

PETFOOD FORUM EUROPE

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Nuremberg, Germany

INSIGHTS INTO EUROPEAN PET FOOD TRENDS AND INNOVATION



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Co-located with

Interzoo 2024

Breakthrough thermal energy extrusion technology for pet food



Ed de Souza
Extrusion Systems Process Director
Wenger Mfg, Inc.

15 Commerce Drive
Sabetha, Kansas 66534, US
M: +55 19 98178 8844



Key Topics:

- The cooking extruder and components;
- defining extrusion cooking energies for producing direct expanded pet foods;
- traditional extrusion process & technologies;
- evolution of processing pet foods;
- advanced cooking extrusion (thermal)TM;
- advanced extrusion systems studies;
- enhanced extrusion systems meat capabilities;
- road map to low SME/thermal cook;
- conclusion



**High Meat Ultra Premium Dog Food 100-200%
meat added**



The Cooking Extruder

A continuous pressure cooker apparatus, by which moistened, expansile, starchy, and/or proteinaceous materials are plasticized and cooked by a combination of moisture, pressure, temperature, and mechanical shear.

Noticed Moistened. To cook starchy carbohydrates, we need:

- ❖ Moisture
- ❖ Time
- ❖ Temperature

Feeding System & preconditioner

Independent variables:

- Dry Recipe (formula) Feed rate)
- Water Injected into preconditioner
- Steam Injected into preconditioner
- Preconditioner Mixing Intensity
- Other additives

Independent variables:

- Mixing Intensity
- Retention Time in preconditioner
- Temperature of the preconditioned formula
- Mixing Quality = absence of clumps



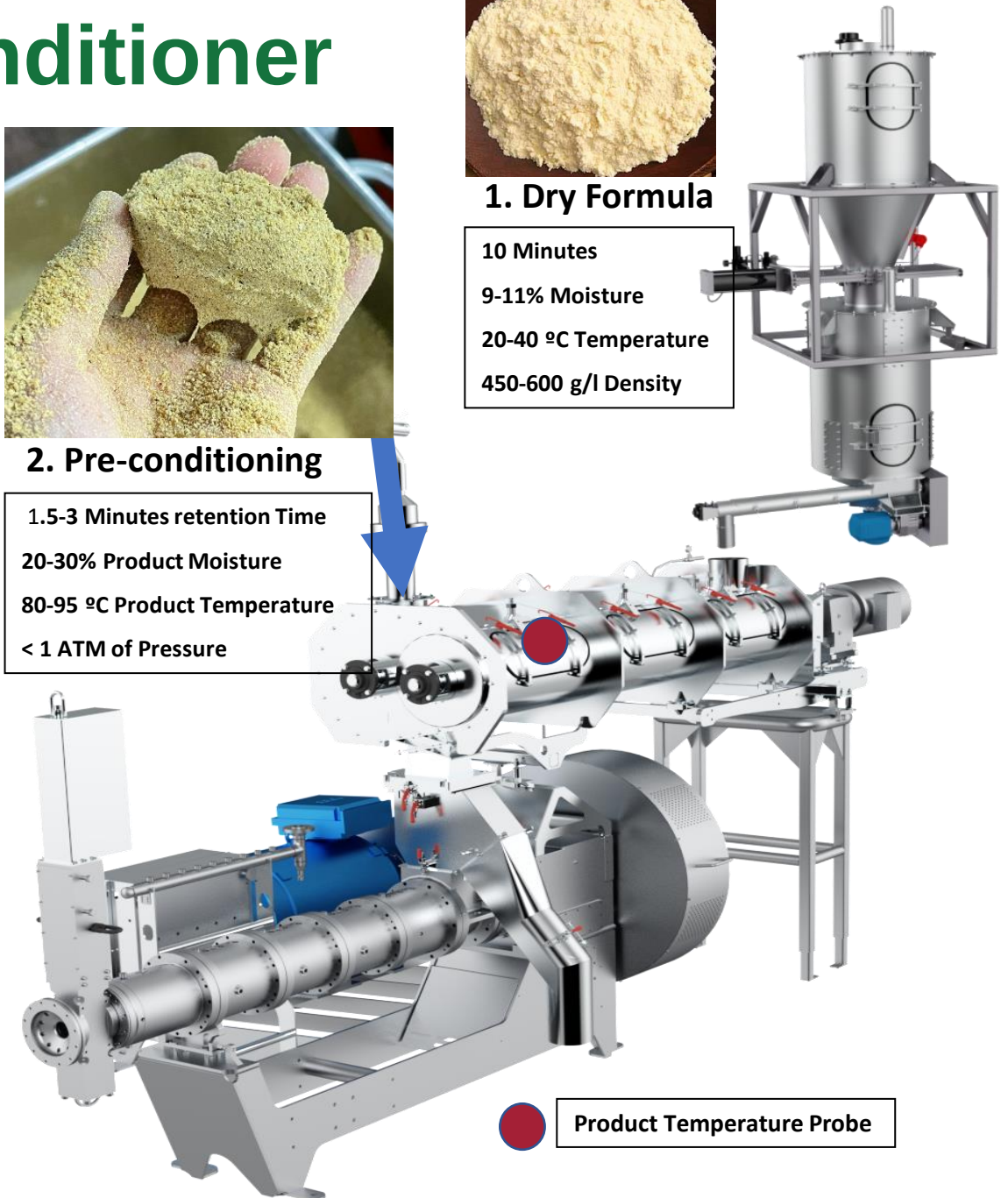
2. Pre-conditioning

1.5-3 Minutes retention Time
20-30% Product Moisture
80-95 °C Product Temperature
< 1 ATM of Pressure



1. Dry Formula

10 Minutes
9-11% Moisture
20-40 °C Temperature
450-600 g/l Density



Extruder Barrel, formatting and cutting

Independent variables:

