MIXING EQUIPMENT
And
MIXER OPERATIONS
Mixing Objective:

To obtain a *uniform, random mixture* of solid and liquid ingredients in the formula *without* nutrient destruction in a *minimum* amount of time.
## Mixer Profile Results

<table>
<thead>
<tr>
<th>CV.</th>
<th>Methionine(^1)</th>
<th>Lysine(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10%</td>
<td>49.40</td>
<td>53.33</td>
</tr>
<tr>
<td>&gt; 10%</td>
<td>50.60</td>
<td>46.67</td>
</tr>
<tr>
<td>10-20%</td>
<td>31.76</td>
<td>30.00</td>
</tr>
<tr>
<td>&gt;20%</td>
<td>18.84</td>
<td>16.67</td>
</tr>
</tbody>
</table>

1. Results of 85 Mixer Profiles
2. Results of 60 Mixer Profiles

Wicker and Poole, 1991
TOPICS

Mixing Equipment Design

Mixing and Mixer Problems

Uniformity Testing

Animal Performance
MIXING EQUIPMENT
MIXER DESIGN and SELECTION

Options:

* Vertical
* Horizontal
  * Ribbon
    * Single Shaft, Double Ribbon
    * Double Shaft, Single Ribbon
  * Paddle, Single or Double Shaft
* Rotating Drum
* Continuous
Mixer Design Considerations
Double Screw Vertical Mixer
Mixing Flow
In a Vertical Mixer
Vertical

+ Low initial investment;
+ Low maintenance cost;
+ Small footprint;
+ Can be installed on a scale.
Vertical

- Increased mixing time (>10 min);
- Low inclusion of liquids;
- Poor clean out.
Horizontal Mixers
Horizontal

+ Decreased mixing time;
+ Higher levels of liquids and/or molasses (paddle);
+ Good clean-out.
Horizontal / Ribbon

- Right and left hand flights;

+ Good side-to-side/tumbling action;

- Higher HP requirements
MIXING PATTERN

HORIZONTAL PADDLE MIXER

Source: Marion Mixers
Horizontal / Paddle

- Good tumbling/poor side-to-side action;
- Best option w/ fibrous ingredients;
- High mineral or molasses.
Rotating Drum Mixers
Rotating Drum Mixer
Rotating Drum

- Dual mixing action: tumbling (rotation) and side-to-side (screw conveyor);
- Low cost;
- Can operate with smaller loads than rated capacity.
Continuous

- Used to bring ingredients together in constant proportions;
- Mixtures including high levels of liquid ingredients;
Most common are the ‘cut-and-folded screw’ and paddles.
Mixing Cycles
• Dry load (10s.);
• Hands add (10s.);
• Dry mix (120s.)???
• Liquids add (10-50s.);
• Wet mix (120s.);
• Discharge (180s.)?????. 
Drop Bottom Discharge

- Opens along entire length of mixer;
- Surge hopper underneath;
- Vents to avoid segregation.
Ingredient Characteristics Affecting Mixing

- Particle Size
- Particle Shape
- Density
- Static Charge
- Hygroscopicity
- Adhesiveness
Effect of Particle Size On Mixing Efficiency

<table>
<thead>
<tr>
<th>Particle Size (Microns)</th>
<th>&lt;699</th>
<th>700-899</th>
<th>&gt;900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of Variation (%)</td>
<td>35.1</td>
<td>43.1</td>
<td>50.1</td>
</tr>
<tr>
<td>Mixing Time (min.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>8.3</td>
<td>10.3</td>
<td>14.3</td>
</tr>
<tr>
<td>1.5</td>
<td>8.8</td>
<td>8.7</td>
<td>11.6</td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mixing

Mixer Underfill/Overfill
Effect of Batch Size and Mix Times On Nutrient Uniformity

<table>
<thead>
<tr>
<th>Tons per Batch</th>
<th>Mixing time (min)</th>
<th>Coefficient of Var.-%</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2.0</td>
<td>34.88</td>
<td>56.18</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>31.37</td>
<td>62.58</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.0</td>
<td>29.80</td>
<td>33.96</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>34.61</td>
<td>11.99</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>4.99</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.0</td>
<td>2.59</td>
<td>4.64</td>
<td></td>
</tr>
</tbody>
</table>

