Chapter 20
Feed Preparation and Processing
Figure 17.1 Examples of sorghum grain processed by several different methods. Courtesy of W. H. Hale, University of Arizona.
COLD PROCESSING METHODS

Rollermill Grinding
✓ Rollermills act on grain by compressing it between two smooth or corrugated rollers that can be screwed together to produce smaller and smaller particles.
✓ With grains such as corn, wheat or sorghum, the product can range in size from cracked grain to a rather fine powder.

Soaked Grain
✓ Grain soaked for 12 to 24 h in water.
✓ Research results do not show any marked improvement in animal performance.
Reconstitution
✓ Moisture content to 25 to 30% and storage of the wet grain in an oxygen-limiting silo for 14 to 21 days prior to feeding.

High-Moisture Grain
✓ High-moisture grain is harvested at a high moisture content (20-35%) and stored in a silo to preserve the grain.

Acid Preservation of High-Moisture Grains
✓ Mixing 1 to 1.5% propionic acid
HOT PROCESSING METHODS

Steam rolling
Steam flaking
Popping
Micronizeing
Roasting
Pelleting
Extruding
Steam-Rolled and Steam-Flaked Grains

- Steam for only a short time (3 to 5 min) prior to rolling
- High-moisture stream for a sufficient time to raise the water content to 18-20% and the grain is then rolled to produce a rather flat flake.
Pelleting

✓ Accomplished by grinding the feed ingredients or feedstuffs and then forcing them through a die.
✓ Usually steamed to some extent before pelleting
✓ Pellets can be made in different shapes, diameters, lengths and degree of hardness
✓ Ruminants on high-grain diets have not been particularly favorable (decreased feed intake)
   → animal cannot sort and select individual components of the diet
Popping and Micronizing

✓ Popped corn is produced by the action of dry heat, causing a sudden expansion that ruptures the endosperm of the seed.
✓ Micronising is essentially the same as popping, except that heat is provided in the form of infrared energy.
Extruding
✓ Passing the grain or grain mixture through a machine with a spiral screw that forces the grain through a tapered head

Spraying Feed with Molasses, Fat or Other Liquid
✓ Improve palatability
✓ Reduce dustiness
✓ Increase the energy density of the feed
✓ Improves the ease of mechanical handling
✓ Serves as a lubricant
FEED PROCESSING FOR NONRUMINANTS

Swine and poultry

- Are the most common means of preparing feed for swine and poultry.
- Grinding to a medium to moderately fine texture results in better performance than when grains are finely ground.
- For pig
  - Digestibility of grains by swine is improved by grinding.
    - finely (0.16 cm screen size) > coarse (1.27 cm screen size)
    - but increased incidence of stomach ulcers in pigs
  - Pelleting improves gain and feed efficiency to a greater extent when applied to feed grains that are low in fiber.
Pelleting results in a 3 to 5% improvement in rate of weight gain
→ eat more in a given period

For poultry, crumbles is to pellet meal diets, then roll them, and screen out fines.

Many seed legumes such as soybeans contain heat-labile toxic factors of protein utilization and other heat-labile toxic factors.

- more practical concern for nonruminants than for ruminants
- enzymes may result in some improvement
  → swine fed cultivars of beta-glucans suggests that pretreatment of the barley with amylases may improve animal performance (improve efficiency of nutrient and energy utilization)
Other Animals

✓ Horse feeds often contain rolled or coarsely cracked grains with liberal amounts of molasses to avoid problems with dust.
GRAIN PROCESSING FOR RUMINANTS

✓ Break up the hull or waxy seed coat and improve digestibility of starch in the endosperm

✓ For a method to be effective, it must
  (a) reduce wastage
  (b) increase consumption and rate of gain
  (c) be utilized more efficiently
Feed Processing for Dairy Cows

- Feed processing may result in somewhat different responses in daily cows than for growing or finishing cattle or lambs.

- Feeding lactating cows high-grain rations, particularly heat-treated grains or pelleted form
  - reduced rumen acetate to propionate ratios and lower milkfat percentages
  - low milkfat also stimulate increased total milk production

- Lactating cows are fed concentrates in which the grains have been coarsely ground or steam-rolled.
Grain Processing for Sheep

✓ Diet sorting and wastage can be reduced by pelleting
✓ Chew grains well enough that processing is not necessary
FEED MIXING

Batch Mixers

✓ Vertical and horizontal are two configurations of batch mixers

✓ To produce a desired quantity of mixed feed, individual feed ingredients are separately added to the mixer in the predetermined amounts.

✓ For most efficient mixing
  ➢ Largest amount is added first
  ➢ Fat is added last and the final diet is mixed again
DRY FORAGE AND ROUGHAGE PROCESSING FOR RUMINANTS

Baled Dry Forage and Roughage

✓ Animals fed for high levels of production, such as dairy cows, may be quite selective so that stems will not be consumed.

→ a high loss of nutrients occurs in feeding baled hay
✓ Consumption is not adequate for high levels of performance.

