Soy Excellence Center
SEC Feed Manufacturing Track – Basic Level

SOY EXCELLENCE CENTER
A USSOY program

Pelleting - Principles, equipment, conditioning

Patrick Clark, PhD

Pelleting

- **Process during which individual ingredients or mixed feeds are agglomerated using heat, moisture, and pressure**

Axe et al., 2015

Cost of Feed Manufacturing

- **Pelleting is expensive and causes a lot of headaches**

	Average Costs, $
Labor	1.89
Electricity	1.16
Gas and Oil	0.62
M&R	0.88
Miscelaneous	0.62
Lease & Depreciation	2.15
Total	7.32

Agri Stats, 2018

Benefits of Pelleting

Reduce:

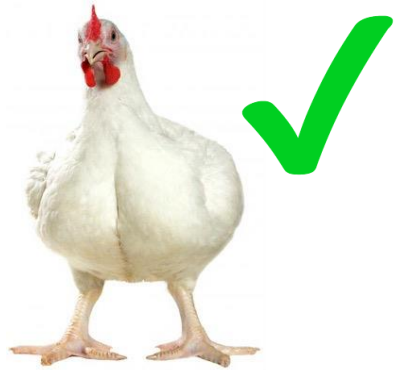
- Nutrient segregation
- Selective feeding
- Feed wastage
- Microbial load

Improve:

- Average daily gain
- Feed efficiency
- Bird uniformity
- Resting time
- Palatability

Increase Feed Intake!

Benefits of Pelleting



Let's assume that the maintenance requirement of these two broilers is 100 kcal ME/day

Feed Intake = 200 kcal ME/day

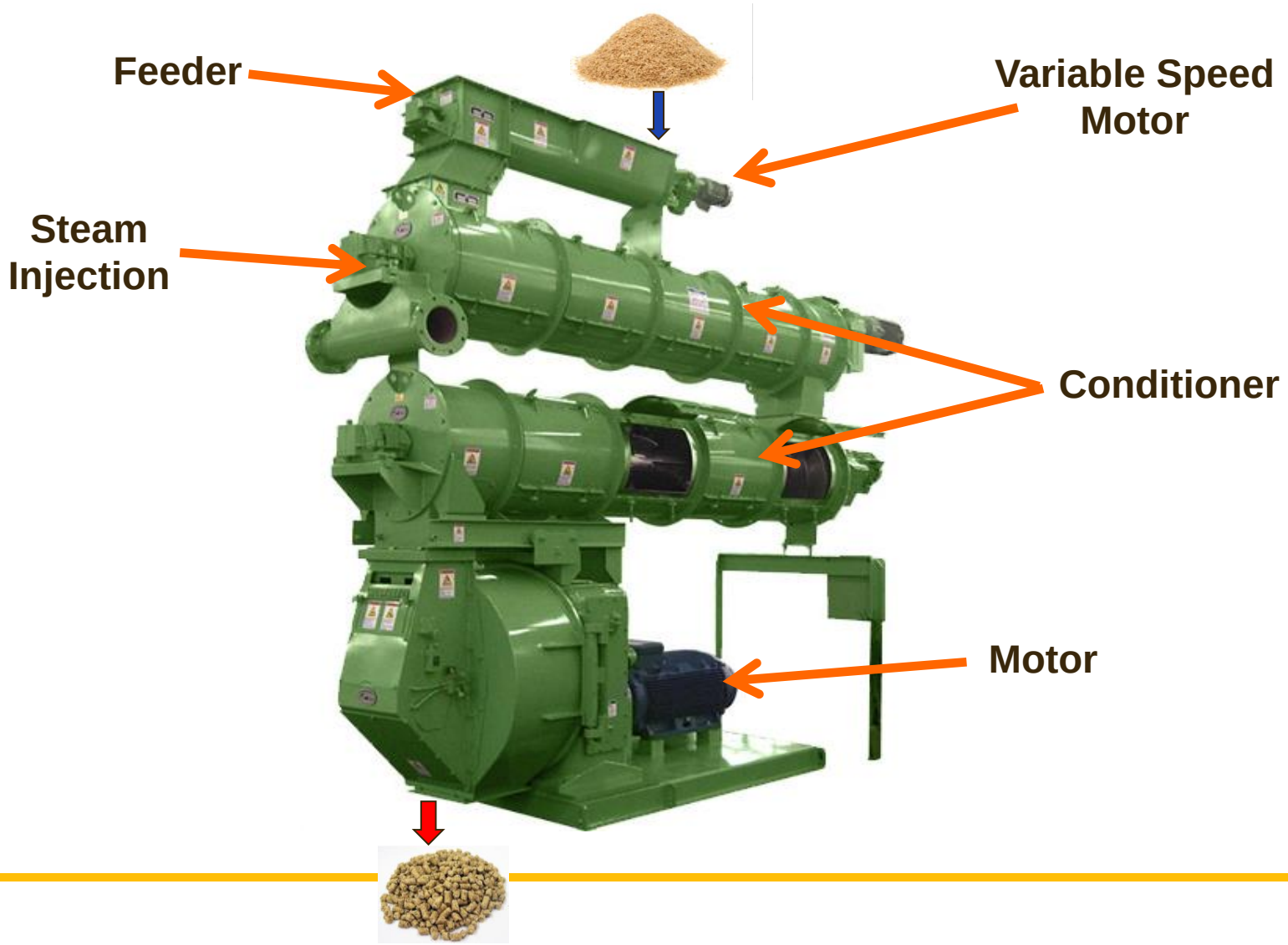
Feed Intake = 300 kcal ME/day

Which broiler will have higher average daily gain and better feed efficiency?

