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

	Mixers Tested- %	
CV.	Methionine[1]	Lysine[2]
< 10%	49.40	53.33
> 10 %	50.60	46.67
10-20%	31.76	30.00
>20%	**18.84**	**16.67**

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

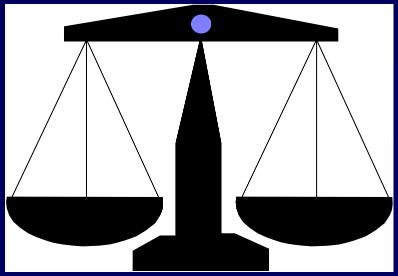
Double Shaft, Single Ribbon

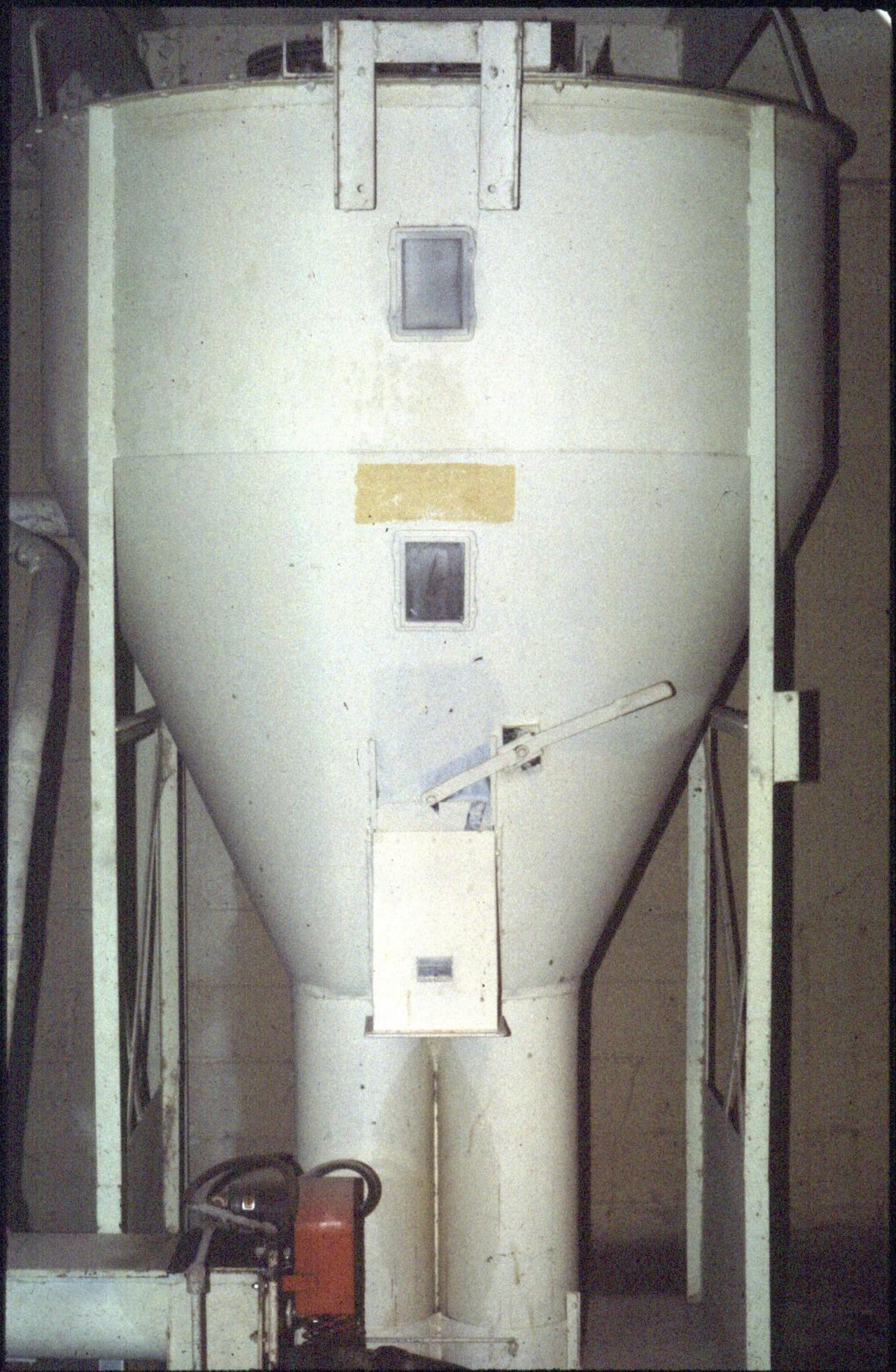
Paddle, Single or Double Shaft

*Rotating Drum

*Continuous

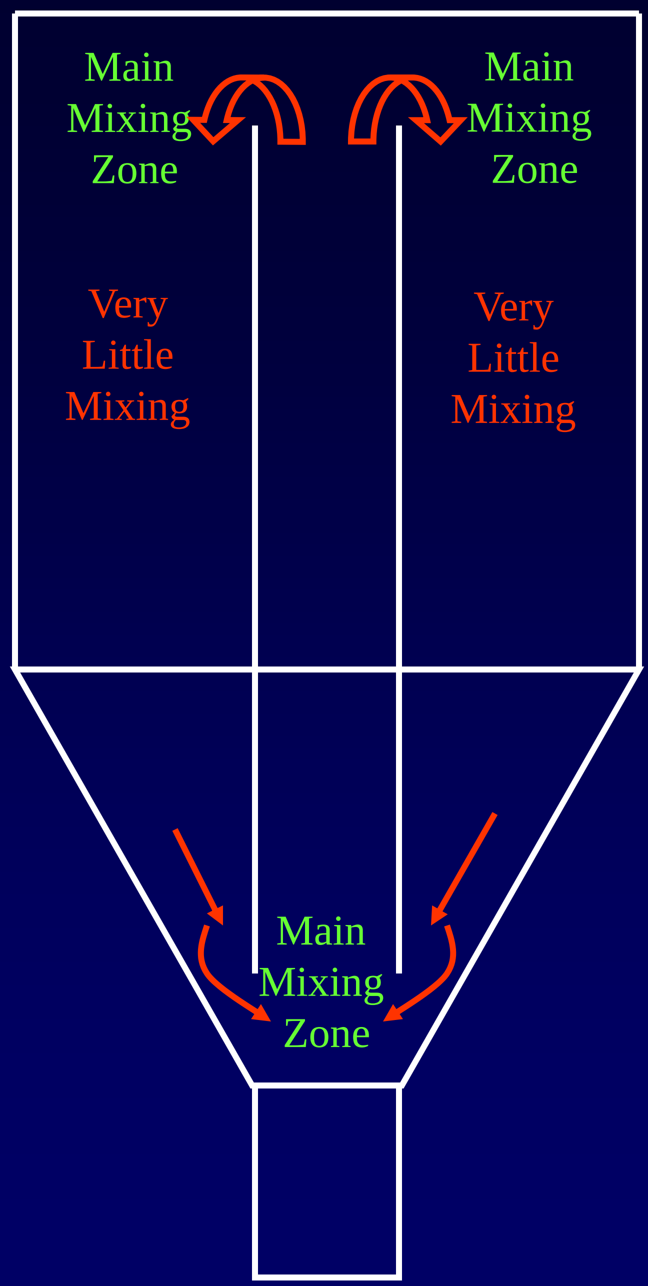
Mixer Design Considerations





Double Screw Vertical Mixer

