Full Fat Processing

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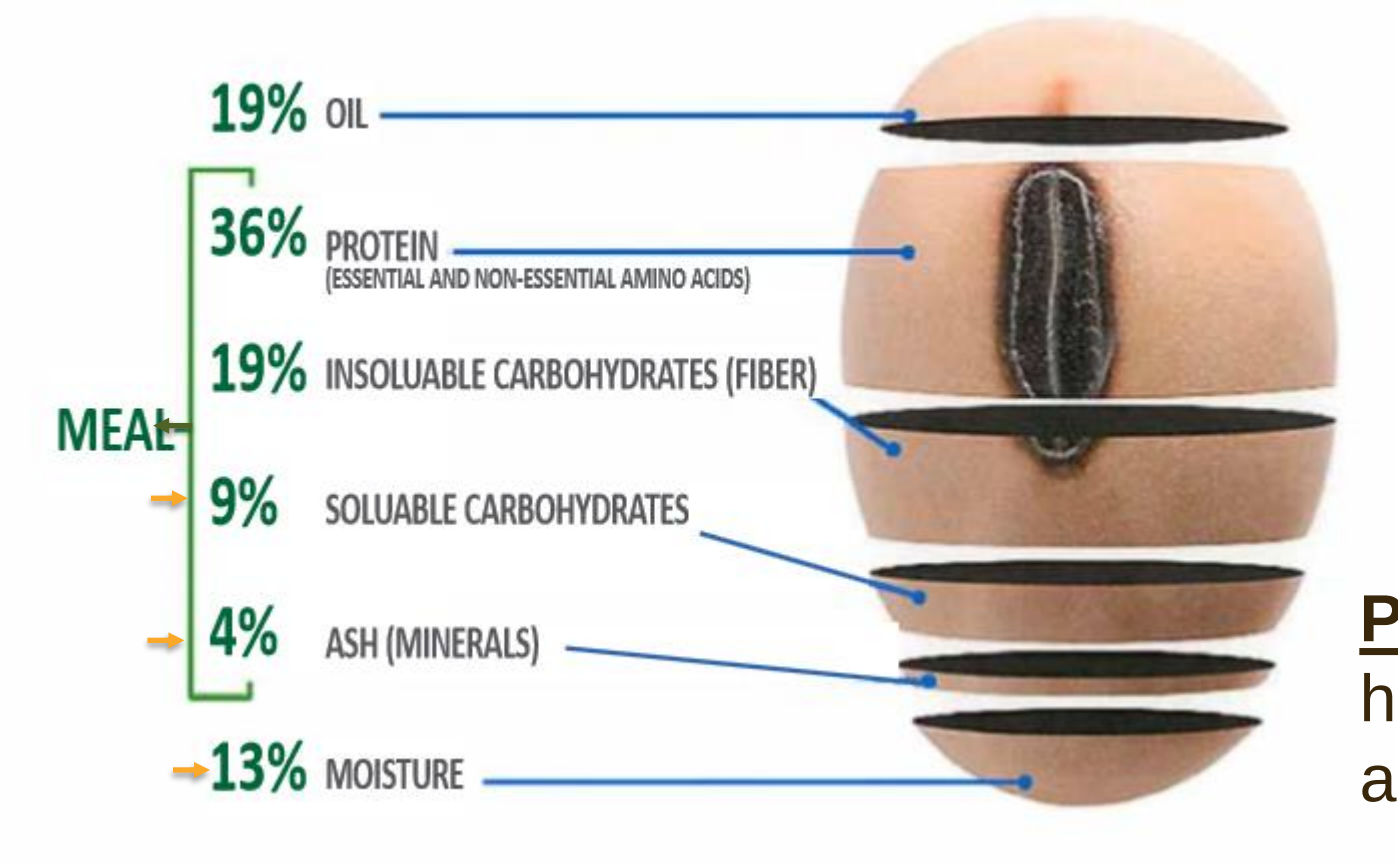
Learning Objectives

- Learn about the differences between soybean and its co-products.
- Learn about the different full fat processes.
- Learn about the basic of oil mechanical press.

Soybean Composition

- **Soybeans**: Source of proteins and fat



Problem: Naturally, soybeans have anti nutritional factors (ANF) and allergens

Types of Soy Processing Co-Products

- **Soybean Meal**:
  - Coproduct of the oil extraction processing using solvents (hexane).
  - Number protein source for animal feed around the world.
  - High protein content (44% with hulls or 48% without hulls).
  - Low oil contents (<1%)
  - El 75% of it is used in poultry and swine diets (Stein, 2013).

Source: Campabadal, 2016 y van Edys, 2013.

Soybean Meal Composition

	Min/Max	With Hulls	Without Hulls
Moisture Content %	Max	12	12
Protein %	Min	44	47-49
Oil %	Min	0.5	0.5
Fiber %	Max	7	3.3-3.5
Anti-Compacting Agents%	Max	0.5	0.5

→ SBM produced from solvent extraction of oil

U.S. SBM specifications →

Total lysine	>2.85% (basis 88% dry matter)
Digestible lysine	Equal or >88% of total lysine
Ash	<7.5%
Acid insoluble ash (silica)	<1%
Protein solubility in 0.2% KOH	78-85%
Urease activity	0.000 – 0.100 pH unit rise
Trypsin inhibitors	1.75 – 2.50 mg/g
Bulk density	57 – 64 g/100cc
Screen analysis (mesh)	95% thru #10, 45% thru #20, 6% thru #80
Texture	Uniform, free flowing, no lumps, cakes, dust
Color	Light tan to light brown
Odor	Fresh, not musty, sour, ammonia, burned
Contaminants	No urea, ammonia, pesticides, grains, seeds, molds

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Source: van Edys, 2013 y www.nopa.org.