Wicker and Poole, 1991
# Mixer Capacity

## Effects of Ingredient Density

<table>
<thead>
<tr>
<th>Mash Density</th>
<th>Maximum Batch Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lbs/cu. ft.</td>
<td>Lbs/batch</td>
</tr>
<tr>
<td>45</td>
<td>12870</td>
</tr>
<tr>
<td>43</td>
<td>12300 (6 tons)</td>
</tr>
<tr>
<td>41</td>
<td>11730</td>
</tr>
<tr>
<td>39</td>
<td>11150</td>
</tr>
<tr>
<td>37</td>
<td>10580 (5 tons)</td>
</tr>
<tr>
<td>35</td>
<td>10010</td>
</tr>
<tr>
<td>33</td>
<td>9440</td>
</tr>
<tr>
<td>31</td>
<td>8870</td>
</tr>
<tr>
<td>29</td>
<td>8290</td>
</tr>
</tbody>
</table>
MIXER CONDITION

- Worn ribbon, paddles or screws
- Reel-to-Tub Clearance
- Molasses or Fat Buildup
High Speed (Short Cycle) Mixers
New Innovation In Mixing Equipment
Short Cycle Mixing

- May reduce mix cycle from 5 or 6 minutes to 2 to 3 minutes.
- ??? Can replacing the mixer double plant capacity??
- System must be “balanced” to gain the time advantage.
### Mixer Tests
with
F-500 Forberg Mixer

<table>
<thead>
<tr>
<th>Mixing Time(^1) (Seconds)</th>
<th>Coef. Of Var.(^2) (%)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>4.56</td>
<td>3.6</td>
</tr>
<tr>
<td>20</td>
<td>5.45</td>
<td>4.0</td>
</tr>
<tr>
<td>25</td>
<td>4.53</td>
<td>3.6</td>
</tr>
<tr>
<td>30</td>
<td>4.61</td>
<td></td>
</tr>
</tbody>
</table>

1. Mixer stopped at 15, 20, 25, and 30 seconds after salt addition.
2. 10 Samples were analyzed for each mix time.
LIQUID ADDITIONS
LIQUID ADDITIONS

- Requires a longer mix time
- Spray-Bar application
- Consider a high-speed blender down stream of the mixer
Liquid Additions

FAT ADDITION
Fat Balls Created During Mixing
FEED UNIFORMITY

- Methods of Measuring Uniformity
- Effects of Nutrient Uniformity on Animal Performance
Effects of mix time and marker selection on mix uniformity
Introduction

Concerns for assuring additive/nutrient uniformity include:

- Nutritional over-fortification (Wicker and Poole, 1991)
- Regulatory aspects (Feed Additive Compendium, 2006)
- Animal performance (McCoy, 1992)
Justification

- Little agreement on how feed uniformity should be measured
- Minimal research has evaluated markers simultaneously
- Ability to eliminate potential markers which do not reflect mixer performance
- FDA regulations require testing to justify mixing time
Objective

Evaluate the effects of marker selection and mix time on Coefficient of Variation (CV) (uniformity) in the mixing process.
Procedures

- Corn-soybean meal based diet formulated for broiler chicks (d 0 to 17)
- Diets mixed using a Sprout-Waldron double ribbon mixer (0.5, 2.5, and 5.0 min)
- Mash collected in 22.7 kg aliquots continuously online. Five-1kg samples collected from 10 odd-numbered bags (i.e. 1,3,5, etc.)
Procedures (cont)

CV Calculation

\[ \%CV = \frac{s}{m} \times 100 \]

\[ m = \frac{\sum X_i}{n} \]

\[ s^2 = \frac{\sum(x_i^2) - nm^2}{n} \]

\[ s = \sqrt{s^2} \]

Where:

\%CV  =  Percent Coefficient of Variation
s     =  Standard Deviation
s^2   =  Variance
m     =  Mean
n     =  Number of samples assayed
Additive/Nutrient markers evaluated

- DL-Methionine (synthetic)
- Lysine-HCl (synthetic)
- Crude Protein
- Chloride Ion (as sodium chloride)
- Phosphorus
- Manganese
- Microtracer™ Red #40 (count)
- Microtracer™ Red #40 (absorbance)
- Microtracer™ RF-Blue Lake
- Roxarsone (3-Nitro®)
- Semduramicin (Aviax®)
## Diet Composition

<table>
<thead>
<tr>
<th>Ingredient,</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>60.48</td>
</tr>
<tr>
<td>Soybean Meal (48%)</td>
<td>31.55</td>
</tr>
<tr>
<td>Porcine Meat Meal (50%)</td>
<td>3.50</td>
</tr>
<tr>
<td>Fat</td>
<td>1.35</td>
</tr>
<tr>
<td>Calcium Carbonate (38%)</td>
<td>0.95</td>
</tr>
<tr>
<td>Monocalcium Phosphate (21%)</td>
<td>1.20</td>
</tr>
<tr>
<td>Salt</td>
<td>0.34</td>
</tr>
<tr>
<td>Lysine-HCl</td>
<td>0.03</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.25</td>
</tr>
<tr>
<td>Vitamin/Mineral Pmx</td>
<td>0.25</td>
</tr>
<tr>
<td>3-Nitro 20 ®</td>
<td>0.05</td>
</tr>
<tr>
<td>Aviax 5% ®</td>
<td>0.05</td>
</tr>
<tr>
<td>Microtracer™ Red #40 (mg/kg)</td>
<td>55.00</td>
</tr>
<tr>
<td>Microtracer™ RF-Blue Lake (mg/kg)</td>
<td>55.00</td>
</tr>
</tbody>
</table>
Results
## Coefficient of Variation

<table>
<thead>
<tr>
<th>Item, %</th>
<th>Mix Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>23.86</td>
</tr>
<tr>
<td>Lysine-HCl</td>
<td>19.75</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>7.73</td>
</tr>
<tr>
<td>Chloride Ion (as sodium chloride)</td>
<td>20.26</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>13.72</td>
</tr>
<tr>
<td>Manganese</td>
<td>36.25</td>
</tr>
<tr>
<td>Microtracer™ Red #40 (count)</td>
<td>21.77</td>
</tr>
<tr>
<td>Microtracer™ Red #40 (absorbance)</td>
<td>21.13</td>
</tr>
<tr>
<td>Microtracer™ RF-Blue Lake</td>
<td>32.49</td>
</tr>
<tr>
<td>Roxarsone (3-Nitro®)</td>
<td>30.24</td>
</tr>
<tr>
<td>Semduramicin (Aviax®)</td>
<td>27.40</td>
</tr>
</tbody>
</table>
Amino Acids/Protein

Mix Time (minutes)

% CV

DL-Methionine
Lysine-HCl
Crude Protein
Minerals

% CV

Mix Time (minutes)

Chloride Ion
Phosphorus
Manganese

Red line: Chloride Ion
Yellow line: Phosphorus
Green line: Manganese
Feed Additives

% CV

Mix Time (minutes)

Roxarsone

Semduramicin
Conclusions

- Protein should never be considered as a marker to indicate mix uniformity
- Phosphorus is of questionable value
- Synthetic Amino Acids proved to be robust
- Iron particles (Microtracer™) could be used for identifying carryover
- Feed additive usefulness likely depends on the accuracy of the assay
Conclusions (cont)

• Continual mixer management
• Each mixer is unique and each will respond differently over time due to mixer style, wear, maintenance, products mixed, and product particle size
• Do not take “grab” samples
Considerations for Selection Of a Mixer Assay Procedure

- Accuracy of the assay - CV<5%
- Ease of Assay
- Assay Cost
- Safety of Operator
- Conducted on Site
- Test for a common ingredient
- Single Source of Test Principle??
- Results easily understood