VALUE ADDED PROCESSING OF DEHYDRATED AND SUNCURED ALFALFA

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ABSTRACT

A pilot scale pellet mill was used to produce pellets using ground alfalfa leaf and stem fractions. Both suncured and dehydrated alfalfa chops were used in the experiments. The moisture content of the suncured and dehydrated chops was 8.4 and 9.6% (wb), respectively. A stack of two square sieves with different opening sizes and a pan were used to separate leaf and stem fractions. The leaf and stem fractions were further segregated into two sample lots and ground in a hammer mill using two screen sizes of 3.20 mm (1/8 in.) and 1.98 mm (5/64 in.). The leaf and stem fractions from each sample lot of same grind sizes were combined to get five different samples with leaf content ranging from 0% to 100% in 25% increments. The moisture content and temperature of the samples were raised to 10-11% (wb) and 76ºC, respectively, in a double chamber steam conditioner prior to the pelleting operation. The temperature of material was further raised to 95ºC in the pellet mill due to the friction between its roller-die assembly. Average particle sizes of sample lots were determined. Temperature and moisture content of samples after various pelleting stages were recorded. High durability pellets were produced using fractionated suncured alfalfa irrespective of grind size (except for 100% stems, which was low). Durability fluctuated between high and medium range for dehydrated alfalfa (except for 100% stems, which was low). Dehydrated alfalfa produced pellets with greener color, while suncured alfalfa produced harder pellets.

BACKGROUND

Fractionation is the separation of forage into two or more component parts (usually leaves and stems). The different fractionated parts allow new uses for the crop. The aim of fractionation is to increase crop usefulness and create products that can more than offset the cost of processing. Forage crops such as alfalfa can produce more protein and energy per hectare than other agricultural crops. Leaf meal can be used as poultry and swine feed, or as a protein supplement for ruminants. Stems are high in fiber and can be used to feed ruminants, used as feedstock for paper and hardboard manufacturing, and energy production (biofuel/ethanol).The alfalfa forage crop is cut, dried, ground and densified in a pellet mill to make pellets. The densified pellets results in lower transportation and storage costs especially for export.

The breakage susceptibility of pellets during handling is a major concern. It has been reported that 20-30% losses in the form of fines are found in bulk product at the user level. Testing and if required improving the durability of pellets is important for the industry to evaluate pellet quality and minimize losses during handling and transportation.

No work has been reported to date on pelleting characteristics of fractionated alfalfa grinds. Therefore, it is important to pursue this aspect of research, which can open new avenues and potential markets for forage industry. The objective of this study is to investigation the pelleting characteristics of grinds in terms of change in pellet density, hardness, durability and color with variation in leaf content of suncured and dehydrated alfalfa.

MATERIAL PREPARATION & MEASUREMENTS

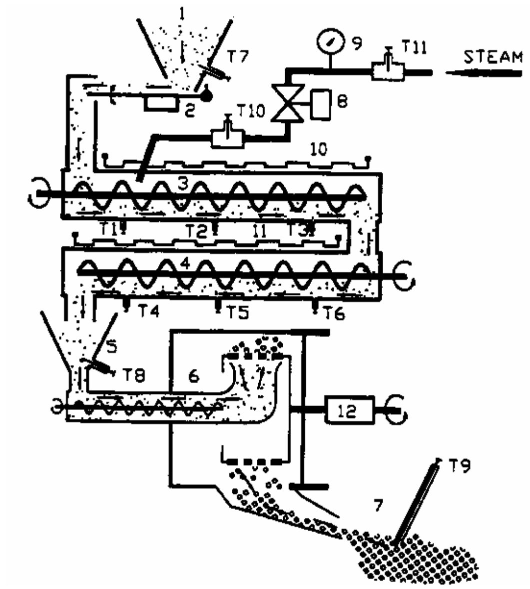
Fractionated suncured and dehydrated alfalfa chops were used to prepare pellets.