Soy Oil Meal (Full Fat Soybean Meal)

- Co-product obtained when soybeans are process and the oil is not extracted.
- Excellent source of protein – amino acids and energy.
- Used in countries were good fat or oil products are no easy to find and the cost benefit is better for soy oil meal.
- Use when the addition of fat is difficult in an animal feed diet.
- At the end its usage is a matter of costs:

  $SBM + $Fat > $FFSBM

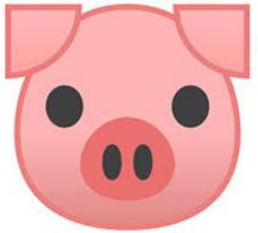
Composition Comparisons

Source: Johnson & Smith

	Soybean Meal Solvent		Dehulled-Solvent	Expeller	Soybeans Full-fat
Proximate Analyses					
Dry Matter	%	90	88	89	90
Crude Protein	%	44.0	47.8	42.0	38.0
Ether Extract	%	0.5	1.0	3.5	18.0
Crude Fiber	%	7.0	3.0	6.5	5.0
Ash	%	6.0	6.0	6.0	4.6
Ruminant Values					
Ruminant Dig. Protein	%	37.5	46.6	35.5	34.1
Ruminant TDN	%	78	79	78	85
Energy Values					
Poultry ME	Kcal/lb	1020	1125	1100	1520
	Kcal/lb	1405	1425	1360	1610
Amino acids					
Methionine	%	0.65	0.70	0.6	0.54
Cystine	%	0.67	0.71	0.62	0.55
Lysine	%	2.9	3.02	2.7	2.4
Tryptophan	%	0.60	0.70	0.58	0.52
Threonine	%	1.7	2.0	1.7	1.69
Isoluecine	%	2.5	2.6	2.8	2.18
Histidine	%	1.1	1.3	1.1	1.01
Valine	%	2.4	2.7	2.2	2.02
Leucine	%	3.4	3.8	3.8	2.8
Arginine	%	3.4	3.6	3.2	2.8
Phenylalanine	%	2.2	2.7	2.1	2.1

Anti-Nutritional Factors (ANF) on Soybeans

- **Trypsin Inhibitors (Proteases)**:
  - Reduce protein digestibility
  - Reduce growth (make susceptible to diseases)
- Lectin:
  - Damage to intestine walls– effect on nutrient absorption.
- Glycinine:
  - Gastrointestinal problems– allergens.
- Urease:
  - Increase available nitrogen (indicator of level of processing)



Composition of ANF in Soybeans

ANF	Units	Soybeans	SBM
Trypsin Inhibitor	mg/g	25-50	1.60-5.00
Glycine	mg/g	150-200	20-70
Lecithin	mg/g	2.100-3.500	20-600

Important:

- Reduction of ANF with heat treatment process called denaturailization since the majority of them are proteins.
- In some process, steam is used.

Why do we process soybeans?

- Heat Treatment
  - It needs to absorb 1650 Joules of energy per gran to inactivate 95% of trypsin inhibitors (Rakis, 1986).
  - If it is too much, proteins will be denatured and can oxidize the oil content.
- Benefits:
  - Reduction of ANF
  - Protein becomes more digestible
  - Oil of better quality
  - More appealing to animals
    - Flavors and aromas
  - More stable
    - Destruction of lipoxidases

Soybean Processing

- The different technologies will use:
  - Temperature
  - Moisture
  - Pressure
  - Surface exposure
  - Particle size reduction
  - Time
  - Different sources of energy

Soybean Processing

- To know which process is the best:
  - Physical and chemical conditions in the process
  - Animal that will be feeding:
    - Extrusion – monogastrics
    - Roasting - ruminants
  - Cost of equipment and source of energy

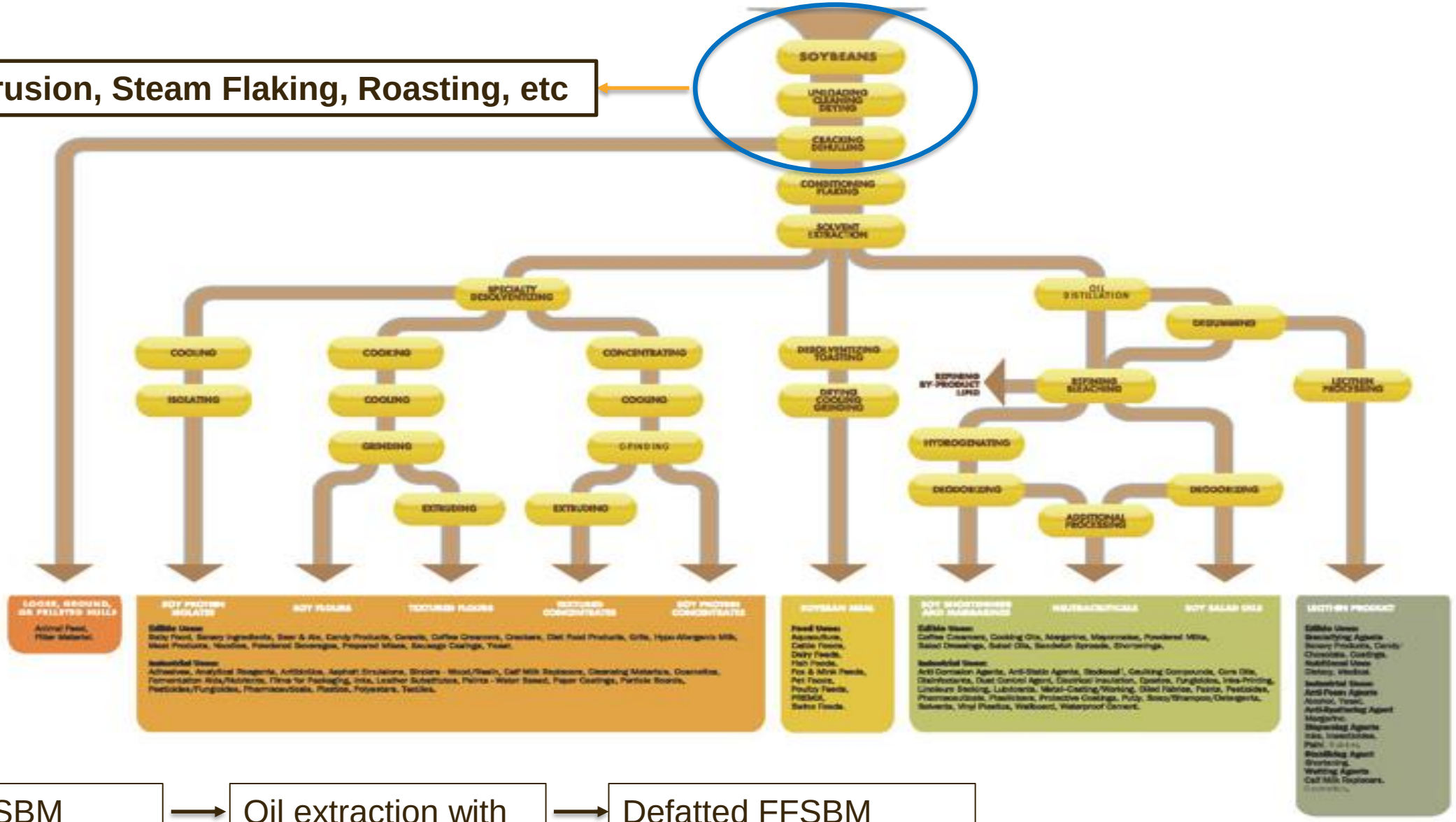
Processes to Denaturalized ANF in Oilseeds

- Cooking (autoclave)
- Micronizing
- Microwave
- Jet-sploding/Expansion
- Steam Flaking
- Roasting
- Extrusion
- Expanders (expansion)

- Longer processing (brown) maximum temperatures of 105 °C for 30 to 120 minutes. Steam Flaking can take longer.
- Short processing (black) temperatures between 130 to 180 ° C for 10 a 180 seconds.