50% of calories for maintenance
50% of calories for growth

33% of calories for maintenance
67% of calories for growth

Pelleting System



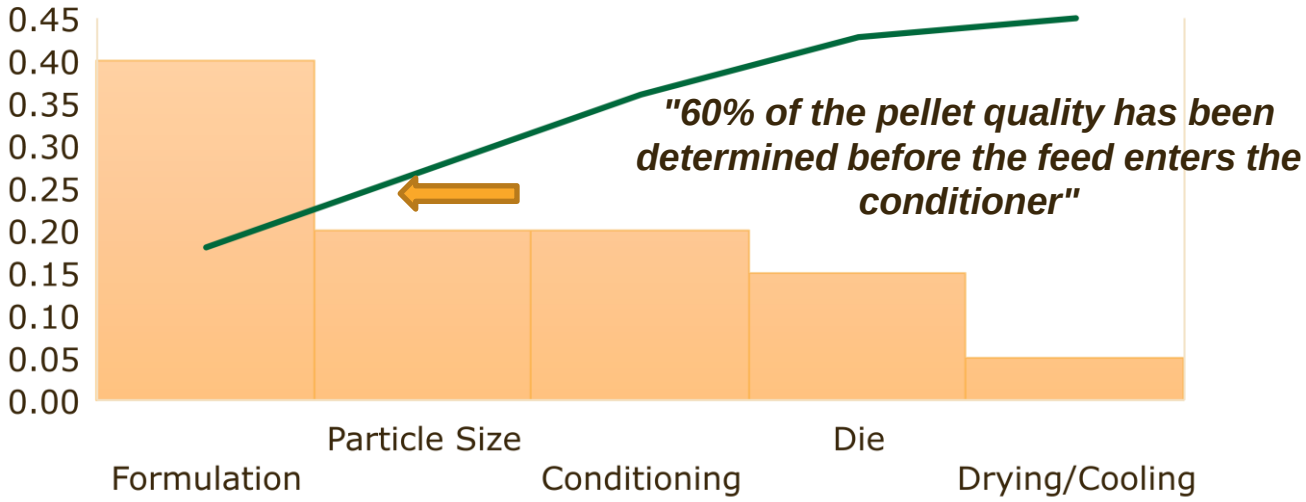
Pelleting Process

Pellet Quality Factors

Particle Size

Pellet die

Cooler



Other Factors:
- **Mixer added fat**
- **Throughput**

Reimer, 1992

Pellet Quality Factors

- Ingredient characteristics
- Protein content – Good for pellet quality and pellet mill capacity
- Fat content – not good for pellet quality, excellent for capacity
- Fiber content – OK for pellet quality, not good for capacity
  - Fiber does accepts steam readily

Pellet Quality Factors

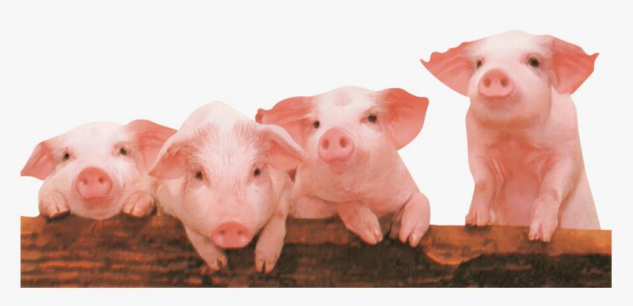
Effect of fat addition on pelleting production characteristics
(Richardson and Day, 1976)

Fat Addition, %		Pelleting Production Characteristics		
Mixer	PPLA	Fines, %	Prod. rate, tph	Energy consumption., kWh/t
1.0	4.7	18.0	11.6	11.0
2.0	3.7	22.0	12.1	9.7
3.0	2.7	29.2	13.2	8.7
4.0	1.7	31.6	13.2	7.9
5.3	0.4	50.8		

Total added fat for this example = 5.7%

Pellet Quality Factors

- Ingredient characteristics
- Sugars – heat sensitive, thin dies – piglets' feed
  - Reduce conditioning temperature to 150°F or 65°C
- Defluorinated Phosphate
  - Great at polishing die holes
  - More expensive than other phosphate sources
- High mineral formulas
  - Thinner dies
  - Higher chromium alloy
  - Abrasive – hard running
- Moisture– essential for good pellet quality
  - Heat transfer

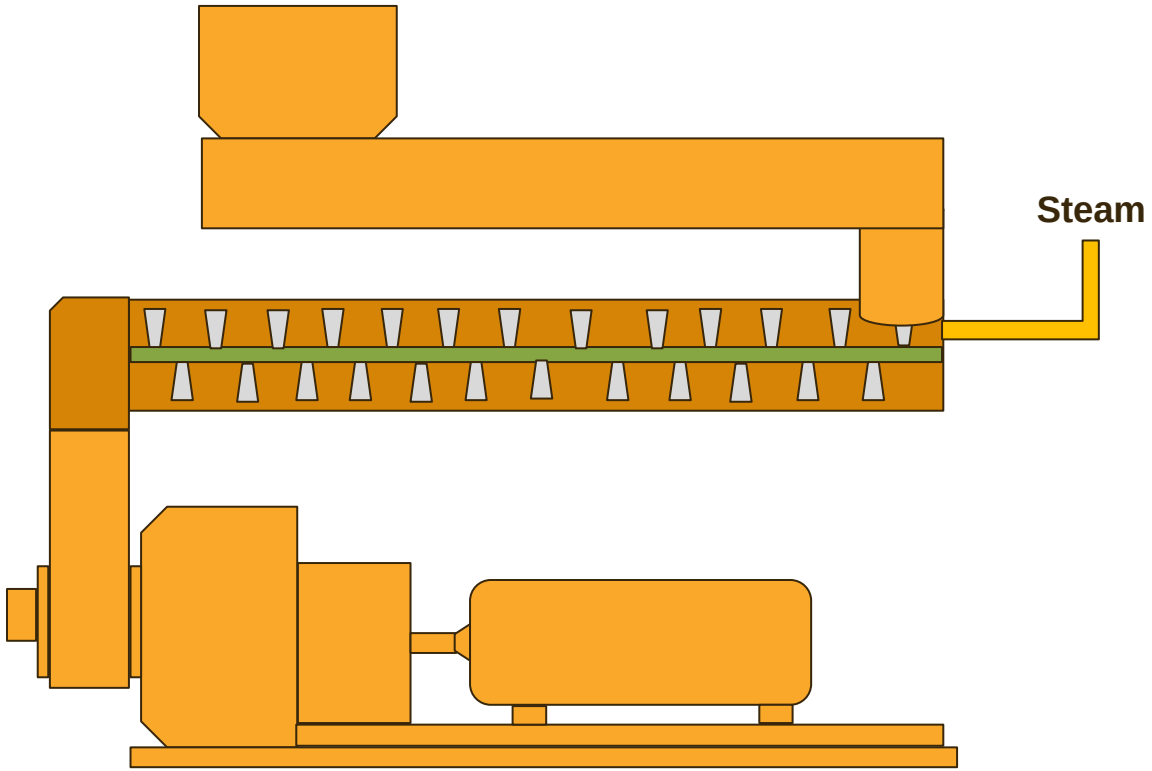


Pellet Quality Factors

Process Factor	PDI
Control	70.0
Increase conditioning temperature 5°C	75.1
Increase conditioning temperature 10°C	79.4
Reduce mixer added fat 0.5%	75.0
Add 1.5% calcium lignosulfonate	82.5
Decrease production rate 20%	71.3
Add 10% wheat	75.4

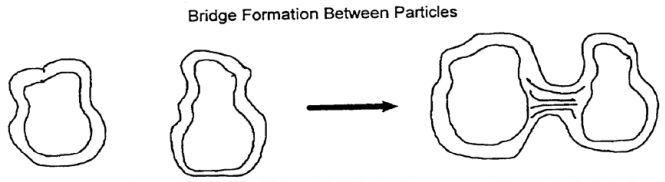
Winowiski, 2008

Conditioning



Conditioning Purpose

- The steam used during conditioning softens feed particles and activates natural binders
  - Protein and starch structures are changed and can serve as “glue” or binders