- Mass Flow into extruder barrel
- Water Injected into extruder barrel
- Steam Injected into extruder barrel
- Extruder screw & barrel configurations
- Extruder speed
- Flow control valve

Extruder Barrel
15-30 Seconds RT
22-30% Moisture
120-135 °C Temperature
20-40 ATM de Pressure
8 – 30 kW-h/ton SME

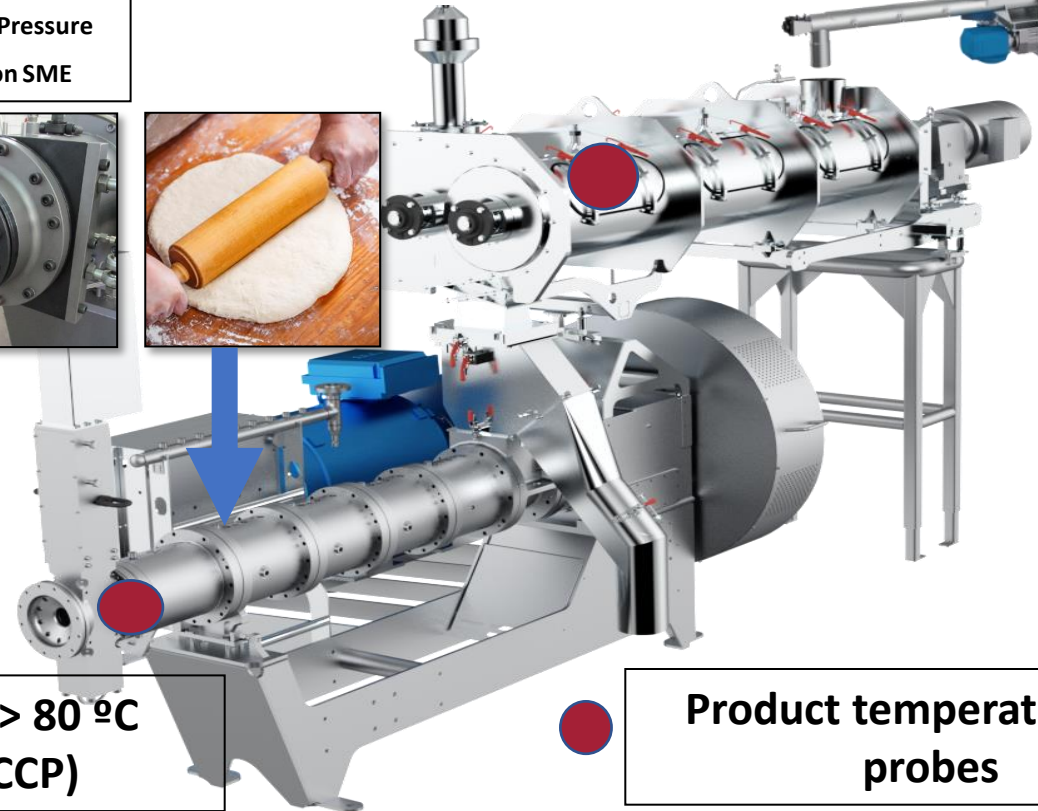


Independent variables:

- Retention time in extruder
- REAL product temperature
- Cone head pressure
- **SME** via Extruder barrel input

Critical Control Point > 80 °C
Temperature (CCP)

Product temperature
probes



Sources of Energy for Cooking Extruded Pet Foods

- An extrusion cooking apparatus known simply as the extruder, depends on **TWO** sources of energy for fully cooking Pet Foods:
 - ✓ **Specific Thermal Energy (STE)**
 - ✓ **Specific Mechanical Energy (STE)**

Defining Specific Mechanical Energy

- Mechanical shear - expressed as **SME** (**S**pecific **M**echanical **E**nergy), is the electrical energy used up by the main drive motor to rotate the extruder shaft.
- The shaft, rotates a stack of screws and locks within the barrel cavity, typically lined by spiral or smooth sleeves, creating shear force on the extrudate, as the extrudate moves pass these elements. Shear forces generate mechanical energy, transferred to the extrudate.
- Per unit produced, mechanical energy becomes **Specific Mechanical Energy (SME)**, and it is measured in kilowatt per ton in one hour time (**kW-h/ton**).