Oil Extraction Process Using Solvents and Mechanically

Extrusion, Steam Flaking, Roasting, etc



FFSBM → Oil extraction with mechanical press → Defatted FFSBM

Source: Diagram from NOPA

Cooking

- **Cooking:** Soybeans are mixed with water and cook to boiling point for 30 to 120 minutes.

- Needs further drying and processing

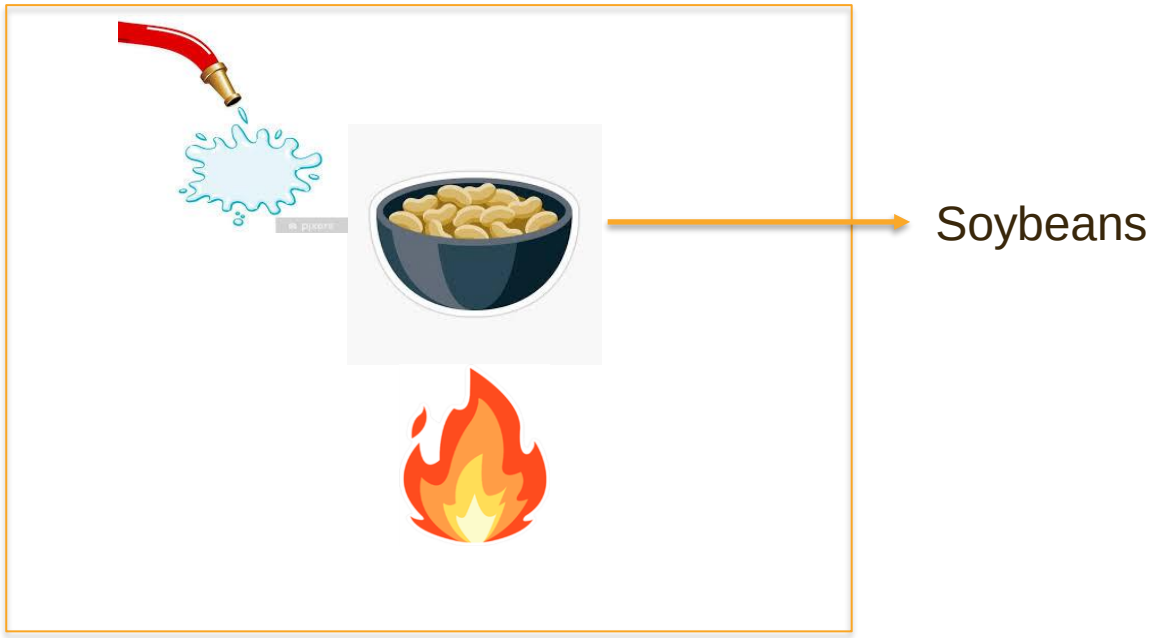
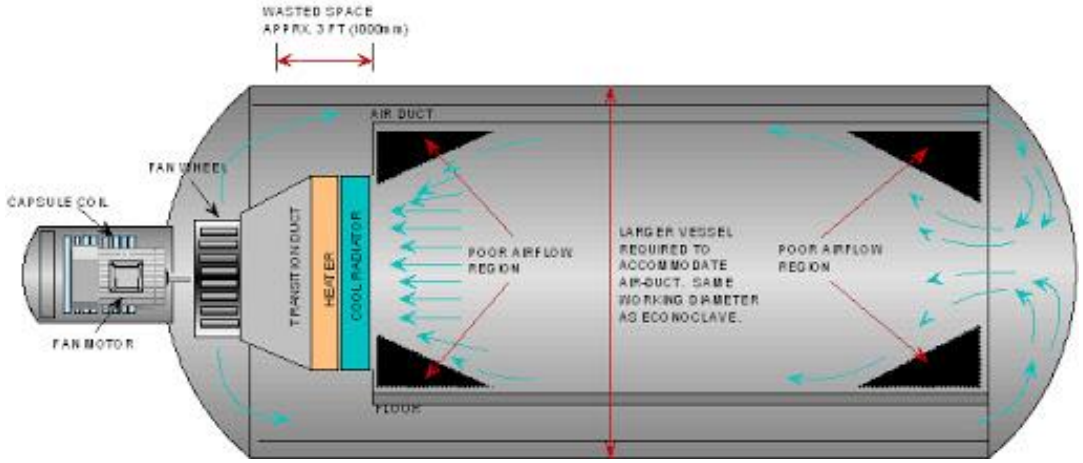


Diagram of cooking

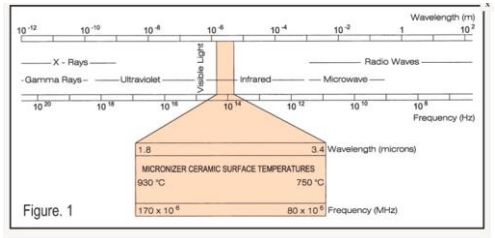
Cooking (Autoclave)

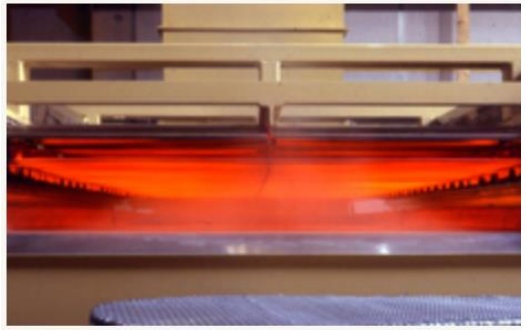
- **Autoclave:** Sterilization process that increases temperature gradually to 121°C then steam pressure to at least 15 psi = 1 bar).
  - **Needs further drying and processing**