- Increases pellet die lubrication
- Retention time is important for greater penetration of steam into the feed particles
- 25°F = 1% moisture addition

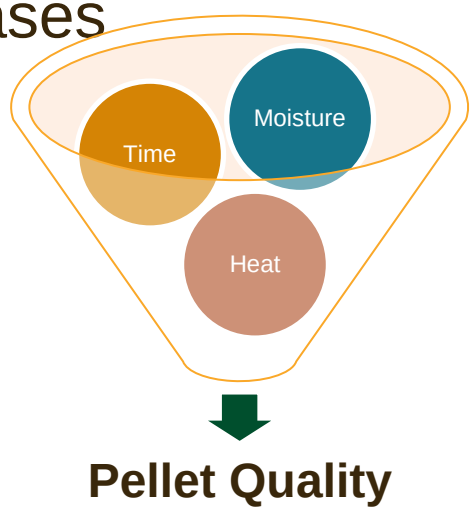
Cold Mash
80°F
13%

→

Conditioned Mash
180°F
17%

Factors Affecting Conditioning

- Mash particle size
  - Surface area increases geometrically as particle size decreases
- Retention time
  - 45 to 60 seconds for optimum pellet quality
  - Pick (Paddle) angle
  - Retention time decreases as forward angle increases.
  - Shaft speed
- Water Addition
  - Optimum conditioning at 16-17.5% moisture, with 4-5% moisture added by the conditioner



Steam Quality

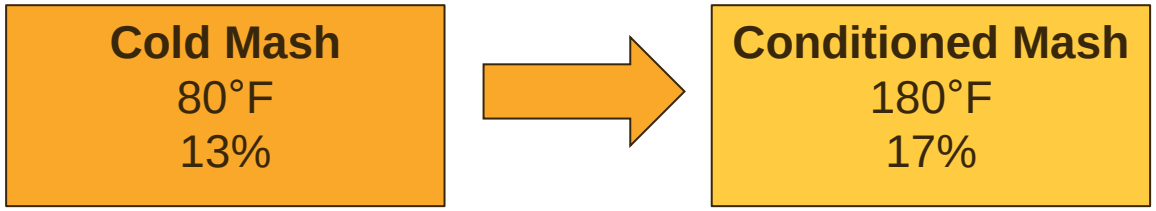
- Amount of moisture in the steam
  - Affects the amount of heat and moisture that is transferred to the feed during the conditioning process
- Low steam quality:
  - Too much moisture and not enough heat transfer and can result into diminished production rates (chocked die, plugging).
- High steam quality
  - If there is not enough retention time in the conditioner = poor gelatinization of the meal

Conditioning

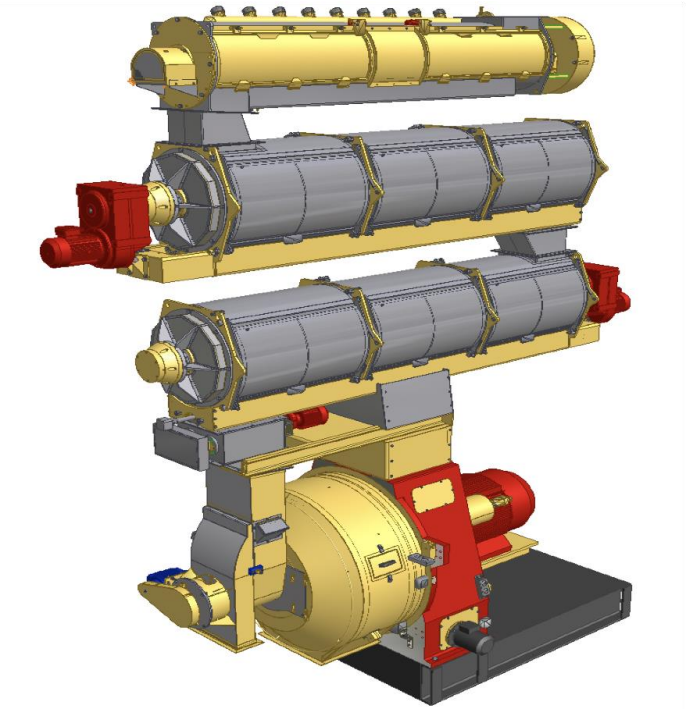
- The level of steam conditioning depends on:
  - Moisture content
  - Fat content
  - Steam quality
  - Die resistance and condition
  - Ambient temperature

Conditioning Targets

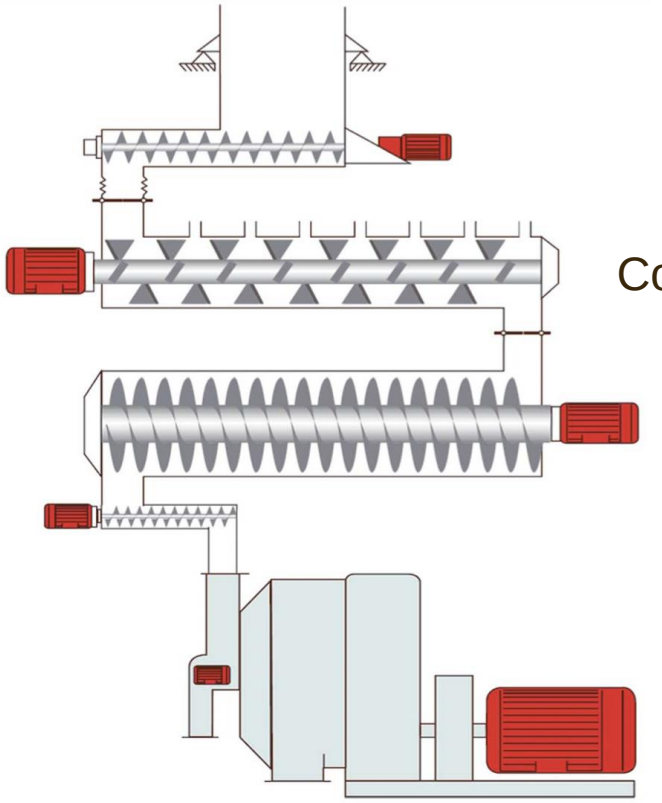
- Temperature: 180-190°F or 82 - 88°C
- Moisture = 16-17.5%
- For every 20-25°F increase in temperature, there is an increase in 1% moisture



Extended Conditioning



Double conditioner



Salmonella Control
Higher Temperature and Retention Time

- Feed is moved through the unit by a screw auger
  - First In, First Out (FIFO)
  - Features
    - Salmonella control
    - Improved pellet quality
    - Flexible temperature and retention times
    - Steam jacketed