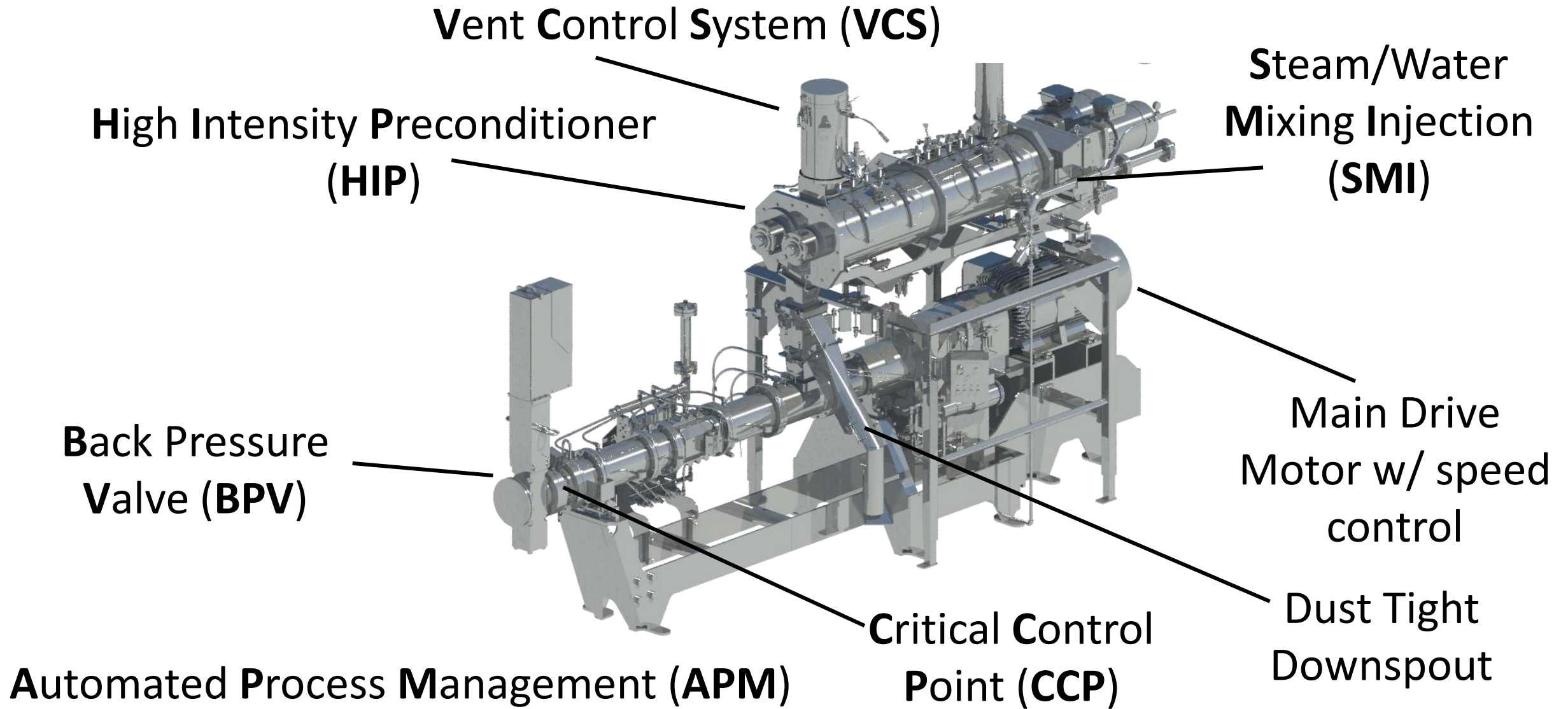
Defining Specific Thermal Energy

- Thermal Energy by unit produced, expressed as **Specific Thermal Energy (STE)**, is the energy from all ingredients imputed to the extrusion process.
- The majority of **STE** is supplied by the steam addition to the extrudate in the pre-conditioner stage and or injected at the extruder barrel.
- Typically Measured in kilocalorie per kilogram processed (**Kcal/kg**). Also measured or converted to **kW-h/ton** for direct comparison to **SME**.

Traditional Process & Technology

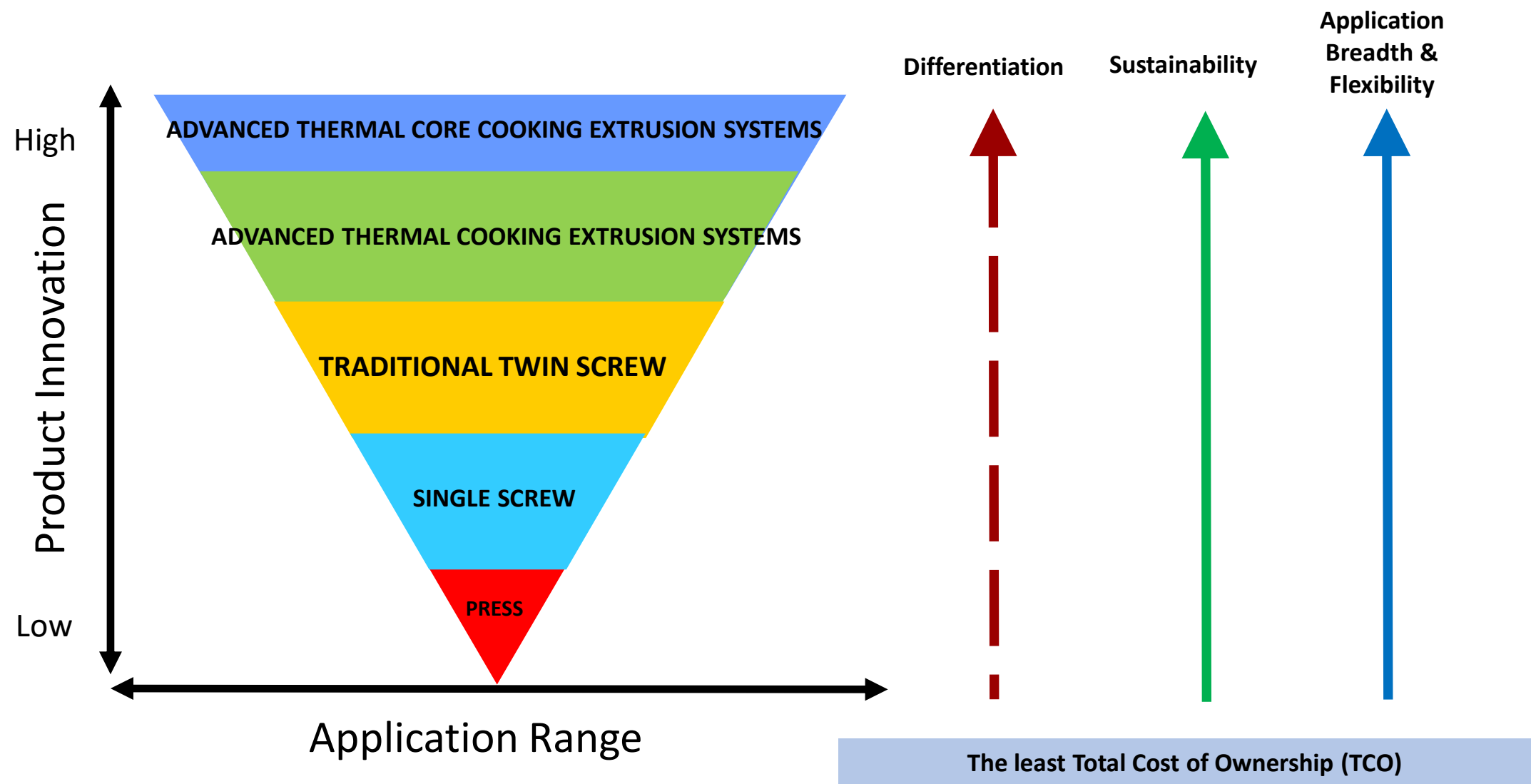
- Product specific extrusion lines – kibble, treat, specialty products
- Typically, high shear (high SME) extrusion used to achieve desired cook and product characteristics required
 - SME greater than 20 kW-H/ton and up to 50 kW-H/ton
 - Traditional equipment limits high STE inputs
- Limited flexibility to proliferate products and to expand product formats
 - Increased downtime
 - Reduced throughput
 - Recipe or ingredient restrictions