Mixing Flow In a Vertical Mixer



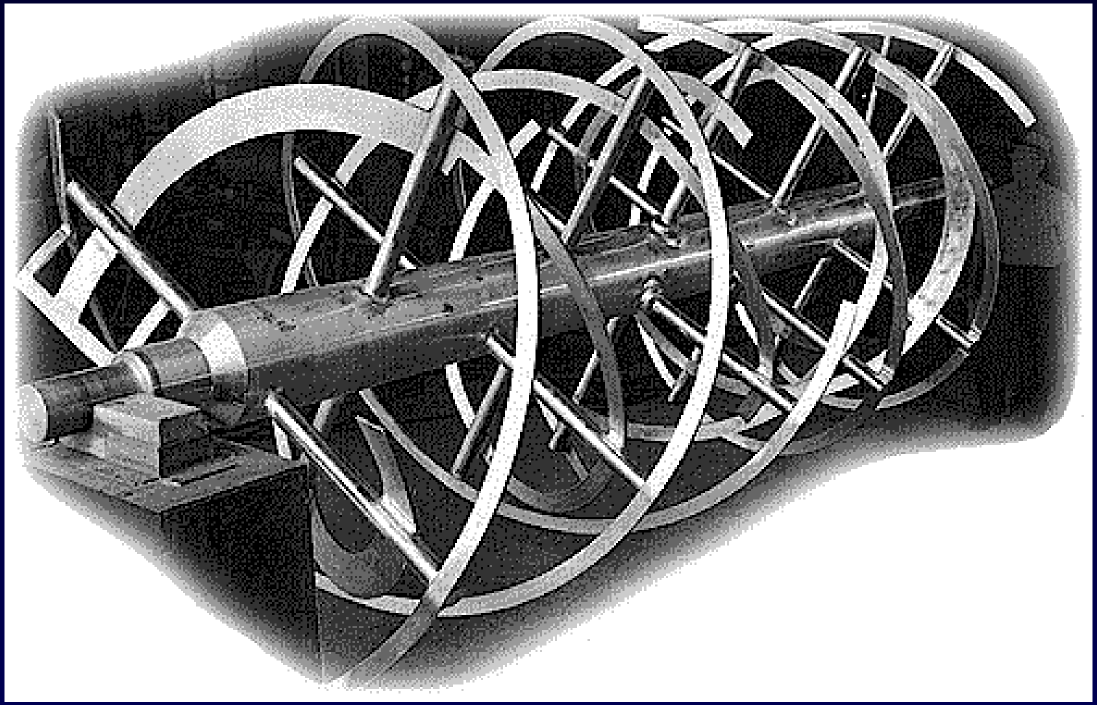
Vertical

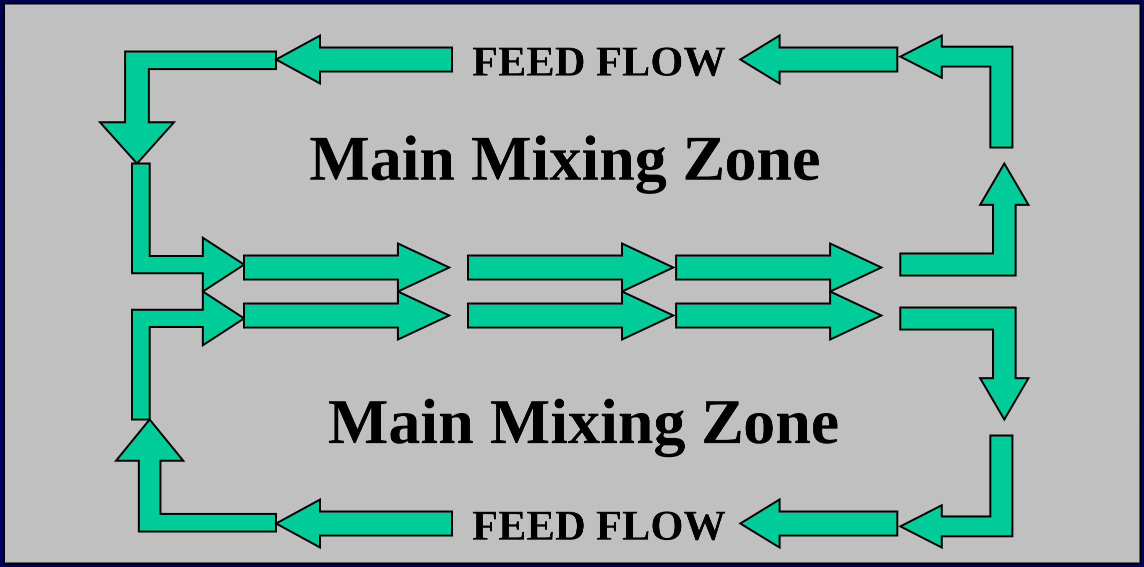
- +Low initial investment;
- +Low maintenance cost;
- +Small footprint;
- +Can be installed on a scale.

Vertical

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

Horizontal Mixers





FEED FLOW
Main Mixing Zone
Main Mixing Zone
FEED FLOW

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

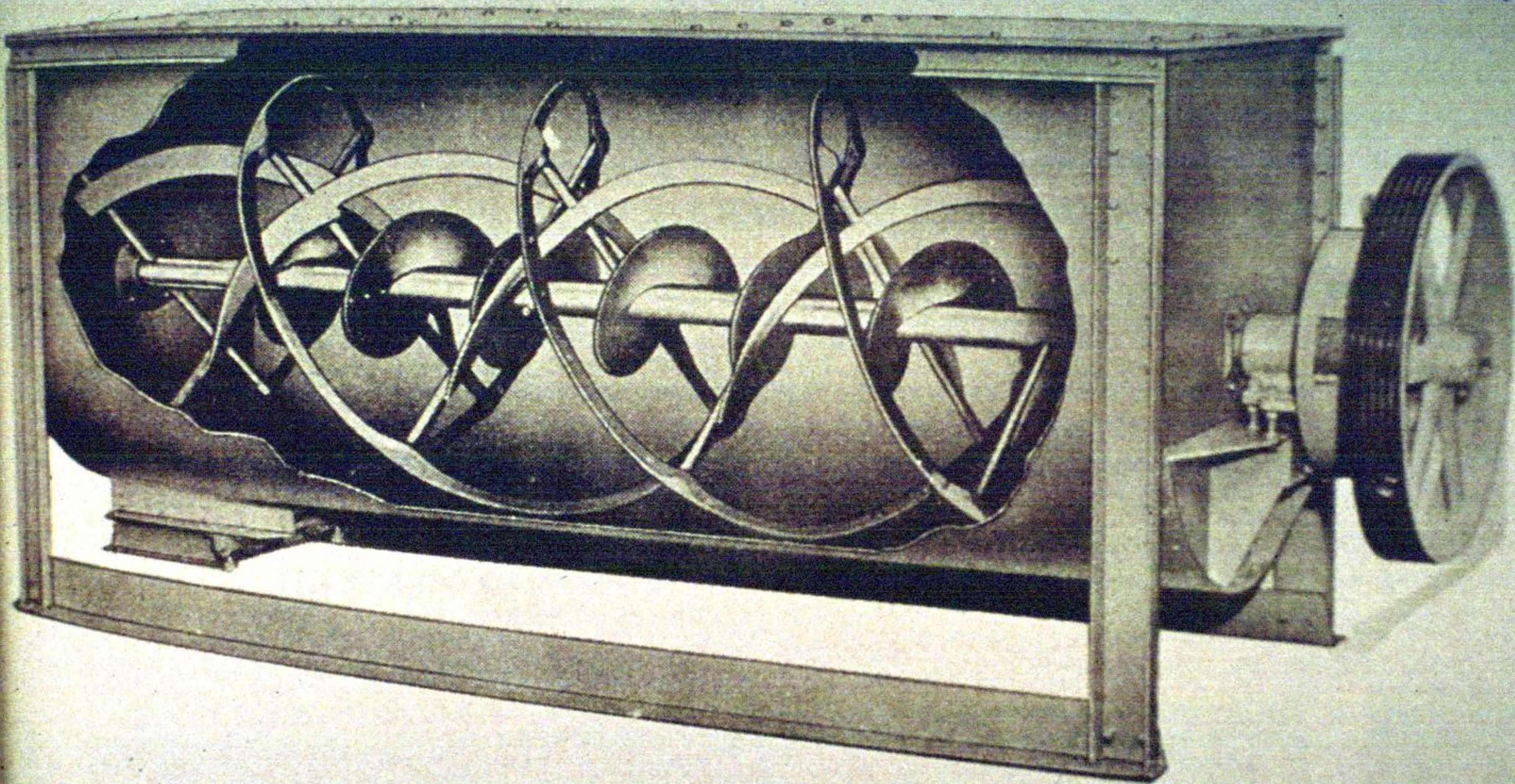
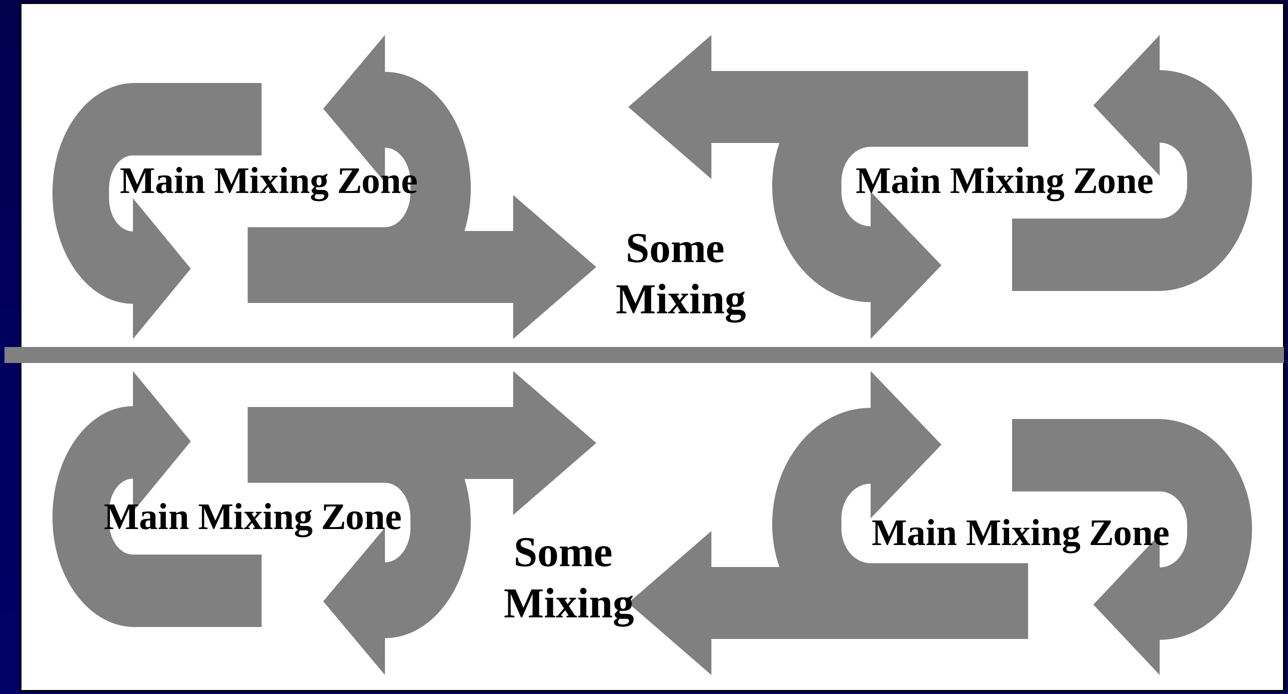