CAPACITY TPH					
MODEL	MINUTES				
	2	3	4	5	6
24LLJ12ST	15.0	10.0	7.5	6.0	5.0
36LLJ13ST	30.0	20.0	15.0	12.0	10.0
48LLJ13ST	60.0	40.0	30.0	25.0	20.0
48LLJ16ST	80.0	50.0	40.0	30.0	25.0

**Based on 80% fill rate and 40 lbs/ft3 product density.

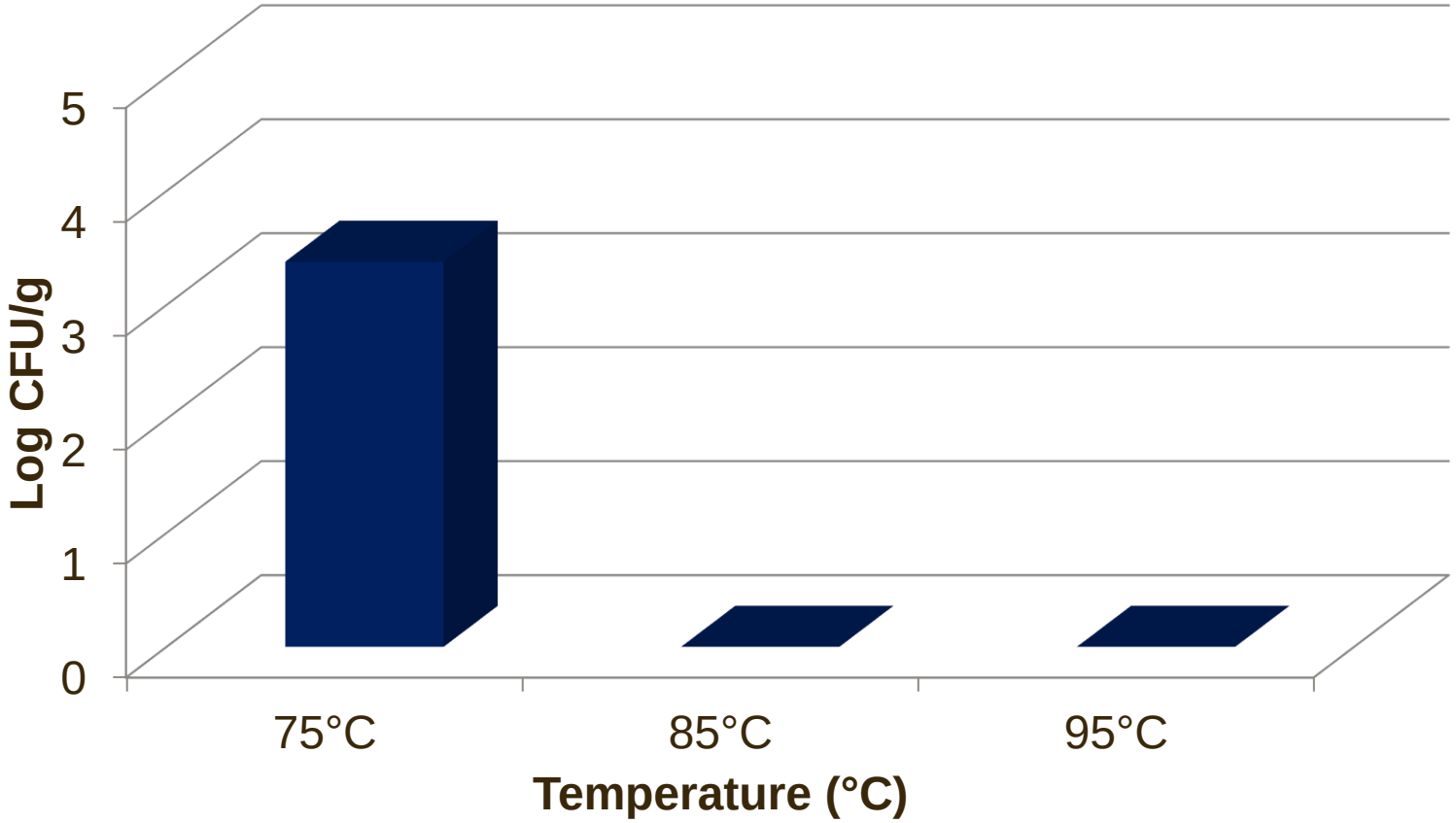
Die Hygieniser Research – Auburn
Enterococcus Faecium

- 3 x 3 factorial treatment structure
  - 2 main effects

Main Effects	
Conditioning Temperature (°C)	Hygieniser® Retention Time (s)
75	80
	160
	240
85	80
	160
	240
95	80
	160
	240