Advanced Extrusion Cooking Technologies for Pet Foods ¹¹



Evolution of Pet Food Processing Technologies

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Advanced Technologies Process Capability

Category	Technologies	Meat Inclusion (% of Dry Feed Rate)
I	Single Screw Extrusion	Up to 40%
II	Twin Screw Extrusion	Up to 70%
III	Thermal Twin Extrusion	Up to 110%
IV	Thermal Screw Processing	More than 200%



% DFR	Label	Category
40%	29%	I
70%	41%	II
110%	52%	III
200%	67%	IV

Chicken Meat vs. Chicken Meal in Cat Foods

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- 1) Chicken meat at 0, 40, 80, and 120% replaced chicken meal in a balanced diet
- 2) Equivalent to 0, 13.3, 26.7, and 40.0% meal in the diet

Ingredient	Total Tract Apparent Digestibility of Crude Protein	Apparent Metabolizable Energy
Chicken Meal	73.90%	3,500 kcal/kg
Chicken Meat	91.27%	5,432 kcal/kg



Highly Density and digestible protein

*UNESP-WENGER RESEARCH led by:

Priscilla Martins Ribeiro – PHD Student under Aulus Advisory.

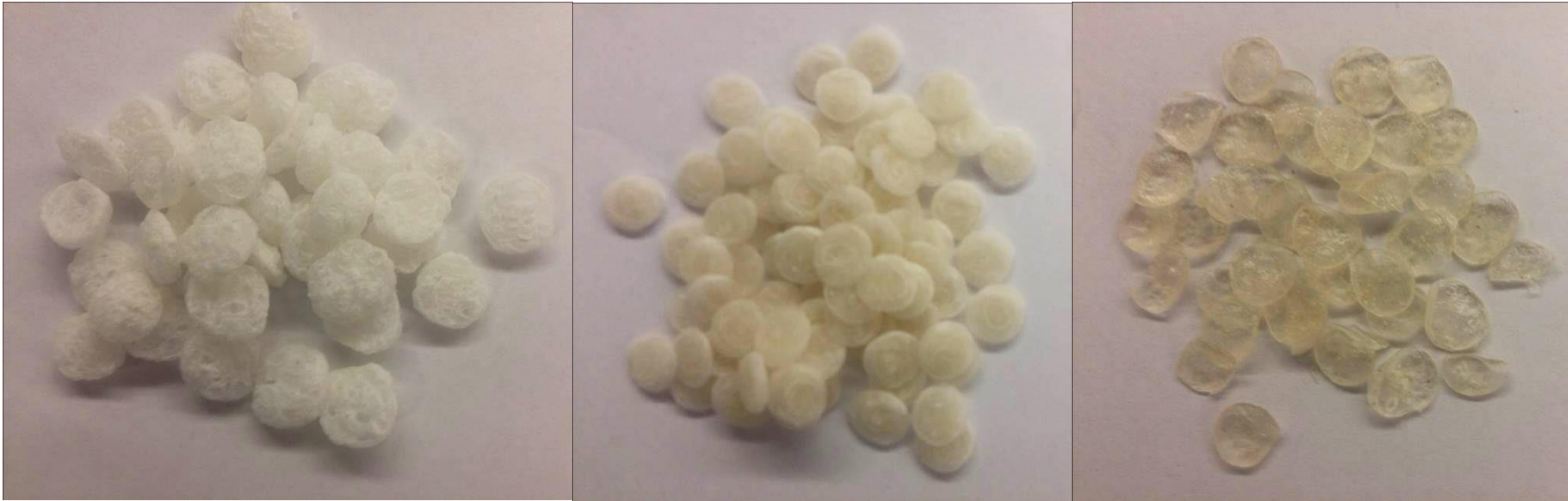
Contributions on the Scientific Research by:

Galen Rokey – Former Pet Food Extrusion Processing Director at Wenger Mfg, Inc.

Aulus Carciofi – Professor at University of the State of Sao Paulo – UNESP, researcher, cat and dog nutritionist.

Fabiano Sa, Thaila Putarov, Fernanda S. Mendonça – Nutritionists for Dog & Cat.

Mechanical VS. Thermal Energy



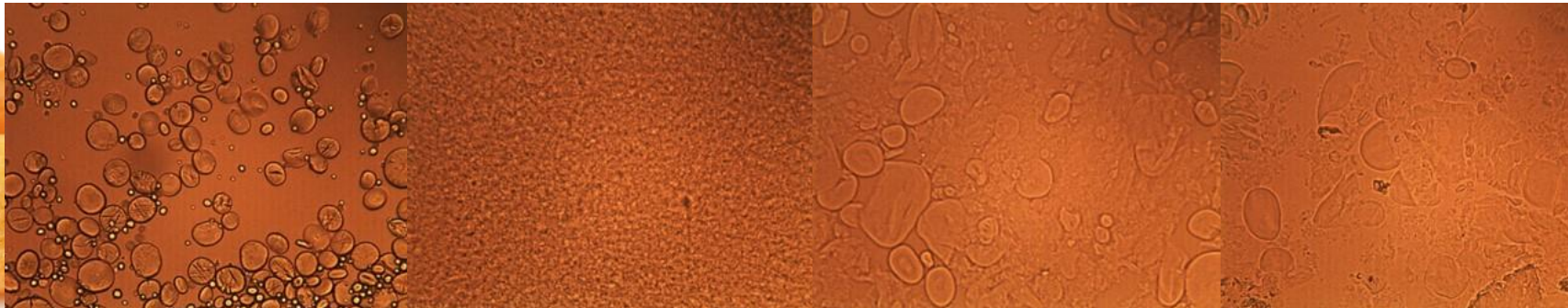
Which has the highest “COOK”?