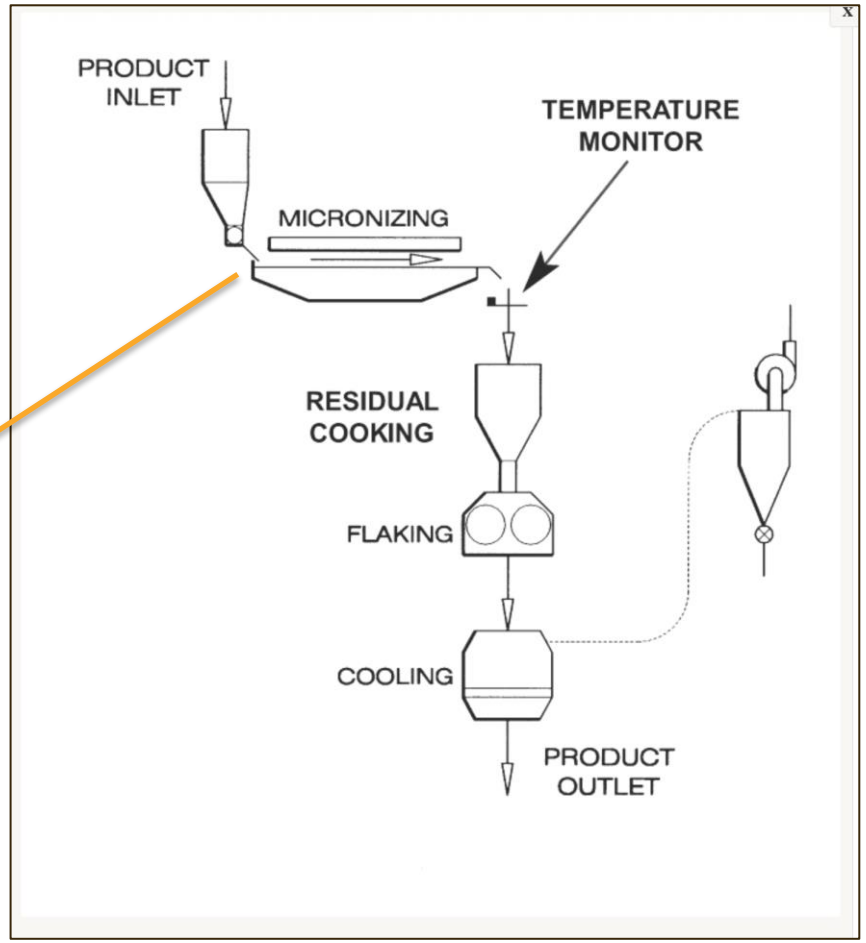


Micronizing

- Ceramic plates heated to 100°C in 35 seconds.
- Plates emit infrared radiation between 1.8 to 3.4 microns (higher tan microwaves).
- Soybeans absorbed heat waves increasing temperature to180°- 220°C).
- Internal molecular vibration breaks the lipase cell walls degrading the ANF
- Used in cocoa processing

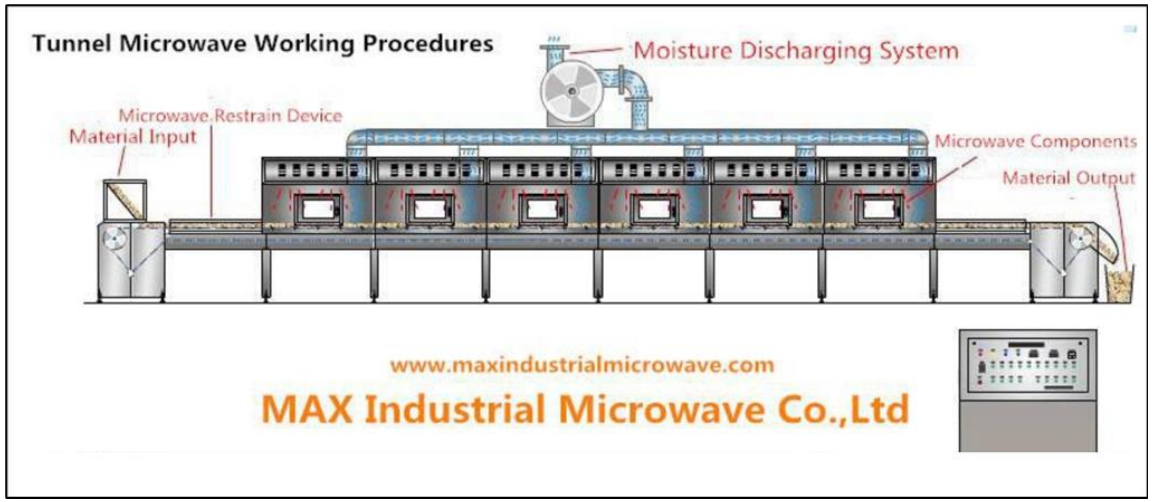






Microwaves

- Uses infrared radiation produced by heat.
- Temperatures up to 150 °C in short times (60 s).
- Microwaves (1-2 cm) in tunnel will generate vibration of the soybean molecules.
- The generated heat will denature the trypsin inhibitors.