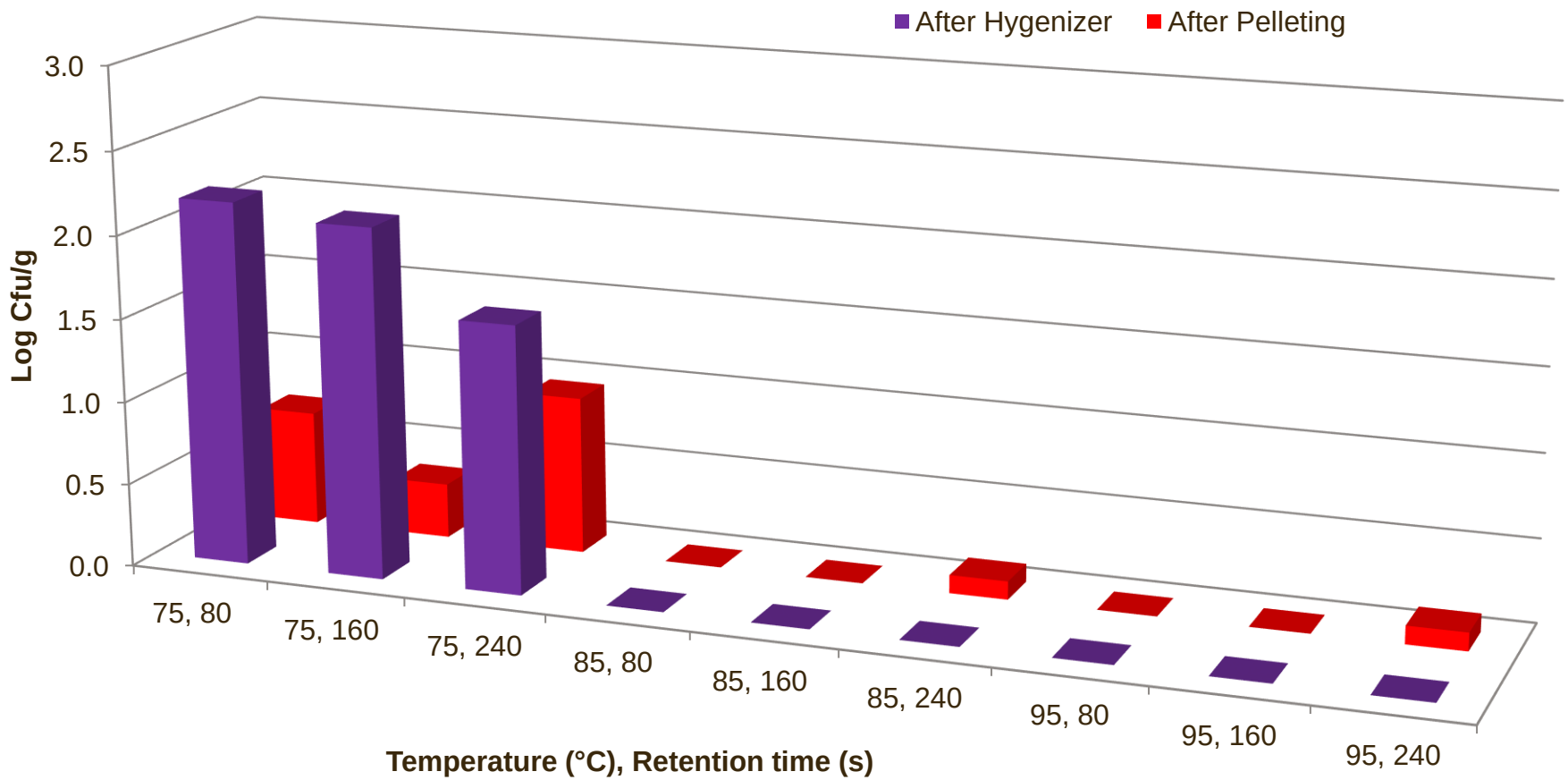
Results

Effect of feed processing on *Enterococcus* spp. levels in inoculated feed after conditioning at different temperatures



Extended Conditioning

Effect of feed processing on *Enterococcus* spp. levels in inoculated feed after Hygieniser® and pelleting at different temperatures and retention times

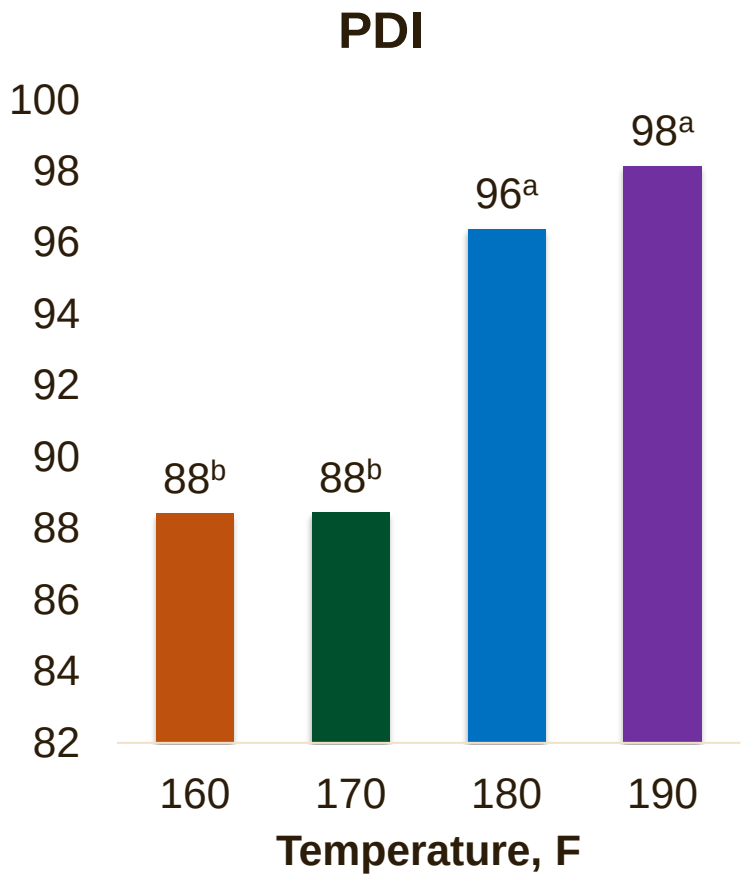


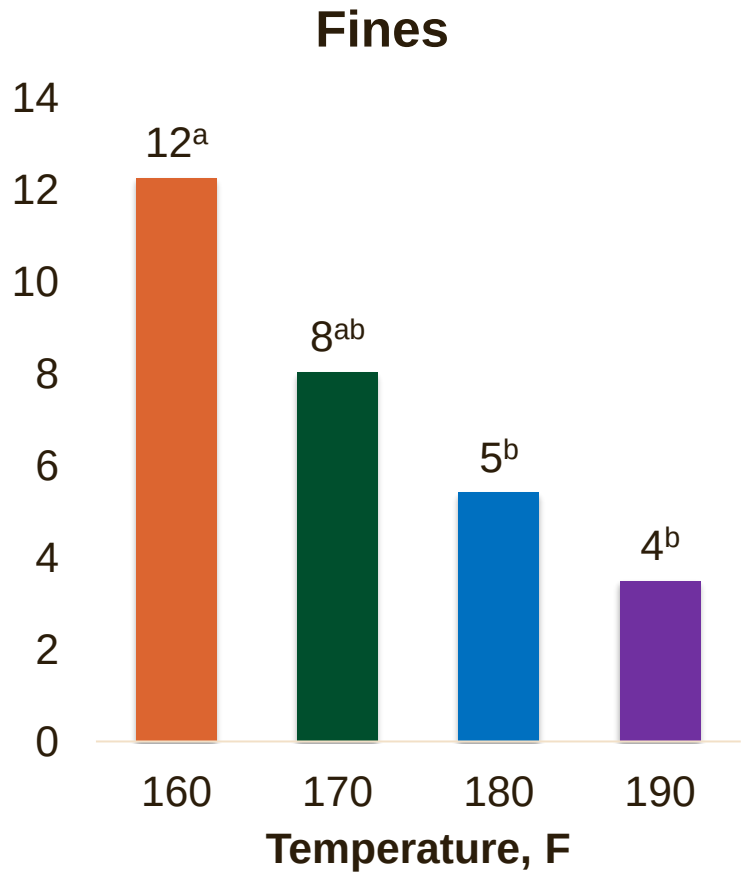
Determining Conditioning Time

- Amp load method
  - Stop feeder, stopwatch until pellet mill is close to idle amps
- Whole corn/dye method
  - Add at discharge of feeder, collect at pellet mill inspection door
- Weigh conditioner contents
  - @ known tph; stop feeder and conditioner.