Mechanical VS. Thermal Energy

SAMPLE	Mechanical Energy (kW-h/m-ton)	Thermal Energy (kJ/kg)	TE / ME	Process Moisture (%)	COOK (%)	Water Solubility (%)
Sample A	122	180	0.3	26	95.7	20.3
Sample B	11	400	9.5	35	96.5	12.6
Sample C	11	370	8.2	38	96.3	4.6



PUFFED CORN
BALLS



PRE-COOKED
PASTA

Excessive Specific Mechanical Energy (SME)

Excessive mechanical energy, thus scorching extruder barrel, may generate issues, such as:

Wedged, off specs products,

premature tool wear:

Rough Surface & fragile products:

Sources of Excessive SME: Aggressive
setups, premature & excessive Tool Wear:



Defective products, fines, low throughput, unscheduled downtime, shorter equipment lifespan, higher processing cost, are common issues of excessive SME.

Reducing Specific Mechanical Energy (SME) Levels

Experiment on Pet Food with Advanced Extrusion Technology (Thermal)

Comparison between 3 levels of SME for processing Cats & Dogs Diets

8
20
30 } kW-h/ton for cooking the experiment pet foods

- ✓ Available Energy Digestibility of nutrients.
- ✓ Starch gelatinization.
- ✓ Kibble Structure (crunchiness)
- ✓ **Palatability.**
- ✓ Protein damage.

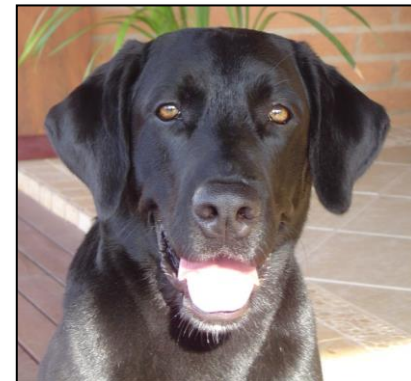


Specific Mechanical Energy (SME) Levels

Study Conclusion:

- 1) No significative differences in relation to the intrinsic qualities of the kibbles, such as digestibility, force of bite (rupture), fecal quality (similar levels of cook and density).
- 2) Palatability results:
Adult Dog food: $20 > 8 > 30$ SME
Adult Cat Foods: $8 > 20 > 30$ SME

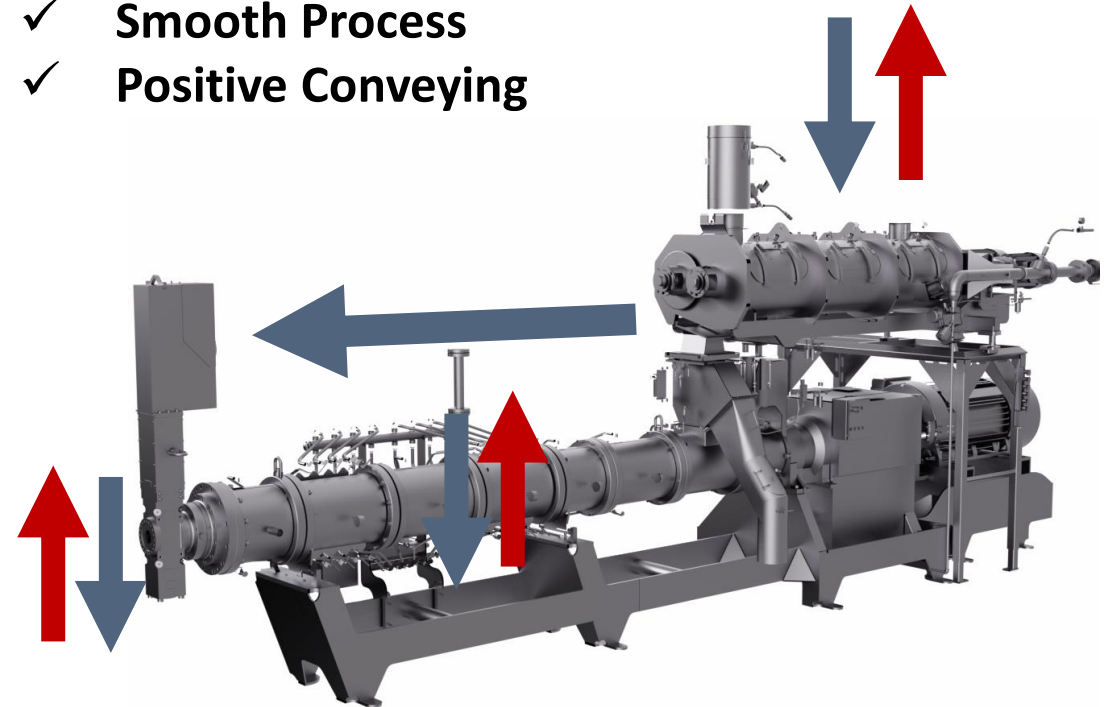
<http://www.athena.biblioteca.unesp.br/exlibris/bd/cathedra/12-08-2015/000835580.pdf>



Choosing Thermal energy to lower SME Levels

The ability to promote:

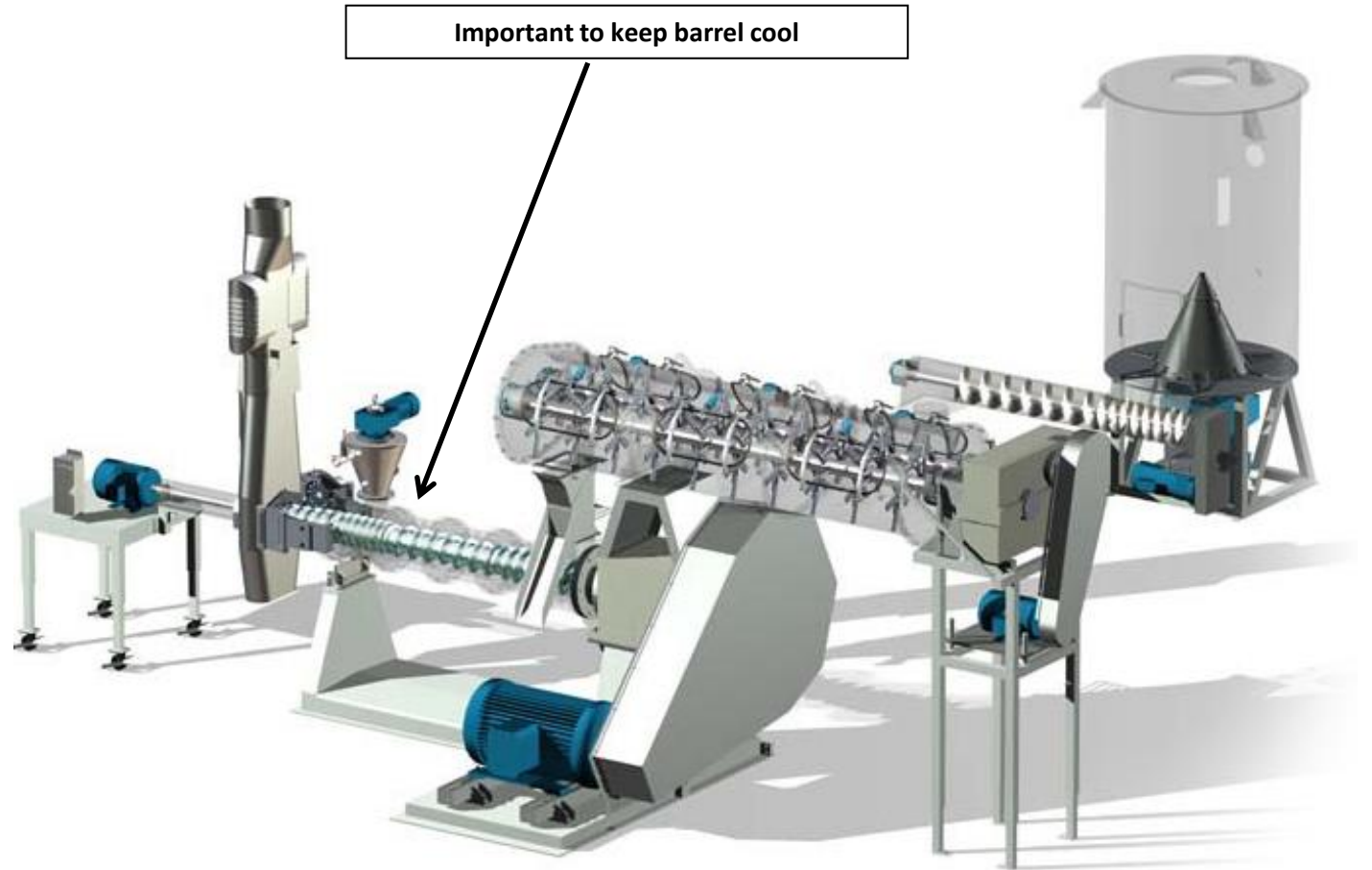
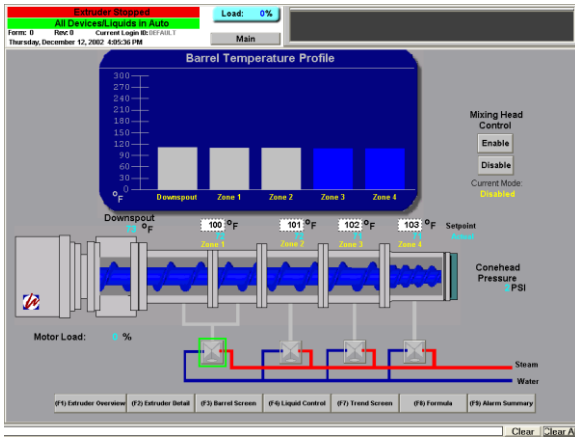
- ✓ Precise Control
- ✓ Smooth Process
- ✓ Positive Conveying



- ✓ Uniform Process
- ✓ STE sourcing and precise dial-in
- ✓ Consistent and Uniform Density
- ✓ Perfect and excellent appearance Products