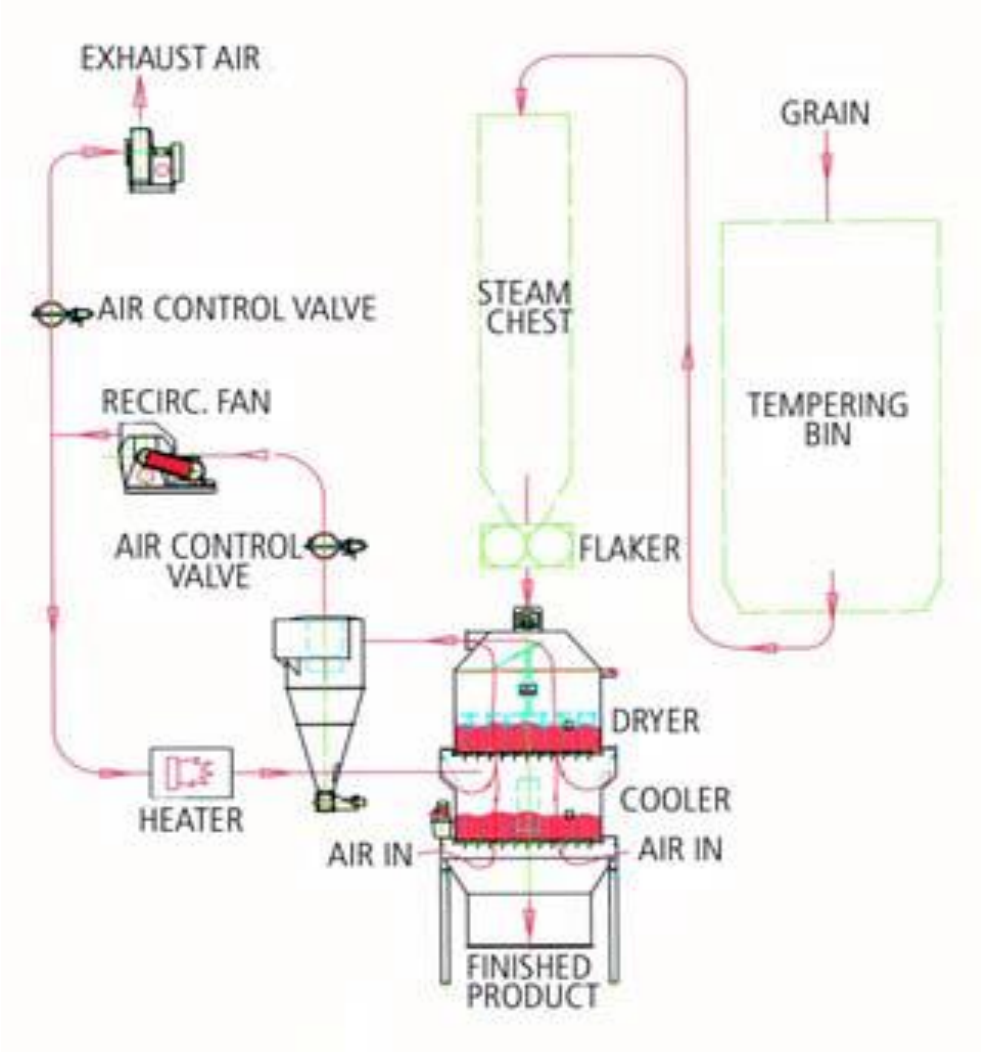


Jet Sploding (Injecting Hot Air)

- Pre-heat air to 140°C to 315°C to avoid contact of heat source with soybeans.
- Process like popcorn cooking.
- Soybean molecules vibrate reaching 90 °C a 95 °C.
- Soybeans expand and explode, so oil can be extracted.
- Use for canola processing.

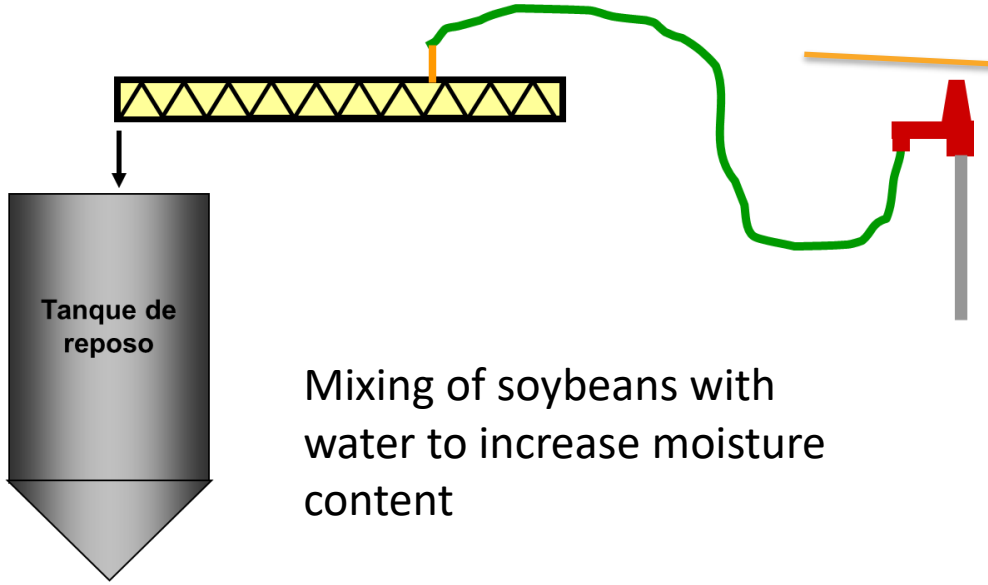
Steam Flaking

- Similar process as corn or sorghum steam flaking for cattle feed.
- Soybeans are mixed with water.
- Cook with steam to 60 psi (4 to 5 bar).
  - Flaker to increase surface area
  - Cooling of flake (dried).