Example: Running 50 tph, 1750 pounds is collected from conditioner; 100,000 pounds per hour =27.8 pounds per second; 1750/27.8 = 63 seconds

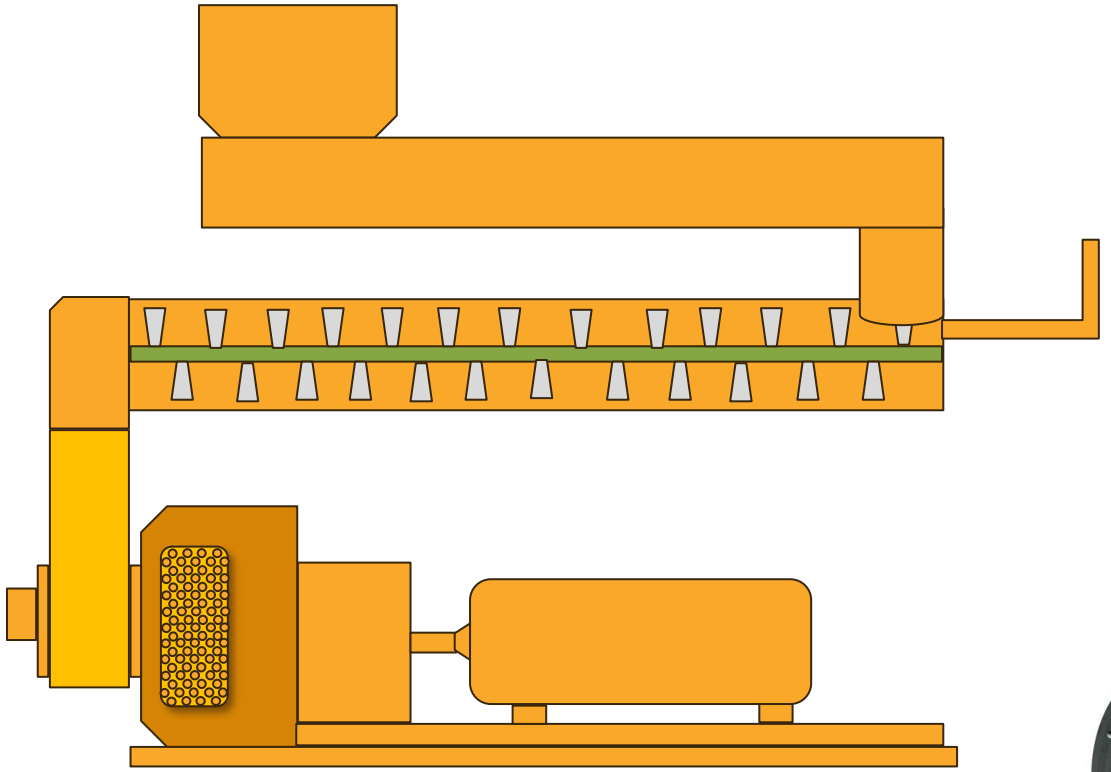
Conditioning Temperature





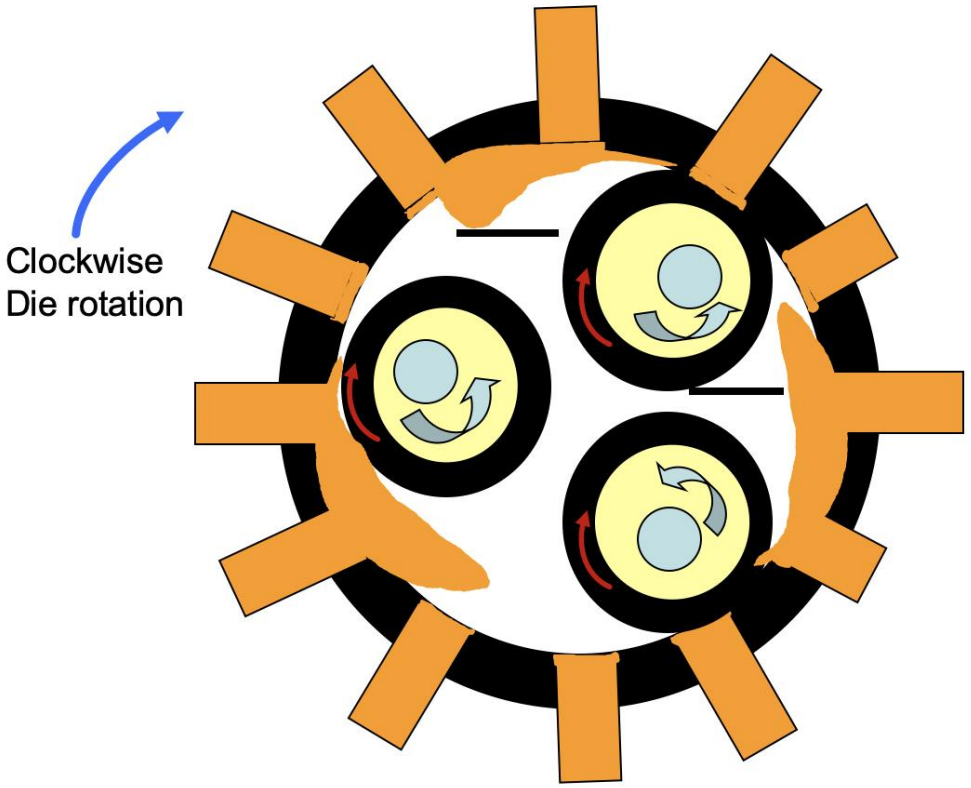
Rueda et al, 2018

Pellet Die



Feeding Objectives

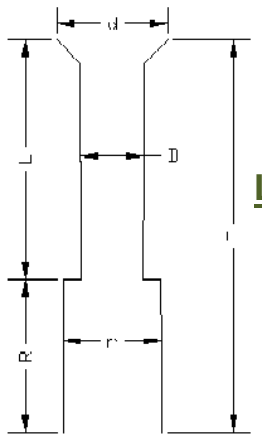
- Spread the feed evenly across the die face
- Prevent material from accumulating in the die
- Prevent material from leaking past the rotary feed cone
- Spread the feed equally between the two or three rollers



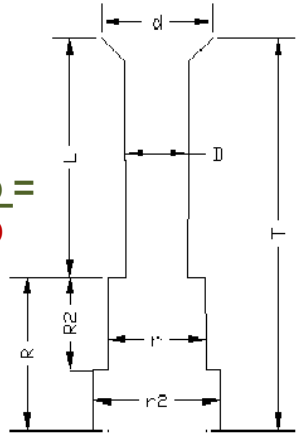
Hartwig, 2014

Pellet Die

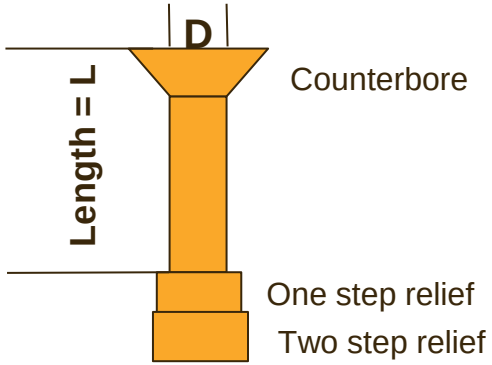
- Die design influences pelleting capacity and pellet quality
- Die material – Typically chrome (13% chrome)
  - Excellent Corrosion Resistance
  - Works good in high grain formulas
- Effective hole size – The part of the hole doing the pelleting
- L/D Ratio - The length of the effective hole/diameter of hole
- Relief – The die thickness that is added for strength
- Open Area – The sum of all the holes relative to total die surface