Procedures Used

Moisture content: ASAE Standard S358, 2000
Forage particle separator: ASAE Standard S424, 1999
Grinding: Hammer mill
Particle size: ASAE Standard S319, 2002
Color of Pellets: Hunter L, a and b values
Pellet durability: Dural pellet tester
Pellet hardness: ASAE Standard S368, 1999
Crude Protein: AOAC Method 976, 1990
Acid detergent fiber (ADF): AOAC Method 973, 1990
Total ash content: AOAC Method 942, 1990

Pellet Mill Specifications

A laboratory scale CPM CL-5 pellet mill (Figure 1) was used for processing fractionated alfalfa grinds into pellets.
Roller diameter = 85.0 mm;
Ring die size (radius) = 125.3 mm;
Length (thickness) = 44.6 mm;
Ring hole diameter = 6.1 mm;
Diameter/Length (ratio) = 7.31; and
RPM of pellet mill = 250.



Thermocouples: T1 to T11

1. Feed Hopper
2. Vibrating Tray
3. Paddle Conveyor
4. Paddle Conveyor
5. Feed Hopper to Pellet Mill
6. Screw Conveyor
7. Pellet Collection Bucket
8. Steam Control Valve
9. Steam Pressure Gauge

10 & 11. Double Chamber Steam Chest

12. V-belt Drive for Pellet Mill

Figure 1. Schematic diagram of CPM CL-5 pellet mill.

Statistical Analysis

A statistical analysis was performed to observe whether variation in sample leaf content had any affect on the experimental results, using Duncan Multiple Range Test (DMRT). DMRT involved the computation of numerical boundaries that allowed for the classification of the difference between any two-treatment means as significant or insignificant. DMRT values were calculated at 5% level of significance.

RESULTS

Particle Size:

a) Particle size decreased with an increase in leaf content.

b) Particle size for suncured & dehydrated alfalfa at grind size of 3.20 mm was higher that grinds size of 1.98 mm (as expected).

c) Mean particle size for dehydrated alfalfa was higher than suncured alfalfa. This could be due to higher moisture content of dehydrated alfalfa.

Proximate analysis & energy content (Table 1):

Component	Suncured			Dehydrated		
	100% leaf	50% leaf	0% leaf	100% leaf	50% leaf	0% leaf
Moisture content, %	9.32	8.51	7.95	8.96	7.1	8.95
Protein, % DM	23.36	16.33	10.52	20.80	15.9	11.12
Total Ash, % DM	11.45	7.53	5.65	11.25	-	7.38
Crude Fiber, % DM	14.03	26.94	40.90	16.86	-	35.80
Acid detergent fiber, % DM	18.76	36.22	44.05	19.00	-	41.32
Total digestible nutrients, % DM	78.60	59.94	51.57	78.35	-	54.49
Digestible energy, Mcal/k DM	3.44	2.60	2.25	3.44	-	2.38
Net energy for lactation, Mcal/k DM	1.81	1.35	1.14	1.80	-	1.22
Net energy for maintenance, Mcal/k DM	1.88	1.28	1.00	1.88	-	1.11
Net energy for gain, Mcal/k DM	1.24	0.71	0.45	1.24	-	0.55

Pellet volume, density, and hardness data (Table 2):