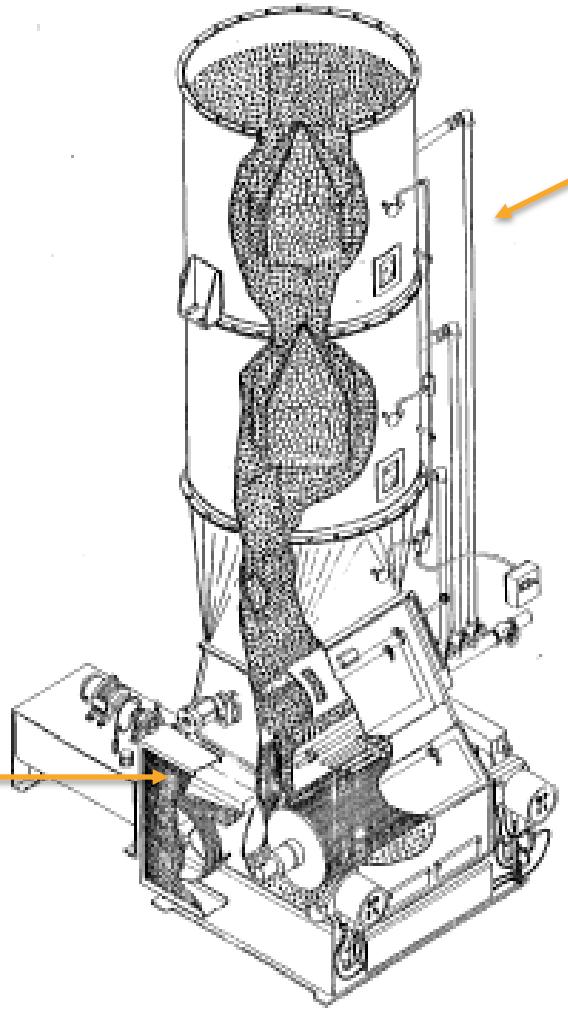
Source: Diagram from World Grain

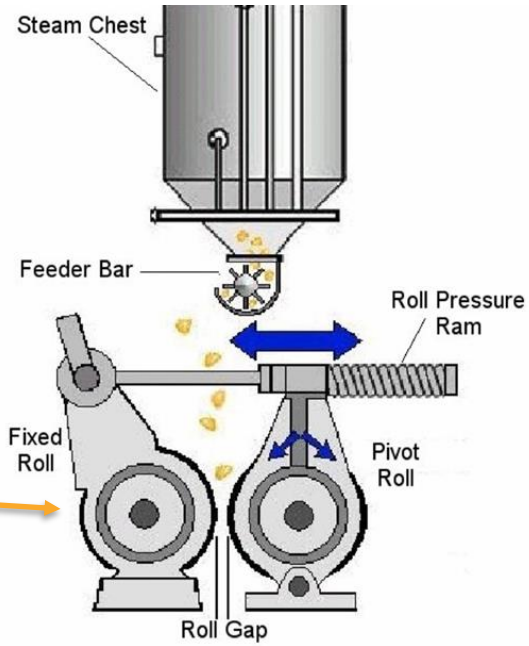
Flaking Process



Mixing of soybeans with water to increase moisture content

Steam at 95°C & 4 to 5 bar





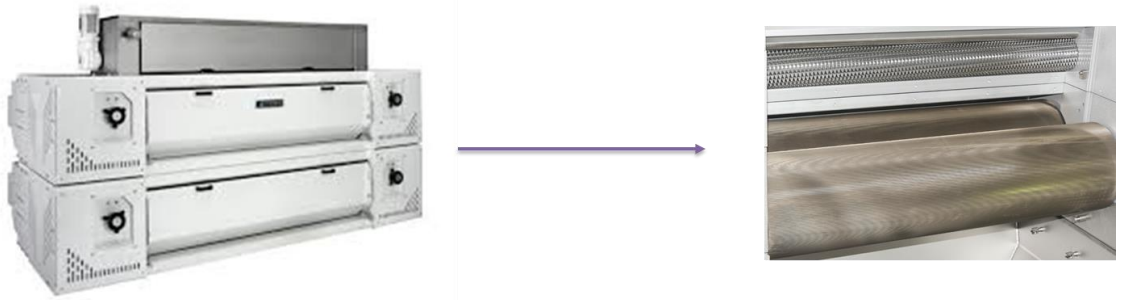
Source: Diagrams from KSU and CPM, photo from Ferrell-Ross

Roasting

- In batches or continuous process.
  - Soybeans lose up to 30% moisture content
  - Direct heat source to cook soybeans.
  - **Heat sources:** oven (heat by resistence), coal cofiring or direct heat flame, (temperatures between 100°C to 210°C).
  - Some processes uses steam

Roasting

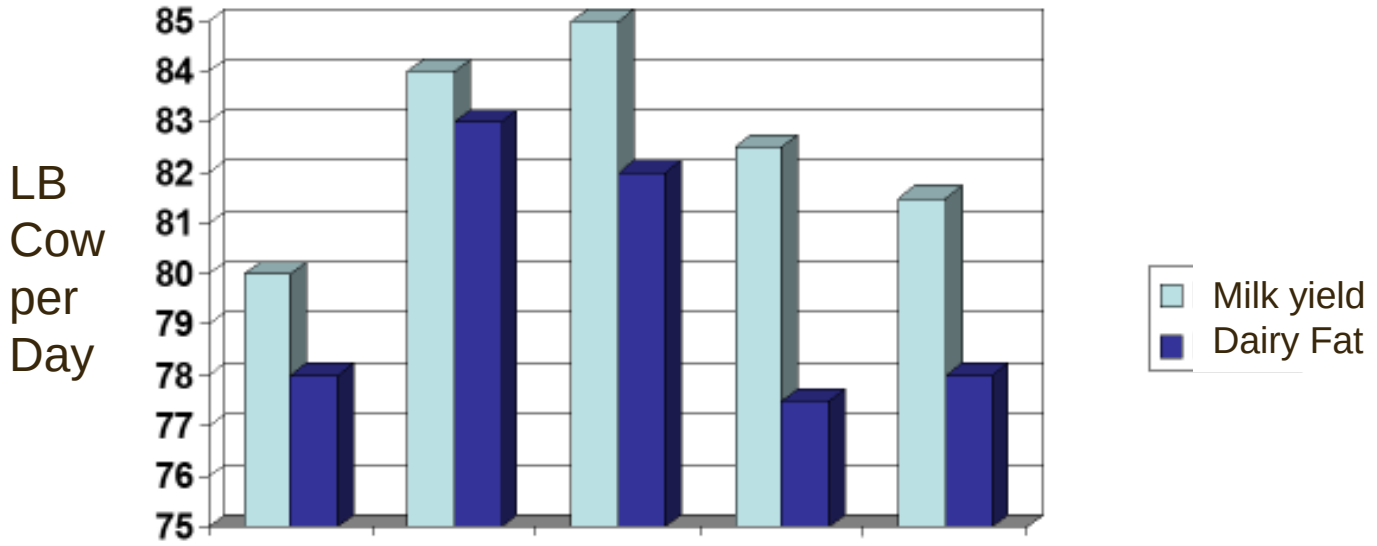
- Short times and don’t exceed temperatures of 110°C to 116°C.
- Optimal temperature for soybeans:
  - 110°C to 113°C for monogastrics.
  - 116°C for ruminants to increase the % of non-degradable protein in the rumen.
  - Destroys pathogens due to high temperatures.
  - Does not break the cell walls that hold the oil in soybeans.
    - To extract the oil, it must be ground or broken into smaller pieces.