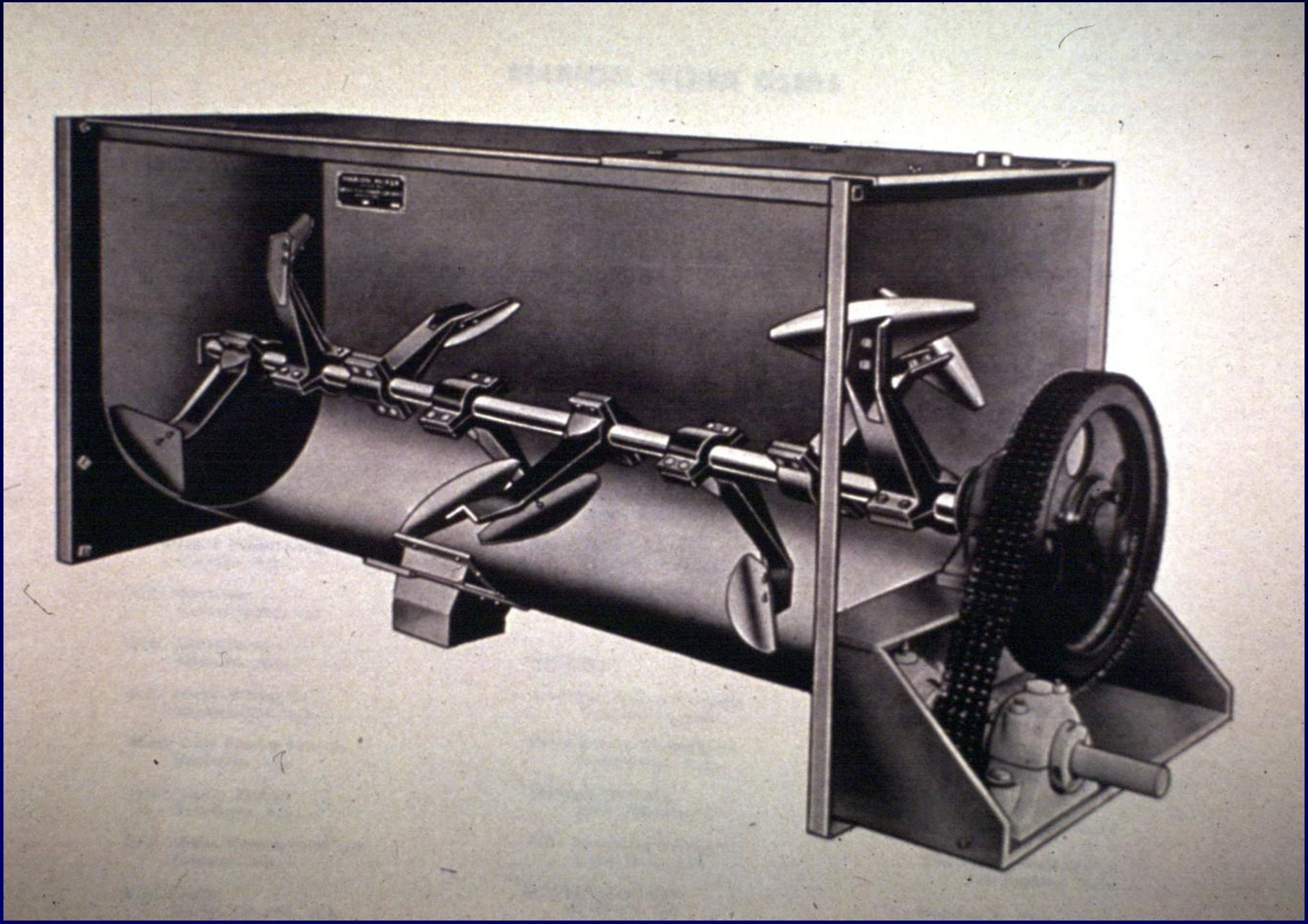
Figure 1.

Source: Marion Mixers

MIXING PATTERN

HORIZONTAL PADDLE MIXER





Horizontal / Paddle

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

Rotating Drum Mixers

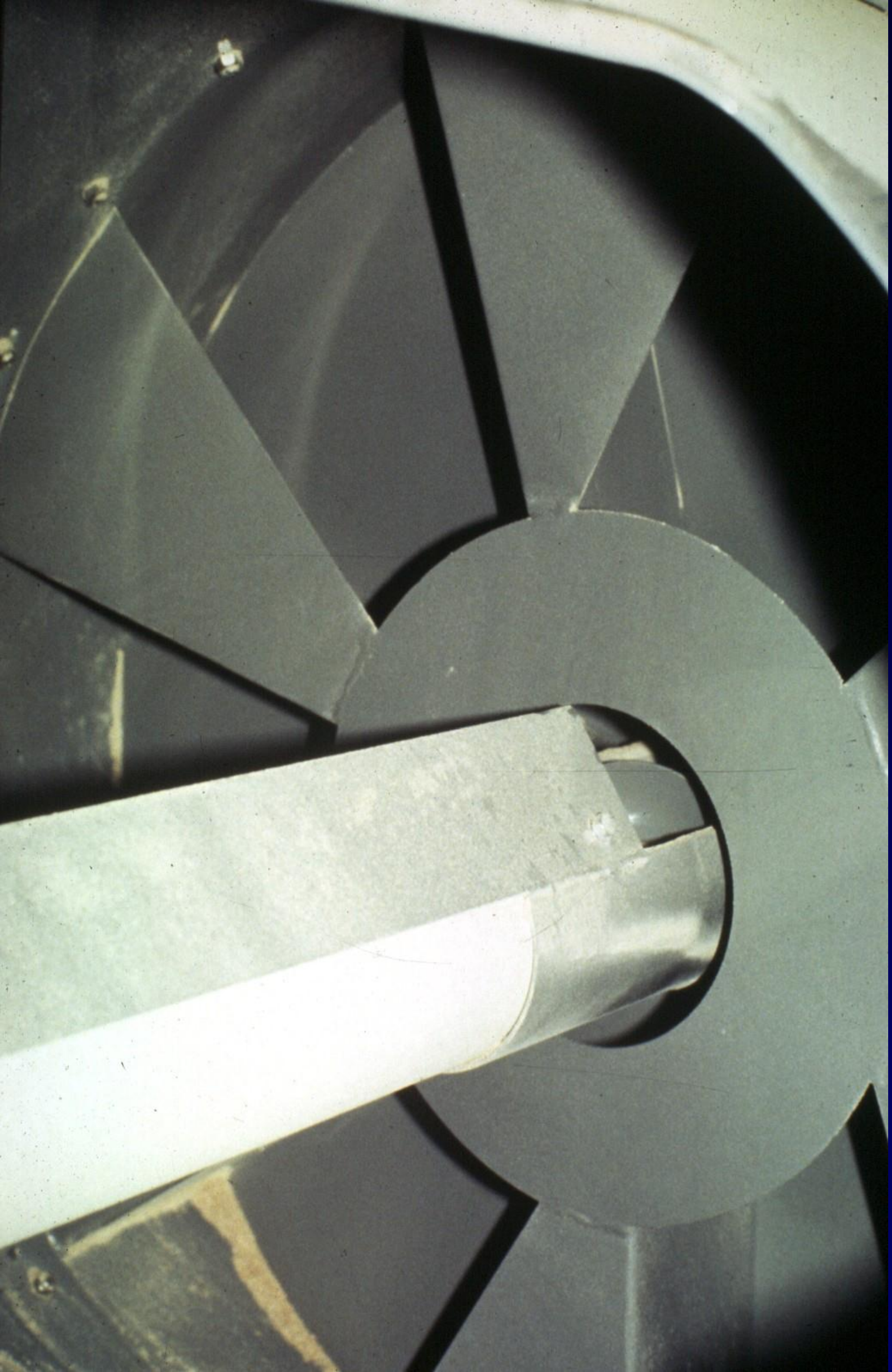
Rotating Drum Mixer

Rotating Drum

- Dual mixing action: tumbling(rotation) and side-to-side (screw conveyor);

+ Low cost;
+ Can operate with smaller loads than rated capacity.