Leaf Content (%)	Length (mm)	Diameter (mm)	Mass (g)	Volume* (mm^3)	Density* (kg/m^3)	Hardness+ (N)	Durability‡ (%)
Suncured Alfalfa							
Screen size 3.20 mm (1/8”)							
100	22.6 ± 4.6†	6.36 ± 0.02	0.98 ± 0.1	717 ± 146	1307 ± 38 a	827 ± 383a	83.2 ± 0.6 b
75	21.1 ± 4.7	6.36 ± 0.03	0.89 ± 0.2	669 ± 146	1310 ± 48 a	867 ± 307 a	87.3 ± 0.8 a
50	21.3 ± 4.9	6.37 ± 0.02	0.89 ± 0.2	682 ± 158	1313 ± 53 a	926 ± 399 a	87.1 ± 0.9 a
25	19.0 ± 4.3	6.38 ± 0.03	0.75 ± 0.2	611 ± 140	1282 ± 63 b	907 ± 377 a	83.0 ± 0.9 b
0	15.1 ± 2.1	6.40 ± 0.02	0.58 ± 0.1	486 ± 68	1197 ± 67 c	1034 ± 687 a	54.4 ± 1.2 c
Screen size 1.98 (5/64”)							
100	15.3 ± 0.3	6.34 ± 0.01	0.65 ± 0.0	483 ± 9	1341 ± 40 a	847 ± 344 ab	84.6 ± 1.8 c
75	15.2 ± 0.5	6.37 ± 0.02	0.64 ± 0.0	482 ± 14	1330 ± 18 ab	972 ± 372 ab	88.0 ± 0.5 b
50	15.4 ± 0.4	6.37 ± 0.02	0.65 ± 0.0	492 ± 15	1330 ± 28 ab	972 ± 264 ab	90.2 ± 0.3 ab
25	15.1 ± 0.6	6.38 ± 0.02	0.63 ± 0.0	481 ± 18	1311 ± 38 b	869 ± 272 a	92.4 ± 1.2 a
0	15.3 ± 0.6	6.38 ± 0.01	0.58 ± 0.1	489 ± 16	1181 ± 90 c	779 ± 510 b	62.1 ± 1.5 d
Dehydrated Alfalfa							
Screen size 3.20 mm (1/8”)							
100	14.8 ± 0.5	6.41 ± 0.05	0.62 ± 0.0	473 ± 17	1301 ± 33 a	674 ± 296 a	85.8 ± 1.6 a
75	14.9 ± 0.4	6.42 ± 0.04	0.63 ± 0.0	486 ± 10	1271 ± 49 b	651 ± 179 ab	80.0 ± 0.9 b
50	14.9 ± 0.3	6.43 ± 0.05	0.61 ± 0.0	485 ± 14	1257 ± 59 bc	637 ± 214 ab	81.1 ± 1.3 b
25	15.1 ± 0.4	6.46 ± 0.02	0.62 ± 0.0	496 ± 12	1246 ± 36 c	690 ± 287 ab	81.8 ± 0.4 b
0	15.1 ± 0.5	6.40 ± 0.04	0.58 ± 0.1	486 ± 14	1189± 90 d	501 ± 304 b	72.4 ± 0.5 c
Screen size 1.98 (5/64”)							
100	14.9 ± 0.4	6.43 ± 0.05	0.62 ± 0.0	483 ± 20	1285 ± 36 a	619 ± 358 a	74.5 ± 0.2 b
75	14.9 ± 0.4	6.43 ± 0.06	0.62 ± 0.0	485 ± 18	1278 ± 58 ab	641 ± 226 a	81.4 ± 0.5 a
50	14.9 ± 0.4	6.47 ± 0.03	0.61 ± 0.0	495 ± 15	1239 ± 37 bc	656 ± 214 ab	78.8 ± 1.3 a
25	15.2 ± 0.7	6.49 ± 0.05	0.62 ± 0.0	500 ± 19	1241 ± 41 bc	603 ± 277 a	81.0 ± 0.7 a
0	14.9 ± 0.5	6.48 ± 0.06	0.59 ± 0.1	500 ± 18	1184 ± 155 c	562 ± 357 b	42.6 ± 1.4 c

*10 replicates
+30 replicates
‡3 replicates
†95% confidence interval
Letters a,b,c and d indicates that means with same letter designation in a column are not significantly different at 5% level of significance (Duncan Multiple Range Test values).

Color of pellets measured using Hunter Lab Spectro-colorimeter:

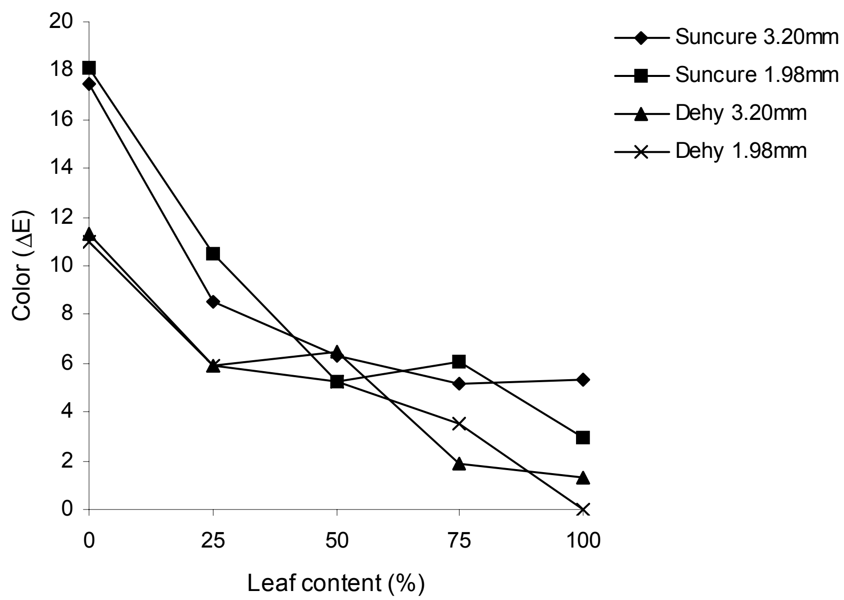


Figure 2. Change in color for suncured and dehydrated alfalfa at two grind sizes with respect to leaf content.

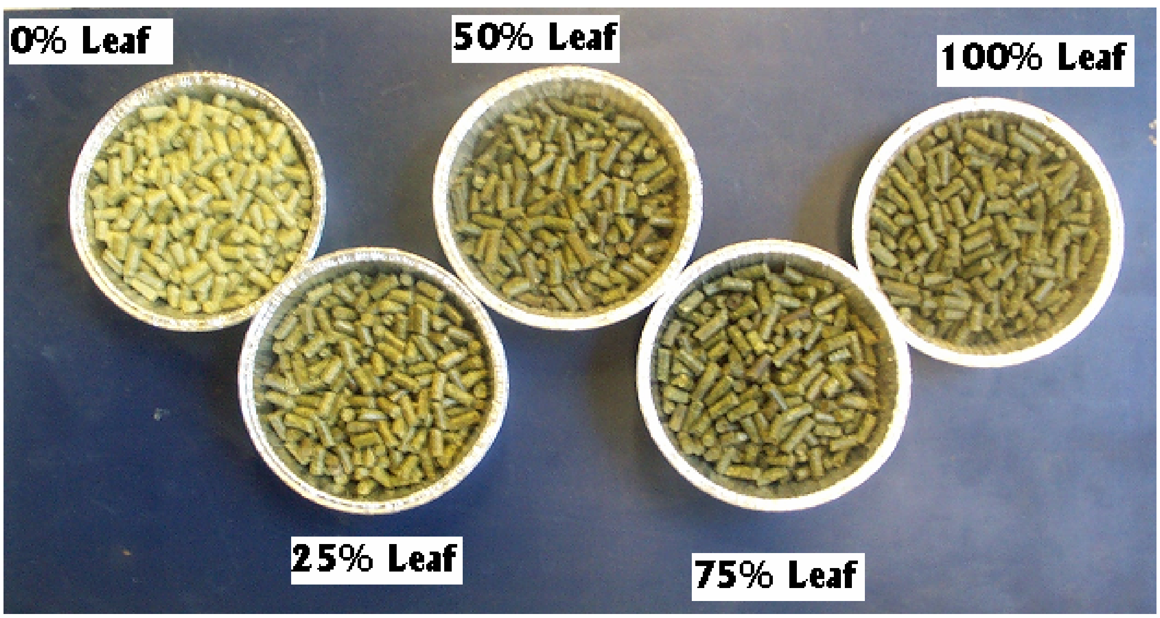


Figure 3. Photograph showing the color of fractionated alfalfa pellets with change in leaf content.

CONCLUSIONS

a) It is possible to custom re-combine leaf and stem fractions in different ratios and produce high durability pellets.

b) Fractionated suncured alfalfa for different leaf and stem ratios produced high durability pellets (except for 100% stems).

c) The durability of dehydrated alfalfa pellets fluctuated between high and medium range (except for 100% stems).

d) For pellets processed from 100% stems, possible addition of artificial binders are required to improve their durability.

e) Variation in grind size of suncured and dehydrated alfalfa had an insignificant affect on pellet durability.

f) Dehydrated alfalfa produced pellets with greener color, while suncured alfalfa produced harder pellets.

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