For lower SME is essential cooling water to process

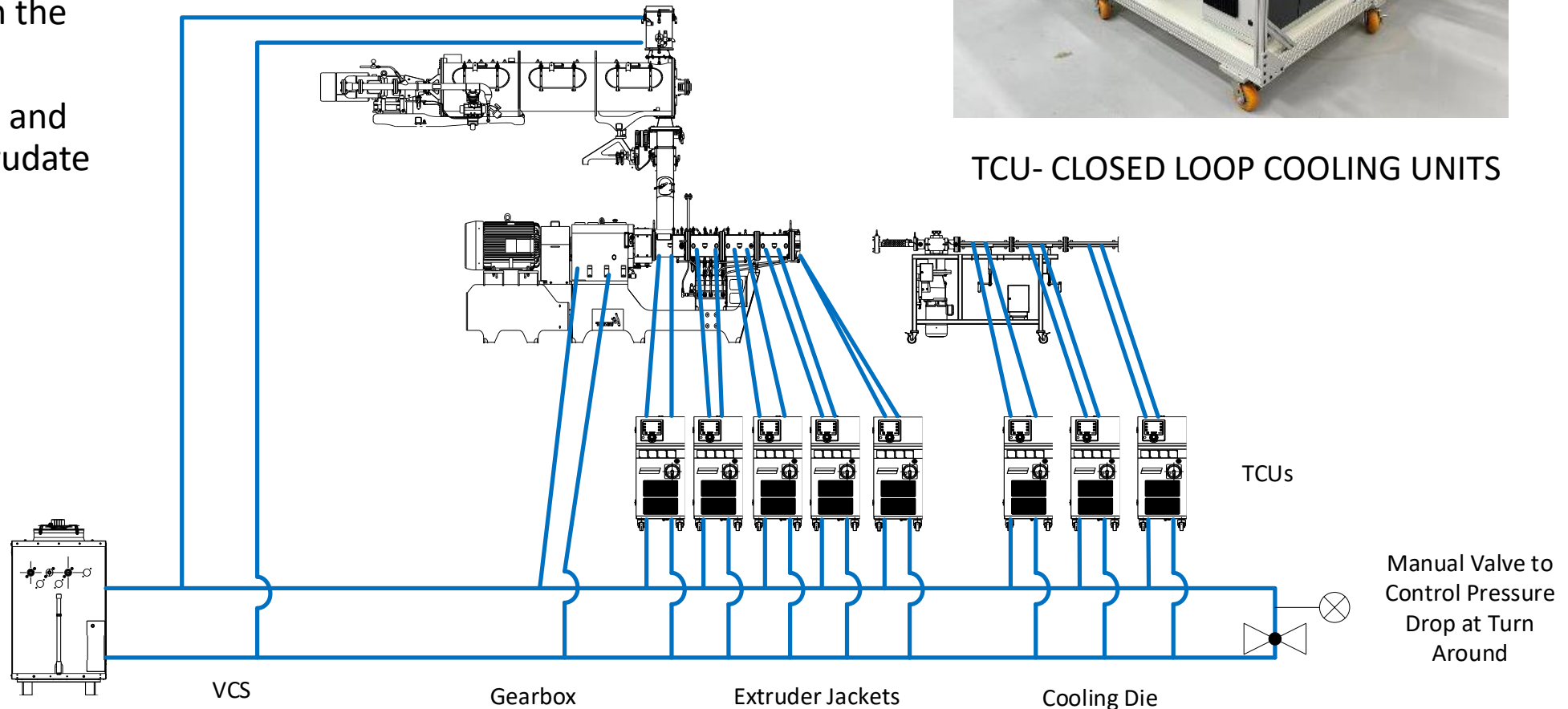


Smart Barrel Temperature Control

- Chiller is the backbone of the system (pump sized for needed ΔP and TCU requirements)
- TCUs for precise temperature control of each zone on the extruder barrel (heads)
- Precision on Conveying and viscosity control of extrudate



TCU- CLOSED LOOP COOLING UNITS



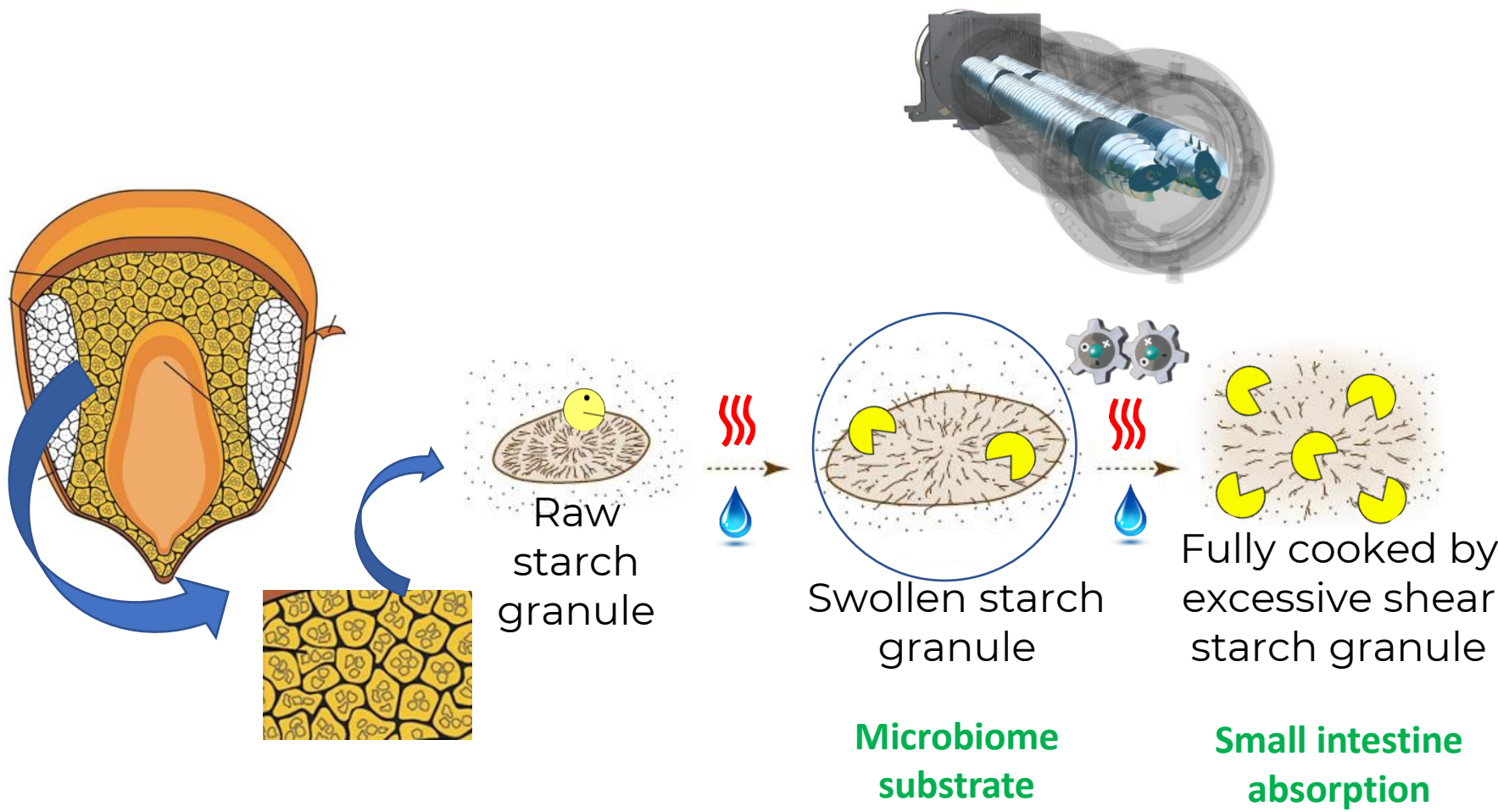
Road Map to Enhancing Gut Flora and Gut Health