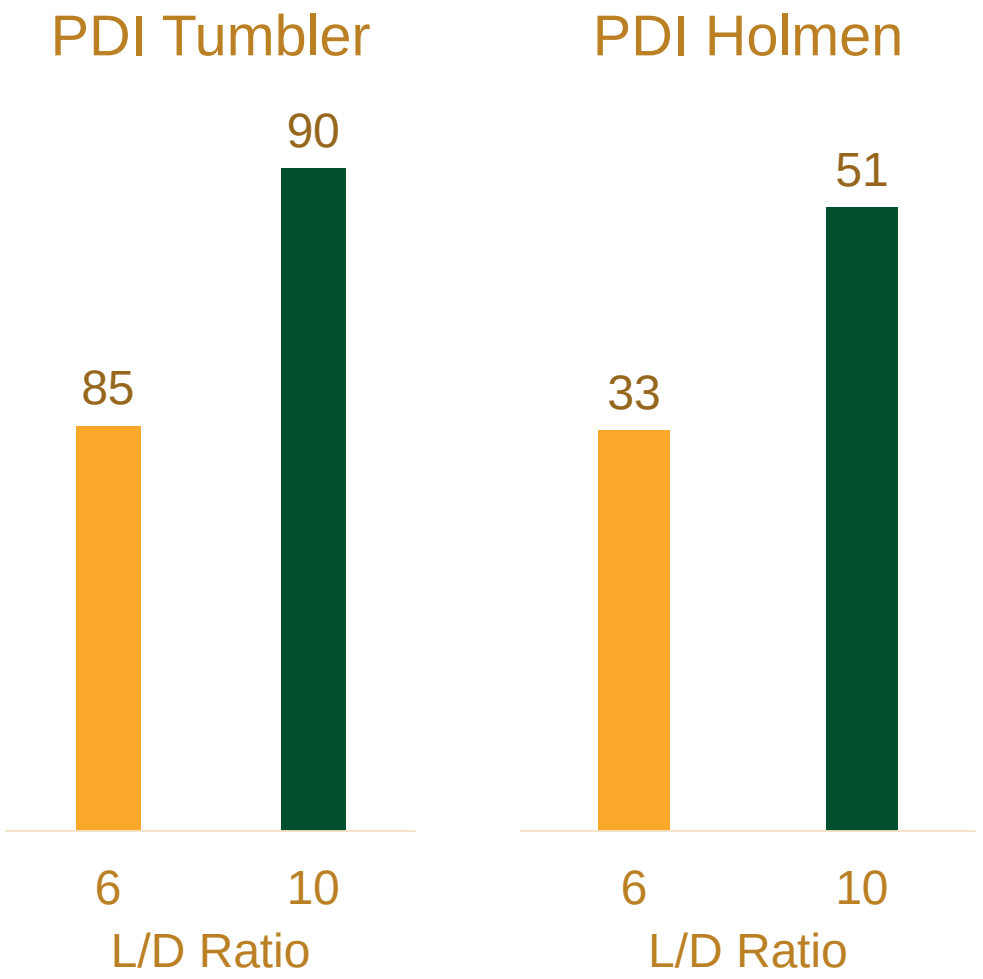
If "L" length = 1 ¾
and D = 5/32 then
L/D or compression ratio =
1.75/0.15625 = **11.2 L/D**



Pellet Die Compression Ratio



$$L/D = \frac{\text{Length}}{\text{Hole Diameter}}$$

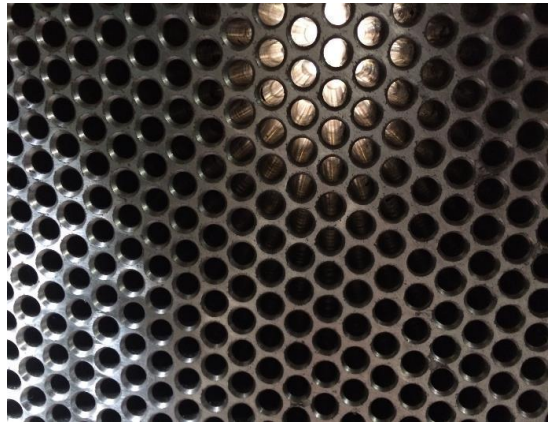


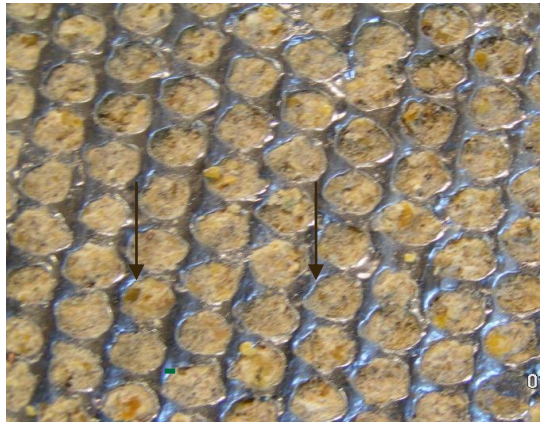
Smith, 2021

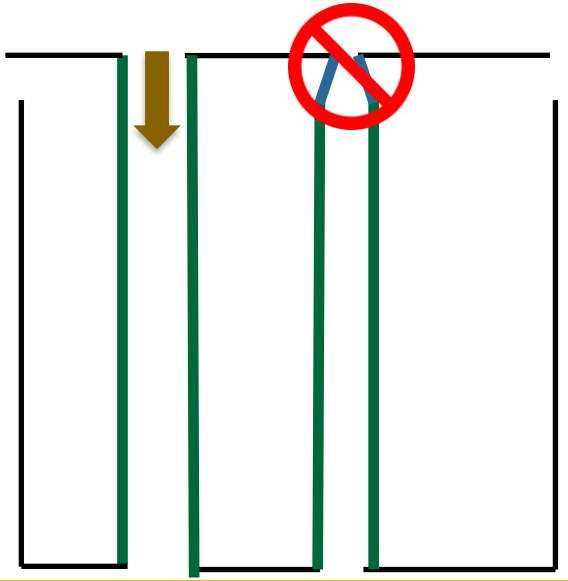
Pellet Die Open Area

- More holes = more throughput
- 1% open area affects throughput approximately 5%
- More holes = longer die retention time at same capacity
- As hole size increases, open area increases
  - 5/32 (4 mm) = 43.9 % open area
  - 11/64 (4.4mm) = 46.2% open area
- Micro pellets of 2 mm are more difficult to produce, likely due to less open area
- Disadvantage: More holes = more prone to breakage