KEEP
OFF
GB63
WARNING



Continuous

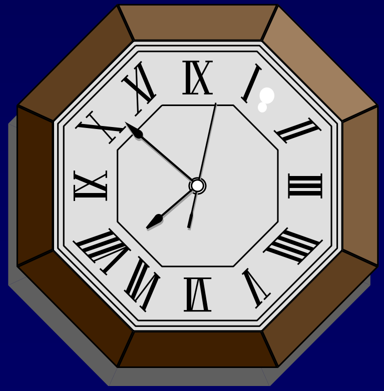
- Used to bring ingredients together in constant proportions;
- Mixtures including high levels of liquid ingredients;

Most common are the ‘cut-and-folded screw’ and paddles.

Source: AMANDUS KAHL

Source: Hayes & Stolz Mfg. Co.

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.

Source: Hayes & Stolz Mfg. Co.

Ingredient Characteristics Affecting Mixing

- Particle Size
- Particle Shape

- Density
- Static Charge
- Hygroscopicity
- Adhesiveness

Effect of Particle Size On Mixing Efficiency

		Mixing Time (min.)	
Particle Size	.5	1.5	3.0
(Microns)		Coefficient of Variation (%)	
<699	35.1	8.3	8.8
700-899	43.1	10.3	8.7
>900	50.1	14.3	11.6

Mixing

Mixer Underfill/Overfill

Effect of Batch Size and Mix Times On Nutrient Uniformity

Tons per Batch	Mixing time (min)	Coefficient of Var.-%	
		Methionine	**Lysine**
6	2.0	34.88	56.18
6	2.5	31.37	62.58
6	3.0	29.80	33.96
5	2.0	34.61	11.99
5	2.5	4.99	8.33
5	3.0	2.59	4.64

Wicker and Poole, 1991

Mixer Capacity
Effects of Ingredient Density

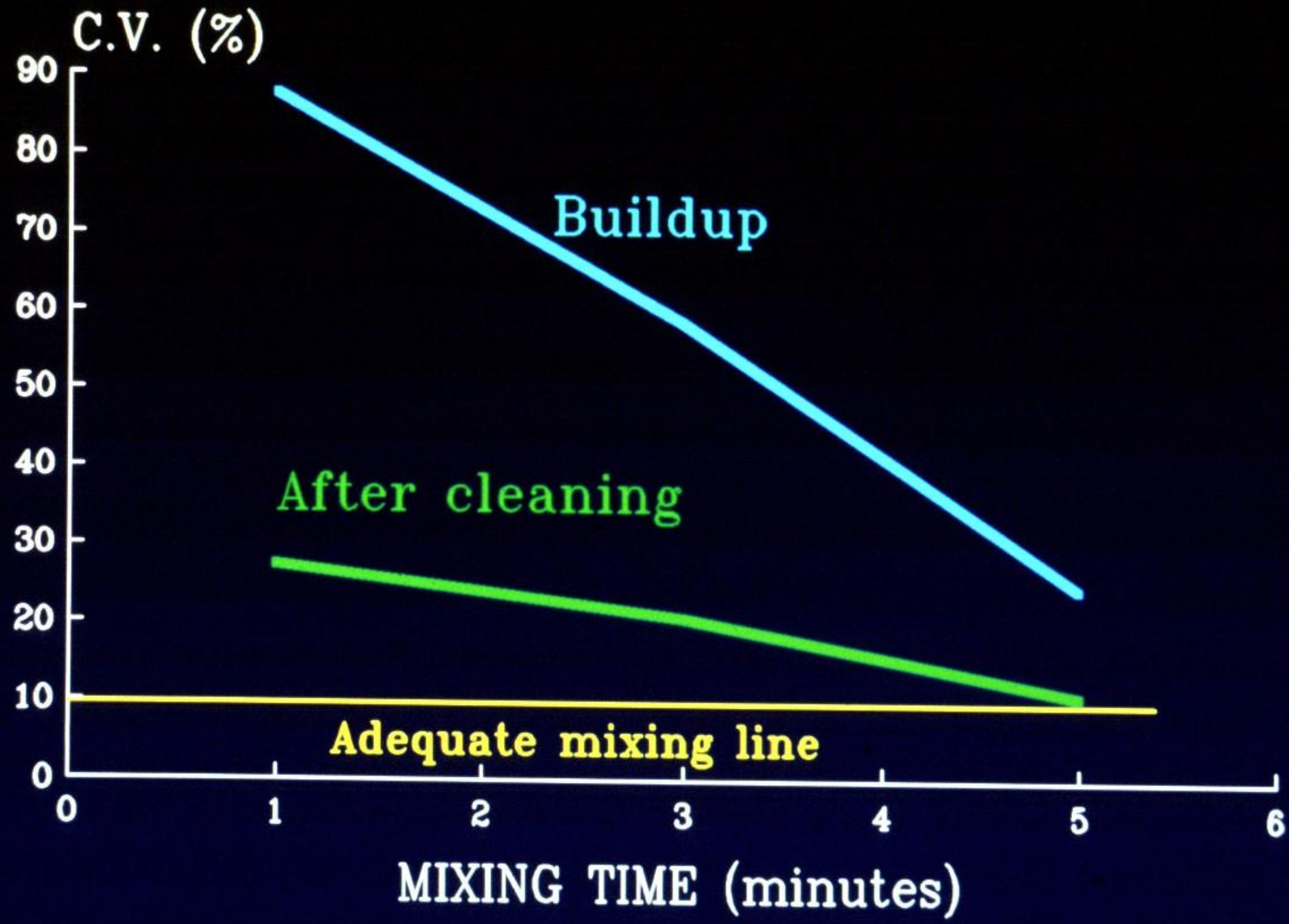
Mash Density Lbs/cu. ft.	Maximum Batch Size Lbs/batch
45	12870
43	12300 (6 tons)
41	11730
39	11150
37	10580 (5 tons)
35	10010
33	9440
31	8870
29	8290

MIXER CONDITION

- Worn ribbon, paddles or screws
- Reel-to-Tub Clearance
- Molasses or Fat Buildup