Source: Thomason, 1987 and www.buhlergroup.com/content/

Usage of FFSBM in Dairy Feed

EFECTO DEL TAMAÑO DE PARTICULA DEL FRIJOL DE SOYA SOBRE LA PRODUCCION DE LECHE
Dhiman et al., 1997



R = Roasting NP = No processing WB = Whole soybeans

Roasting

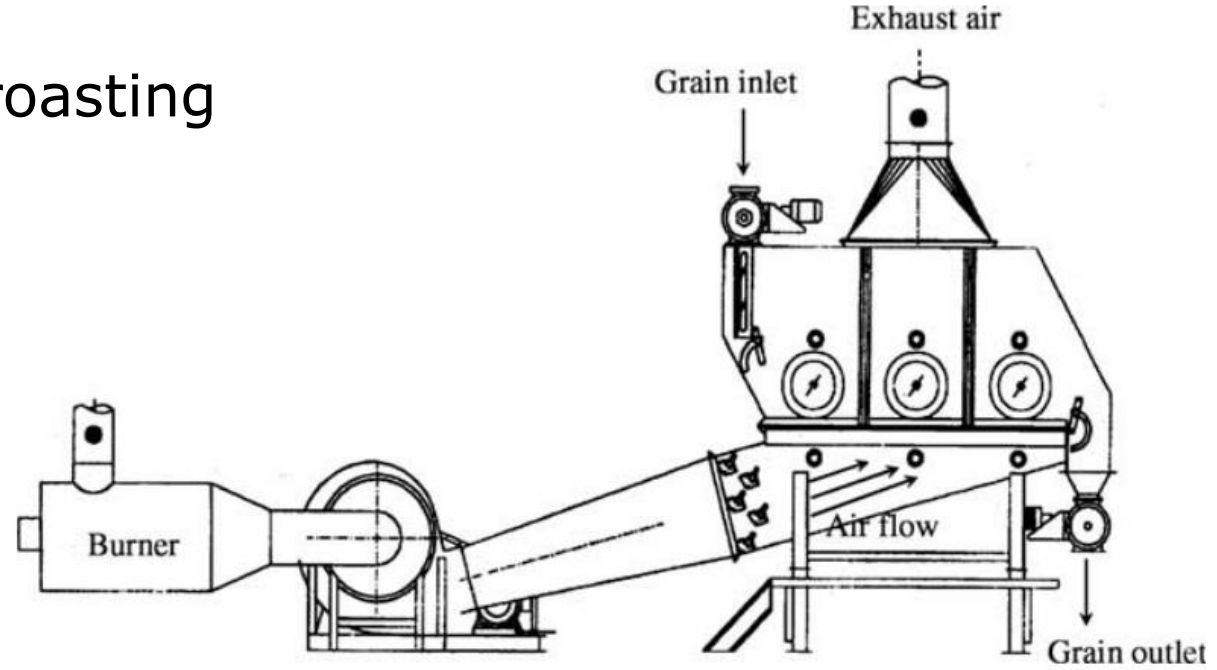
- Rotating drum: Rost-A-Matic & Agrotechnology

Capacity	**18-20t/hr**
Size	**250"x74"**
Voltage	**230/440v**
Amps	**50/30**
BTU's	**8,500,000**
Gas pressure	**10-15 psi**
Gas consumption	**4 gal/ton**
Shutdown	**High temperature**

Cooler to lower temperature

Roasting with Fluidized Bed

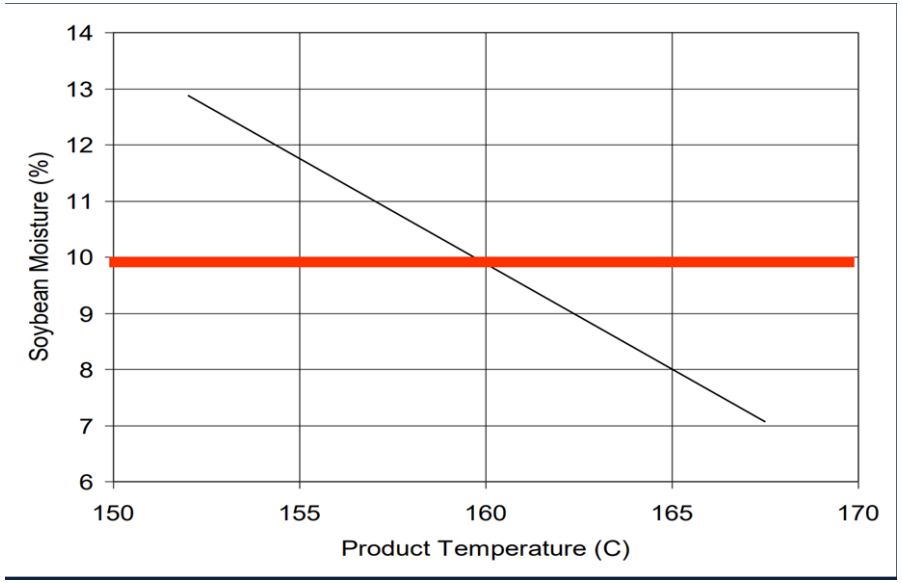
- Mix soybeans with air to make it floating to improve heat transfer and cooking.
- Max temperature of 150°C.
- Final temperature cooler than regular roasting
- Similar quality results as extrusion
- Might need water.
- Does not "toast" the soybeans.



Source: Wiriyaumpaiwong, 2004 y Monari, 1996

Extrusion

- Continuous process where the soybeans are cook by temperature, pressure, mechanical force.
- Mechanical and thermal energy to cook soybeans.
- Variables of process can be easily controlled.
- Temperatures between 150 to 160 °C (m.c. 9 to 11%).
- Dry or wet using steam.



www.insta-pro.com/en/equipment/extruders/

Low Protein Full Fat Soybean Extrusion (Expeller)

Cooling after Dry Extrusion

- Trypsin inhibitor and urease levels can go back up if product if not properly cool down.
- Can have compaction and condensation problems during storage.
- Coolers can take out 1% to 2.5% of moisture.
- Cooling with ambient temperatures above 37°C is difficult.