A low to medium shear extruded kibble with greater resistant starch type II leads to improvements in the gut health of dogs

- Isabella Corsato Alvarenga, PhD DVM
- Post-doc at Colorado State University, 2024
- PhD, Kansas State University, 2021
- M.S., Kansas State University, 2016
- DVM, University of São Paulo, 2012



Extrusion parameters direct impacts how starches cook



Feed Rate:	1000	kg/hr	1006	kg/hr
Dry Feed Bulk Density:	445	kg/m³		
Aux Dry Feeder Rate:	0.00	%	0	0 kg/hr
Aux Dry Feeder Bulk Density:	0	kg/m³		
HIP Mixing Intensity:	80.0	%	HIP#1 261 RPM	HIP#2 698 RPM
Cylinder Steam:	10.00	%		99 kg/hr
Cylinder Water:	21.00	%		210 kg/hr
Liquid 1 (HIP Meat):	0.00	%		0 kg/hr
Liquid 2 Ext Meat):	0.00	%		0 kg/hr

Extruder Steam:	0.00	%		0 kg/hr
Extruder Water:	8.00	%		80 kg/hr
Knife Speed:	550.0	RPM	550	RPM
Extruder Speed:	225.0	RPM	224	RPM

Cylinder Condensate Temp:	99	°C	24	°C
Downspout Temp:			78	°C
Zone 1 Temp:	35.0	°C	69	°C
Zone 2 Temp:	80.0	°C	79	°C
Zone 3 Temp:	80.0	°C	79	°C
Zone 4 Temp:	75.0	°C	74	°C
Zone 5 Temp:	0.0	°C	999	°C

Extrudate Temp:	999	°C
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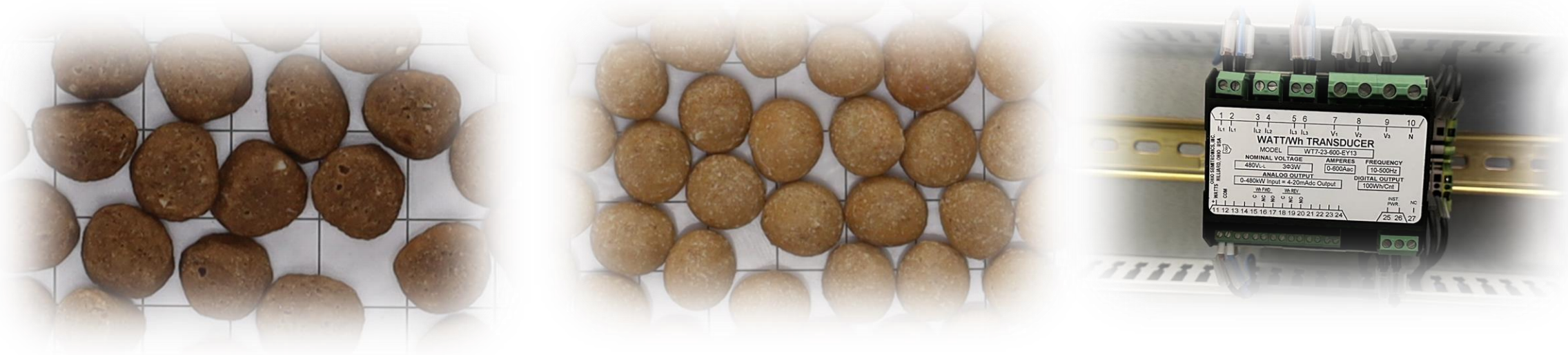
Liquid 1 Temp:	24	°C
Liquid 2 Temp:	54	°C
Head Pressure:	21	bar
Feeder Screw Speed:	70	RPM
Live Bin Contents:	63	kgs
SME:	16	kWhr/ton
Motor Load:	78	%
Motor kW:	16	kW

System Steam Pressure:	OK	
System Water Pressure:	OK	
System Air Pressure:	OK	
Dry Feeder Screw Speed:	0	RPM
Dry Live Bin Contents:	6	kgs

Road Map to Enhancing Thermal Energy Cooking

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- Advanced cooking extrusion (thermal)TM;
- essential process control tools;
- process training to all involved in production;
- enhanced dashboard of process conditions;
- Power meter for accurate SME;



A low shear extruded kibble with greater resistant starch

Conclusion

There are HEALTH Benefits of Thermal Cooking™ Extrusion Process

1. Mostly thermal (steam Cooked)
2. Preservation of Starch Granules
3. May increase Resistant Starch)
4. Provides Gut flora substrate
5. Increased palatability
6. Increase digestibility – by thermally cooking raw meats.

To be explored...

1. preservation of additives...
2. Higher capacities possible...
4. Super foods: Fruits & Vegetables Bits...
4. & more...



Conclusion



To cook delicious and nutritious pet foods with smart use of Energy, through technology and process know-how