MIXER CONDITION

HORIZONTAL RIBBON MIXER
2 TON

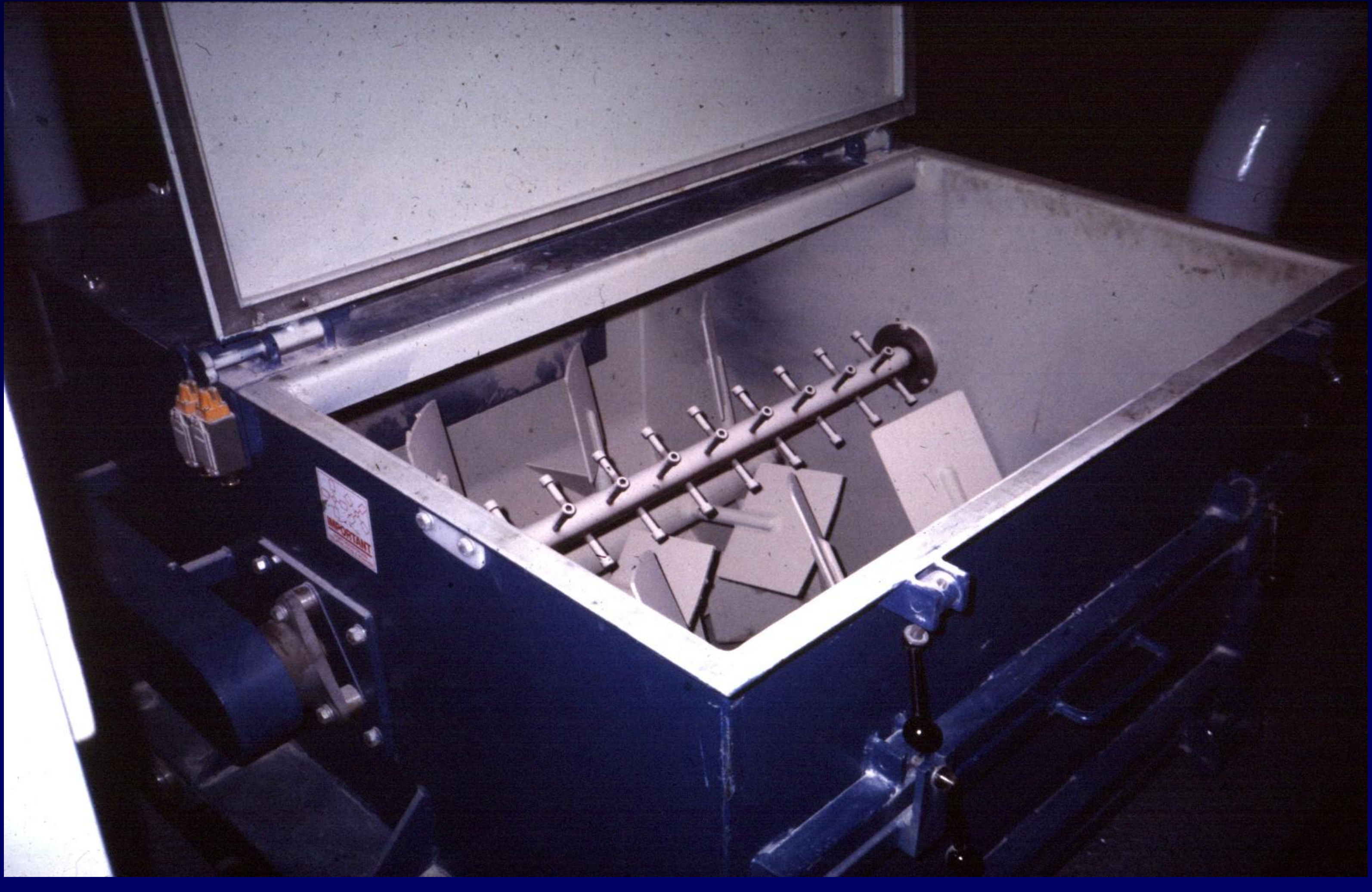


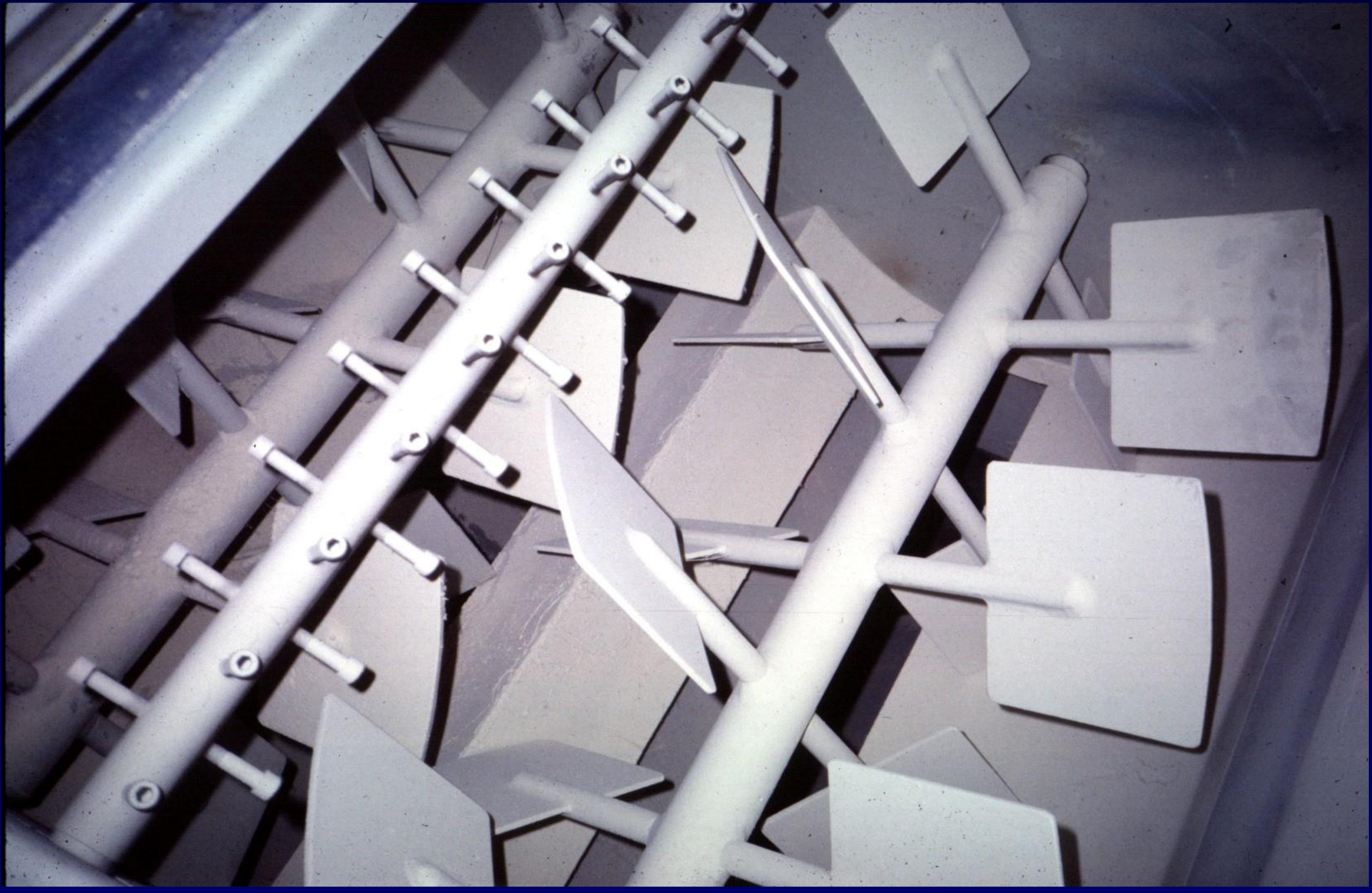
High Speed (Short Cycle) Mixers

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.