**TABLE 17.4** Effect of forage processing on animal performance of cattle.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>AV. DAILY GAIN, KG</th>
<th>DAILY DRY MATTER INTAKE, KG</th>
<th>FEED/UNIT OF GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Bermuda grass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>0.33</td>
<td>4.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.0</td>
</tr>
<tr>
<td>vs. ground</td>
<td>0.50</td>
<td>6.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.9</td>
</tr>
<tr>
<td>vs. pelleted</td>
<td>0.66</td>
<td>6.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.3</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baled</td>
<td>0.29</td>
<td>4.31&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.1</td>
</tr>
<tr>
<td>Chopped</td>
<td>0.28</td>
<td>4.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.1</td>
</tr>
<tr>
<td>Pelleted</td>
<td>0.78</td>
<td>6.49&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.3</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baled</td>
<td>0.67</td>
<td>6.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.1</td>
</tr>
<tr>
<td>Cubes</td>
<td>0.86</td>
<td>6.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.8</td>
</tr>
<tr>
<td>Haulage</td>
<td>0.77</td>
<td>6.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.9</td>
</tr>
</tbody>
</table>

<sup>a</sup>Data excerpted from Church (1984).

<sup>b</sup>Feed intake as fed.
Copped and Ground Forages and Roughages

✓ Chopping or grinding puts forages and roughages into a physical form that allows easier handling by some mechanical equipment

→ provide a more uniform product for consumption and reduces feed refusals and waste

✓ Adding molasses, fat or water usually improves intake

✓ Chopping produces a physical texture of a more desirable nature than grinding
Pelleting

- Is a slow, costly process compared to similar treatment of grains
  - cost of pelleting is of greater concern than for most other feed processing methods
- Gives the greatest relative increase in performance for low-quality forages and roughages
  (increase in diet density and greater feed intake associated with more rapid passage through the GI tract and not from any great improvement in digestibility)
- Pelleted forages and roughages are metabolized somewhat differently
  - more rapid passage out the rumen
  - Less cellulose is digested
  - Relatively less acetic acid is produced with relatively greater digestion in the intestines
Figure 17.4  An example of the densification of alfalfa hay which can be achieved by baling, grinding and pelleting (left to right). Each sample contains 2.27 kg of hay.
Cubed Roughages

- Dry hay is forced through diets that produce a square product of varying lengths
- Water is sprayed on the dry hay as it is cubed
- Alfalfa hay produces the best cubes
  - Produce satisfactory performance in cattle, provided the cubes are not too hard
Chemical Treatments

✓ Poor quality forage and other roughage high in cellulose represent a substantial resource for animal feed

✓ Range from soaking straws in alkali solutions to treatments involving heat, pressure and chemicals
  - Spraying with NaOH solutions
  - Ensiling with NaOH, molasses, water and so on

✓ N is added to the straw to enhance the activity of rumen microorganisms
  → improving breakdown and utilization of the fiber present in straw
TABLE 17.5 Effect of ammoniation of wheat straw on intake and digestibility by sheep.\textsuperscript{a}

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TREATED STRAW</th>
<th></th>
<th></th>
<th>HMAWS\textsuperscript{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UNTREATED</td>
<td>STACK</td>
<td>DIRECT</td>
<td>AIRED</td>
</tr>
<tr>
<td>Straw DM intake, % of body weight</td>
<td>1.16</td>
<td>1.56</td>
<td>1.69</td>
<td>2.00</td>
</tr>
<tr>
<td>Straw DM digestibility, % Fed ad libitum</td>
<td>39.4</td>
<td>47.6</td>
<td>53.1</td>
<td>58.4</td>
</tr>
<tr>
<td>Straw cellulose digestibility, %</td>
<td>57.7</td>
<td>63.8</td>
<td>63.3</td>
<td>68.1</td>
</tr>
<tr>
<td>Straw hemicellulose digestibility, %</td>
<td>47.6</td>
<td>55.4</td>
<td>75.6</td>
<td>79.0</td>
</tr>
</tbody>
</table>

\textsuperscript{a}From Streeter and Horn (1984).

\textsuperscript{b}HMAWS = high-moisture ammoniated wheat straw. All straws were fed with a supplement containing soybean meal, ground corn, molasses, minerals, and salt.
Ammoniation of poor quality roughage
- increases consumption of the roughage
- improves digestibility of cellulose and hemicellulose
- improves animal live-weight gain

Urea is used in place of more expensive and volatile anhydrous ammonia as a source of N

APH causes some solubilization of lignin in highly lignified forages such as straw
TABLE 17.6  Effect of treating wheat straw with alkaline hydrogen peroxide on intake and digestibility by sheep.\(^a\)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>UNTREATED STRAW</th>
<th></th>
<th>TREATED STRAW</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW WS</td>
<td>HIGH WS</td>
<td>LOW WS</td>
<td>HIGH WS</td>
</tr>
<tr>
<td>Intake, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>2271</td>
<td>1297</td>
<td>2234</td>
<td>2526</td>
</tr>
<tr>
<td>Crude protein</td>
<td>302</td>
<td>180</td>
<td>303</td>
<td>390</td>
</tr>
<tr>
<td>Digestibility, % of intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter</td>
<td>68.4</td>
<td>58.0</td>
<td>82.7</td>
<td>70.7</td>
</tr>
<tr>
<td>Crude protein</td>
<td>74.4</td>
<td>75.0</td>
<td>78.6</td>
<td>71.7</td>
</tr>
<tr>
<td>Cellulose</td>
<td>53.8</td>
<td>37.5</td>
<td>78.0</td>
<td>84.0</td>
</tr>
</tbody>
</table>

\(^a\)Data after Kerley et al. (1986). Wheat straw (WS) made up ca. 33% of the diet in the low-WS and ca. 52% in the high-WS diets. The remainder of the diet was composed of ground corn, soybean meal, urea, molasses, minerals, and vitamins.