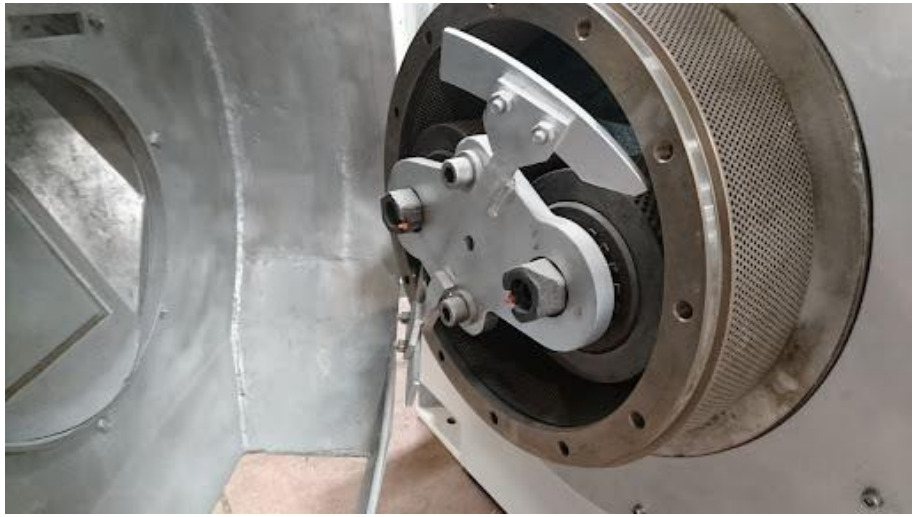
Pellet Die Protection







Other Components

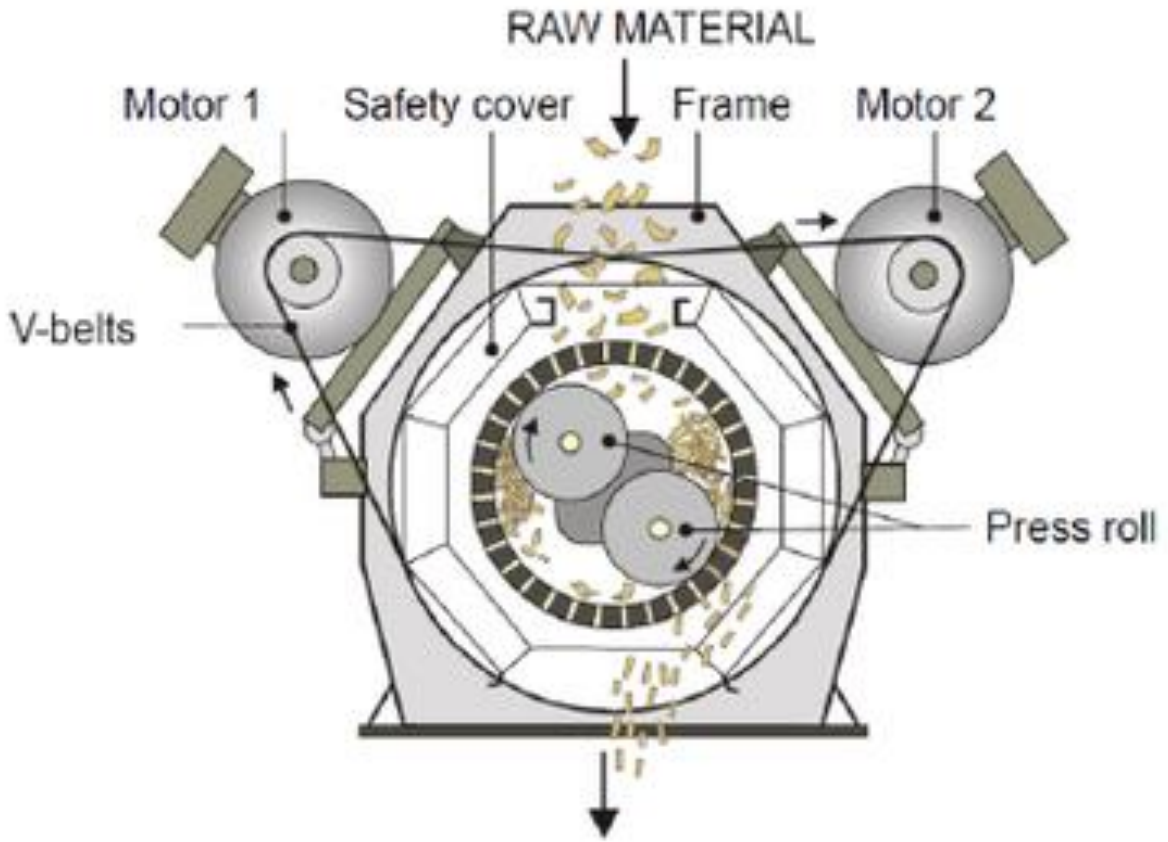


Deflectors: Help to distribute the feed uniformly across the face of the rolls. Ideally rolls should get equal amount of feed for even wear of rolls and smooth operation of pellet mill

Wipers: To move feed from the rear of the die and spread it back onto die face

Roll Adjustments

- Clean Die & rolls
- Adjust rolls counterclockwise to the die
- Adjust to skip touch



Shear Pins

- Protect the pellet mill motor
- Check that shear pin groove is in center
- Bushings – check for cracks when replacing shear pins
  - Cracked bushing will result in shear pin fatigue/failure

Troubleshooting

- Avoid metal to metal contact
- Minimize tramp metal – punch out regularly
- Uniform feeding – deflector, wiper adjustment
- New rolls with new die when possible
- Preventive maintenance (PM) – greasing following PM program

Maintenance

- **Daily**
  - Clean magnet, check roller setting, lubricate rolls every 2-4 hours, check die for tramp metal, check gear box oil level
- **Weekly**
  - Check deflectors and wipers, grease feeder bearings, inspect die face wear
- **Monthly**
  - Check all chain and belt drives for wear, tension, lubrication, check oil level in all gearboxes

Conclusions

- Pelleting is an expensive process, but improvements in…
  - Feed conversion
  - Nutrient digestibility
- To maintain a good balance between pellet quality and poultry performance, it is essential to understand the role that each component of the pelleting system plays in the overall quality of finished products

Thank You!

Wilmer Javier Pacheco, MSc., PhD.
Extension Specialist and Assistant Professor
Auburn University
wjp0010@auburn.edu