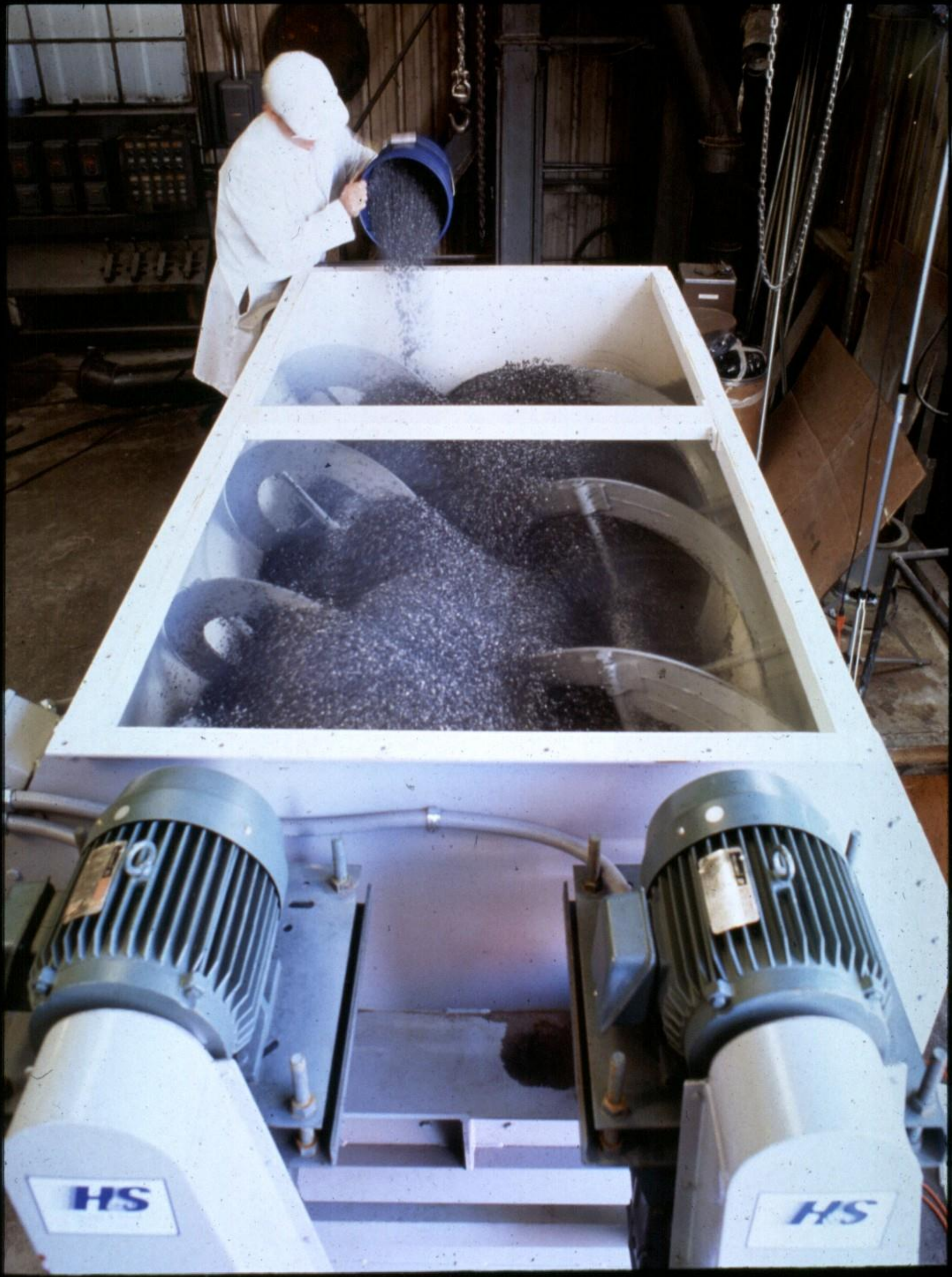


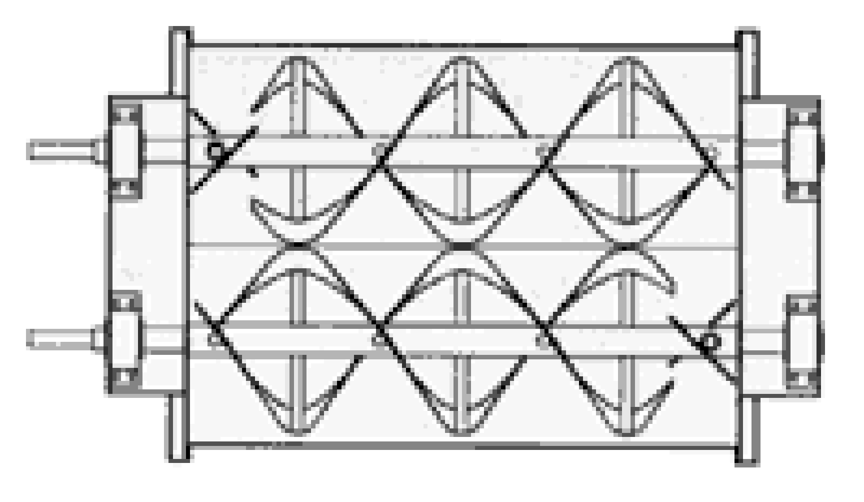
Mixer Tests
with
F-500 Forberg Mixer

Mixing Time[1] (Seconds)	Coef. Of Var.[2] (%)	Std. Deviation
15	4.56	3.6
20	5.45	4.0
25	4.53	3.6
30	4.61	

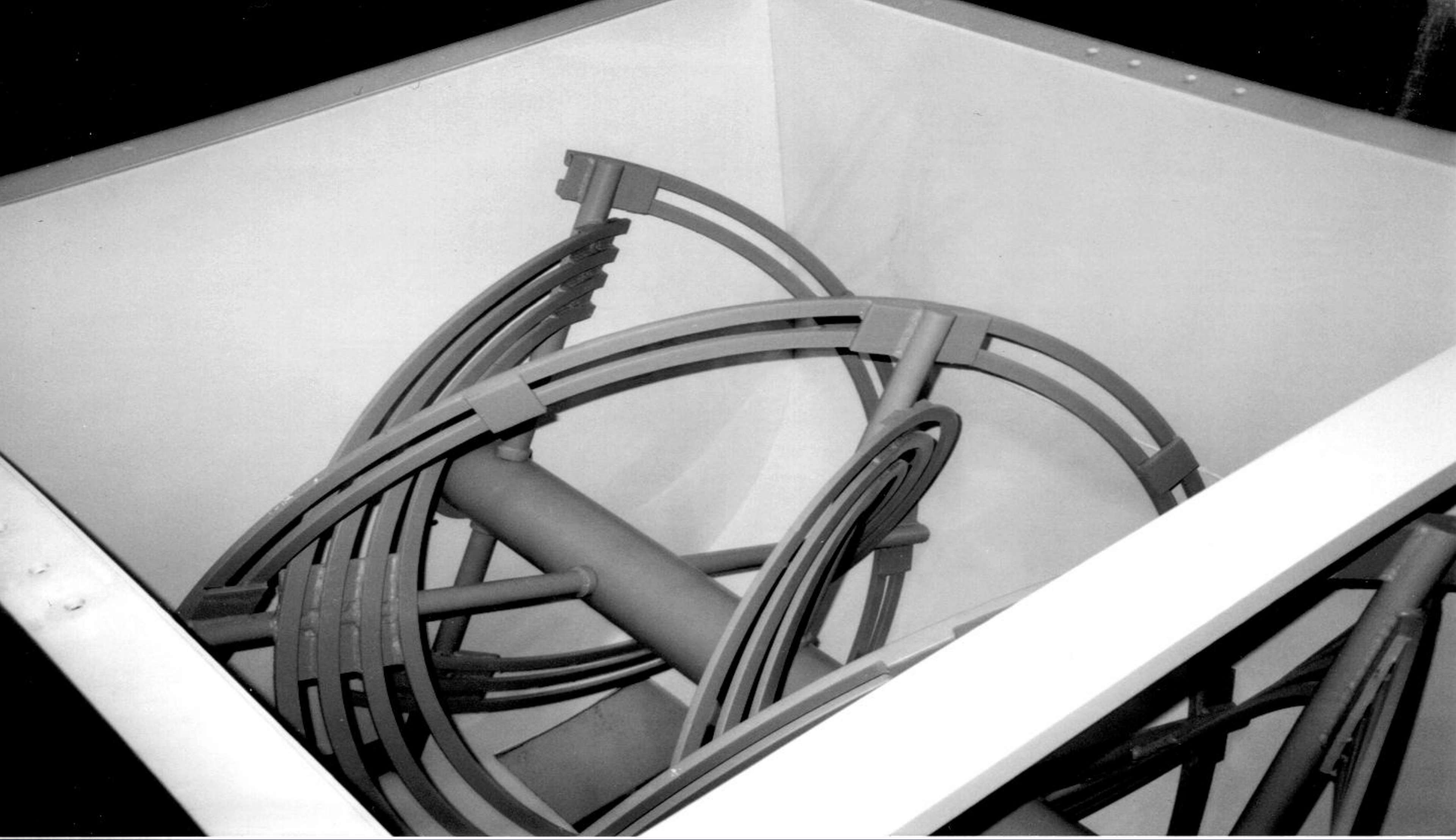
1. Mixer stopped at 15, 20, 25, and 30 seconds after salt addition.

2. 10 Samples were analyzed for each mix time.





Hayes and Stolz CounterPoise Mixer



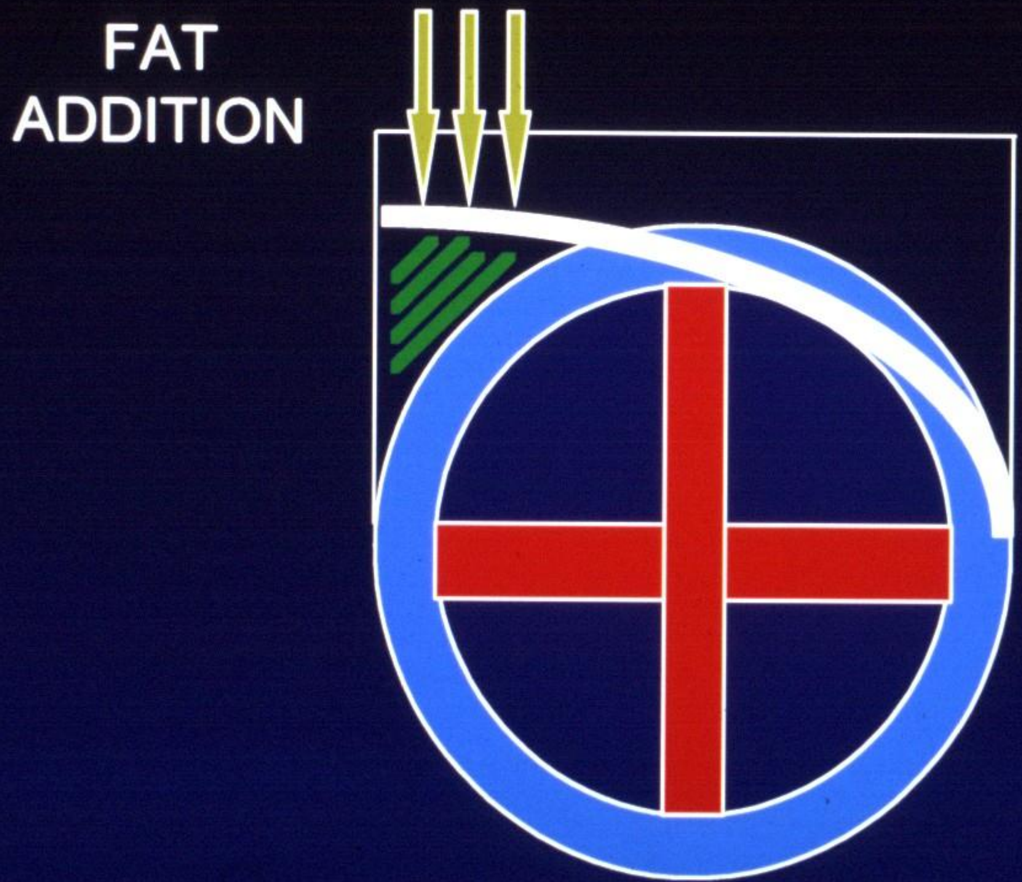
IMPROVED RIBBON DESIGN

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 Balls Created During Mixing

FEED

UNIFORMITY

TESTING

Source: Hayes & Stolz Mfg. Co.

