}	3.0^{ab}	0.16	0.20	0.86	0.04	0.06
Bale, gal/bale	0.03^{c}	0.07^{a}	0.03^{c}	0.05^{b}	0.03^{c}	0.07^{a}	0.003	0.01	0.02	0.33	0.02

[1] n = 46 cornstalk bales (treatments 1-4 and 6, n = 8, treatment 5, n = 7).
[2] Conventionally processed bales.
[3] Bale weight on an as-is basis.
Means within a row without a common superscript letter differ (P<0.05).