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

$$\%CV = s/m * 100$$

$$m = (\Sigma X_i)/n$$

$$s^2 = (\Sigma(x_i^2)-nm^2)/n$$

$$s = \sqrt{s^2}$$

Where:

%CV	= Percent Coefficient of Variation
s	= Standard Deviation
s^2	= Variance
m	= Mean
n	= Number of samples assayed

Procedures (cont)

- **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

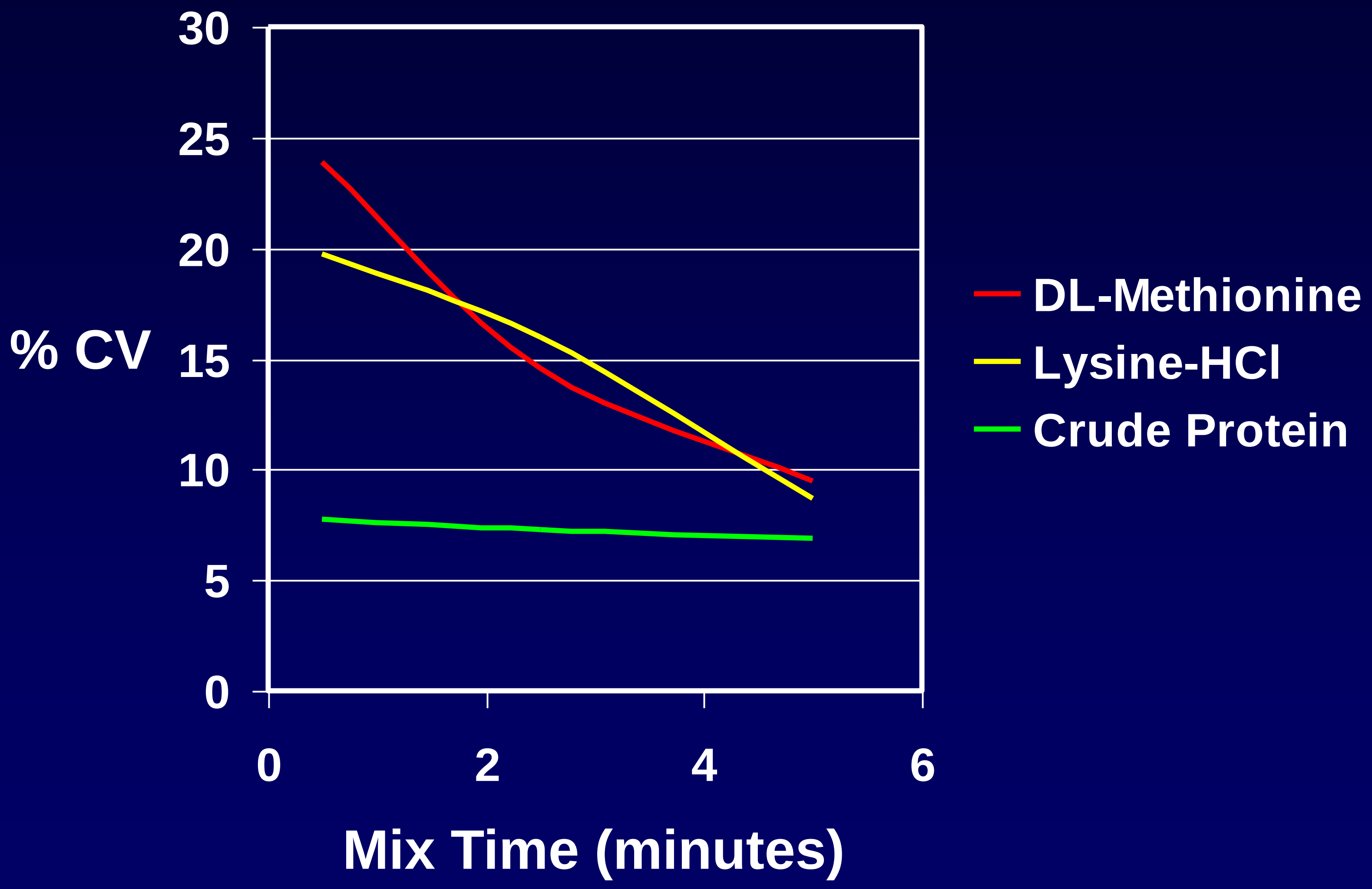
Ingredient,	%
Corn	60.48
Soybean Meal (48%)	31.55
Porcine Meat Meal (50%)	3.50
Fat	1.35
Calcium Carbonate (38%)	0.95
Monocalcium Phosphate (21%)	1.20
Salt	0.34
Lysine-HCl	0.03
DL-Methionine	0.25
Vitamin/Mineral Pmx	0.25
3-Nitro 20 ®	0.05
Aviax 5% ®	0.05
Microtracer™ Red #40 (mg/kg)	55.00
Microtracer™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

Results

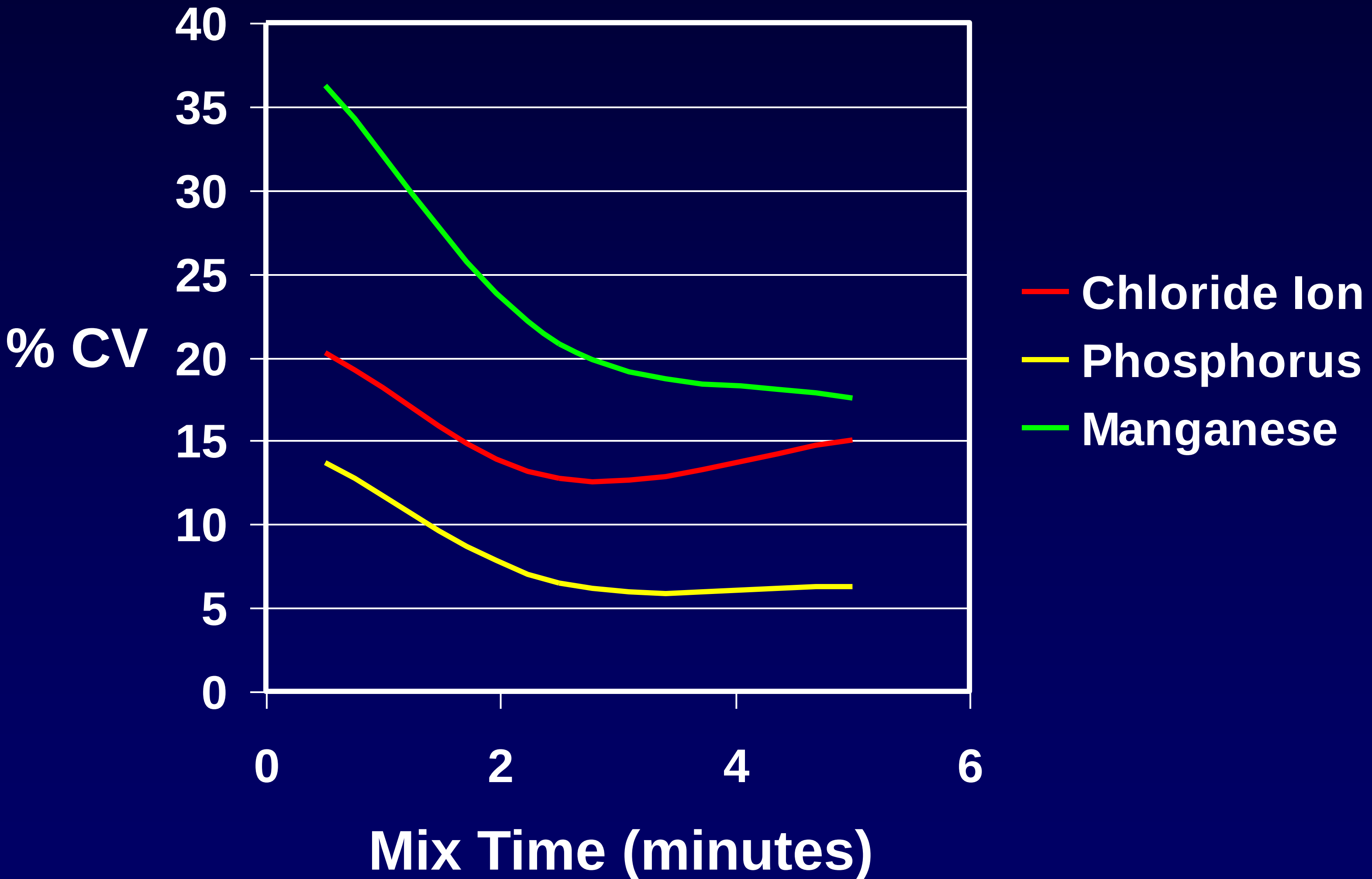
Coefficient of Variation

Item, %	Mix Time (min) 0.5	2.5	5.0
DL-Methionine	23.86	14.56	9.47
Lysine-HCl	19.75	16.00	8.70
Crude Protein	7.73	7.29	6.86
Chloride Ion (as sodium chloride)	20.26	12.75	15.08
Phosphorus	13.72	6.46	6.27
Manganese	36.25	20.80	17.59
Microtracer™ Red #40 (count)	21.77	11.72	15.08
Microtracer™ Red #40 (absorbance)	21.13	20.52	16.88
Microtracer™ RF-Blue Lake	32.49	20.09	18.64
Roxarsone (3-Nitro®)	30.24	25.15	25.54
Semduramicin (Aviax®)	27.40	16.11	11.23

Amino Acids/Protein

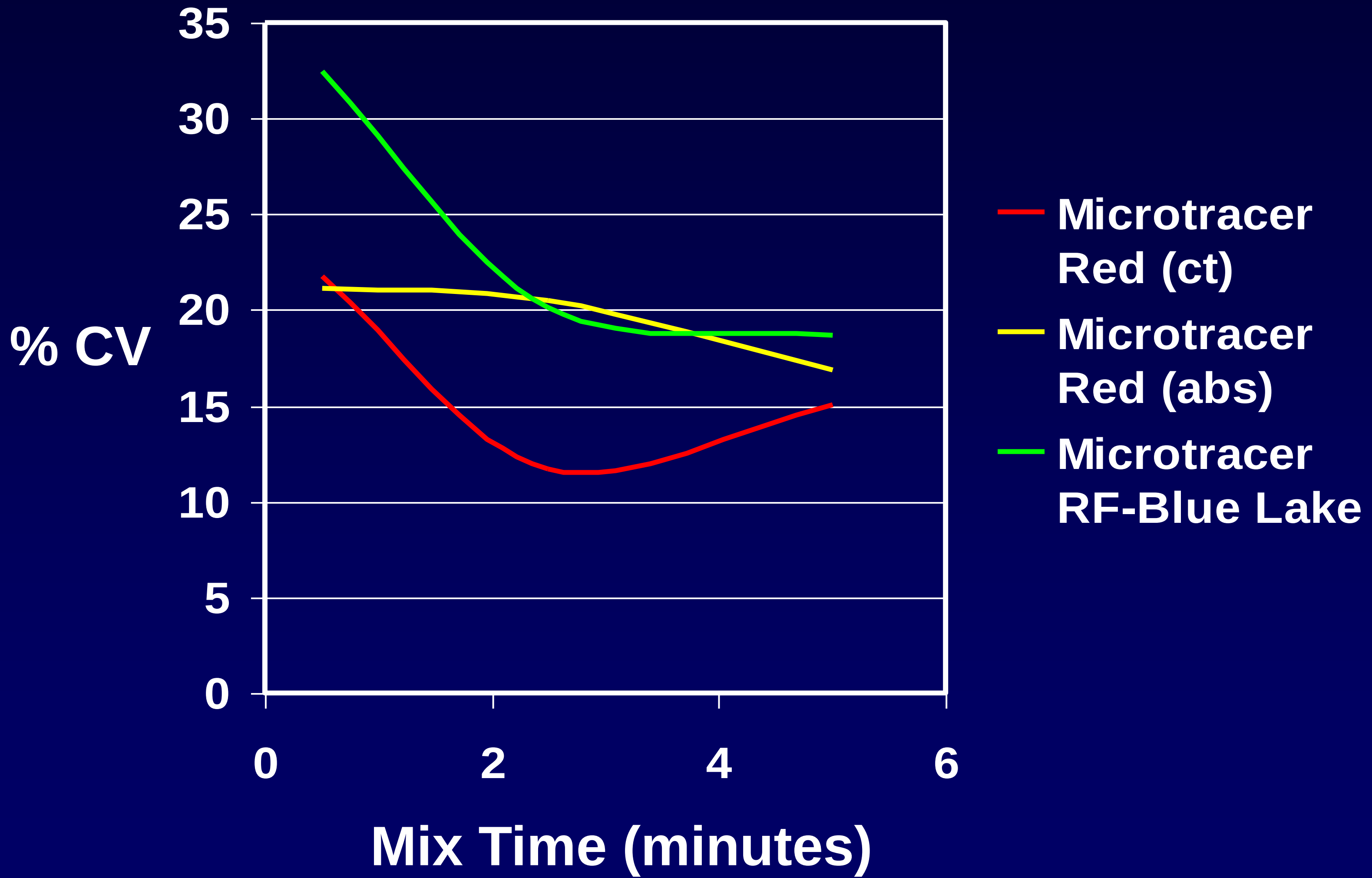


Minerals

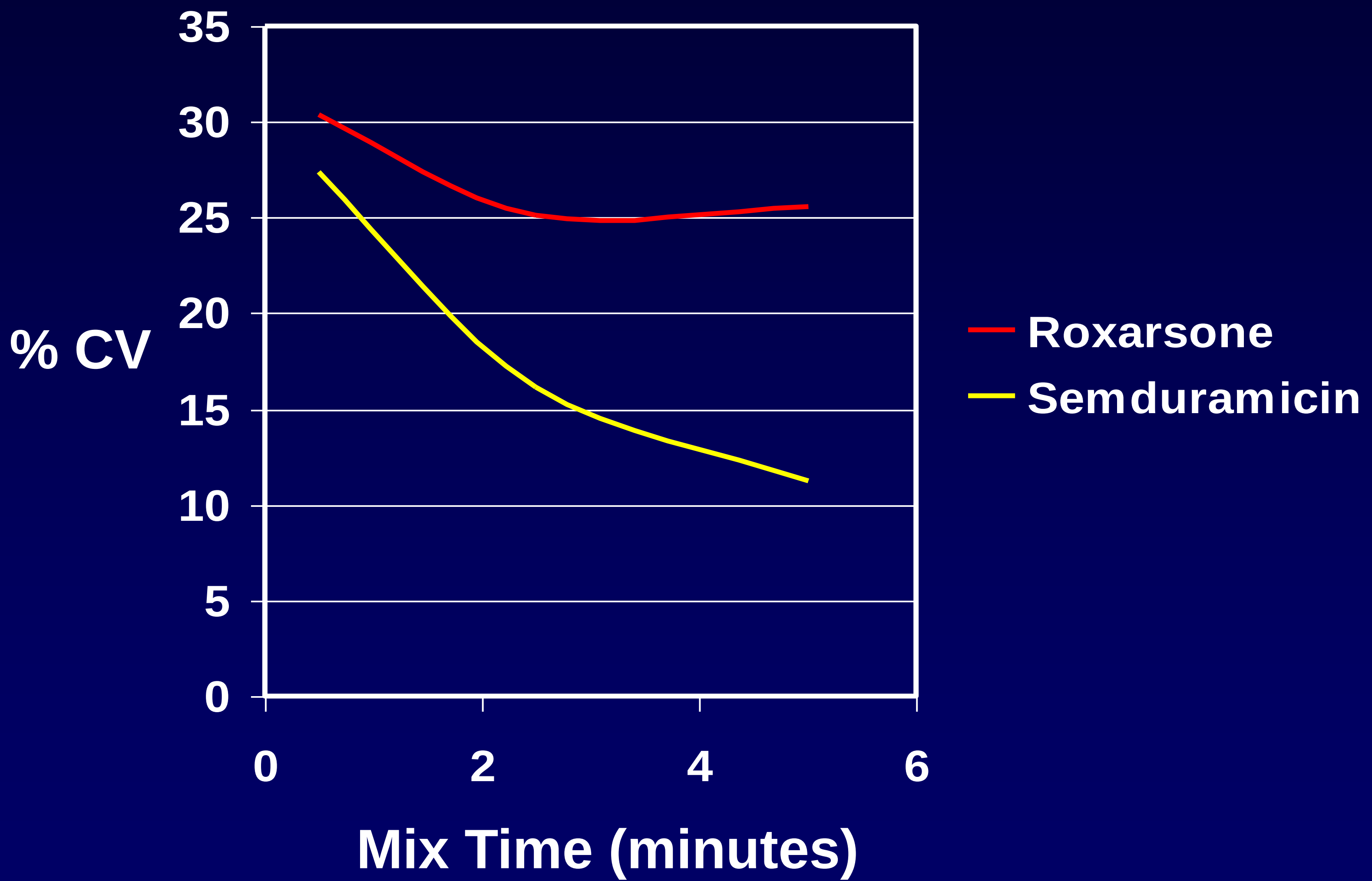


% CV
40
35
30
25
20
15
10
5
0
0
2
4
6
Mix Time (minutes)
Chloride Ion
Phosphorus
Manganese

Microtracer™



Feed Additives



Conclusions

- Protein should <u>never</u> 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


QUANTAB
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MICROTRACER F - RED
MICROTRACER F - BLUE