Source: www.insta-pro.com/en/blog/engineeringandmaintenance/cooler-maintenance/

Wet Extrusion

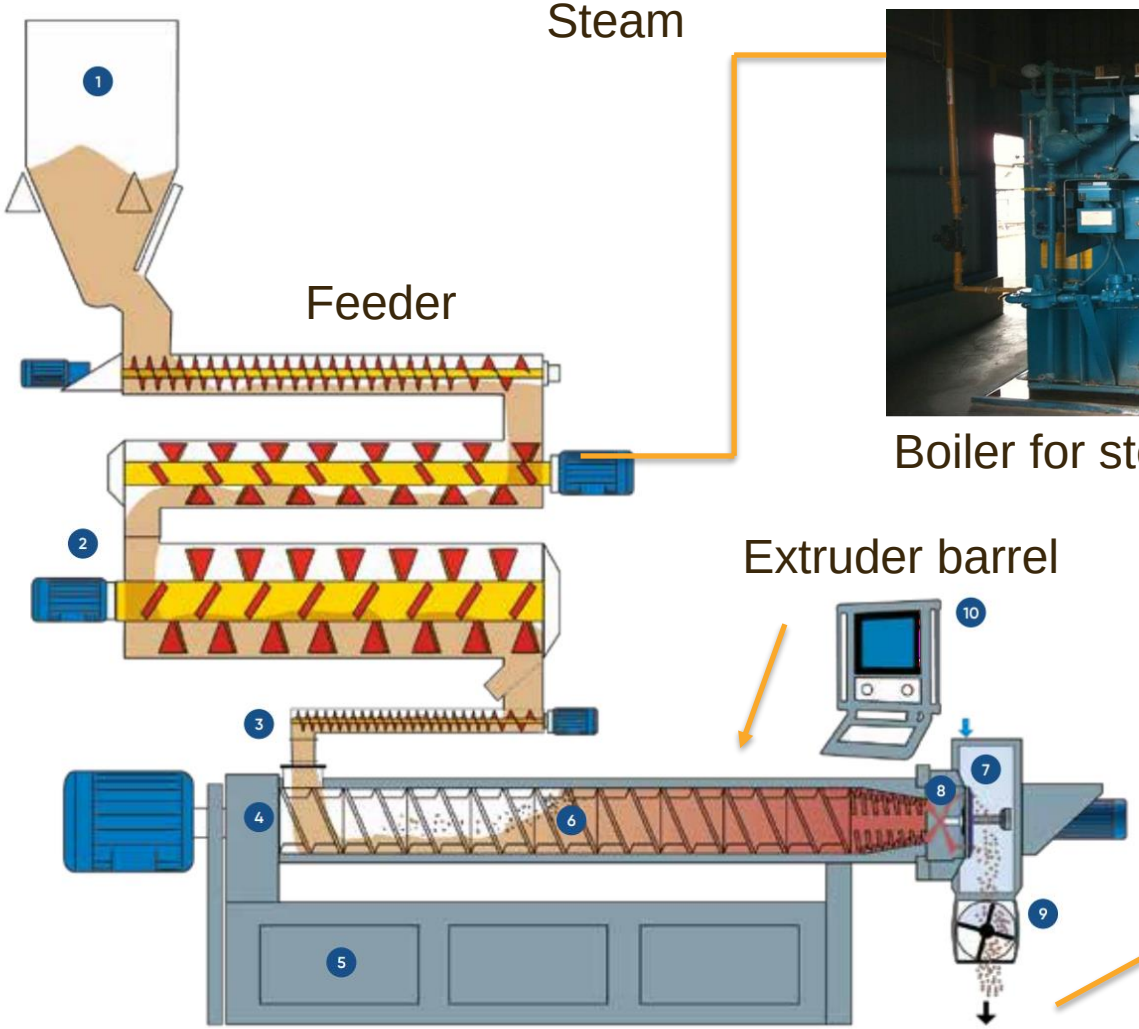
Steam

Boiler for steam production

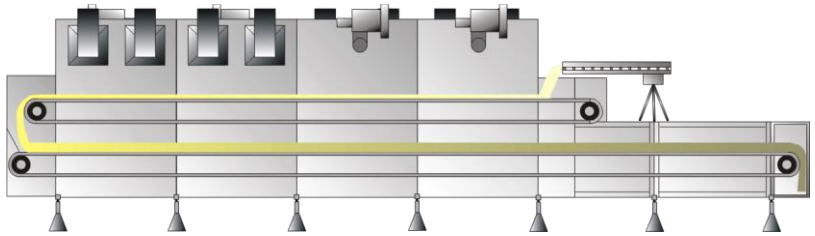
Feeder

Conditioner

Extruder barrel



Cooler



Product oulet

Comparison Extrusion vs Roasting

Extrusion

- More expensive but versatile.
- Process is more uniform.
- Can under or over cook soybeans
- Dairy:
  - Breaks cells that have the fat
  - Reduces the amount of milk production

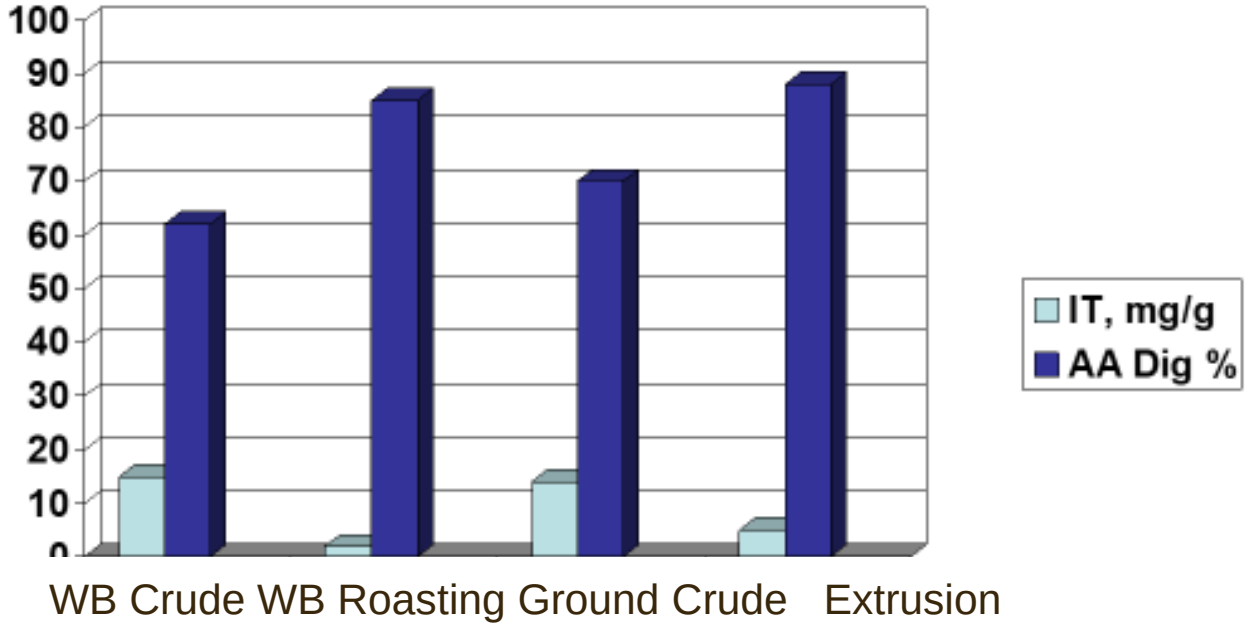
Roasting

- Cheaper process.
- Process is less uniform
- Results in less soluble protein increasing the protein passage to the rumen.
- Can denature protein.
- Less metabolize energy.

Comparison of Extrusion and Roasting

Effect of Heat Treatment on Trypsin Inhibitors

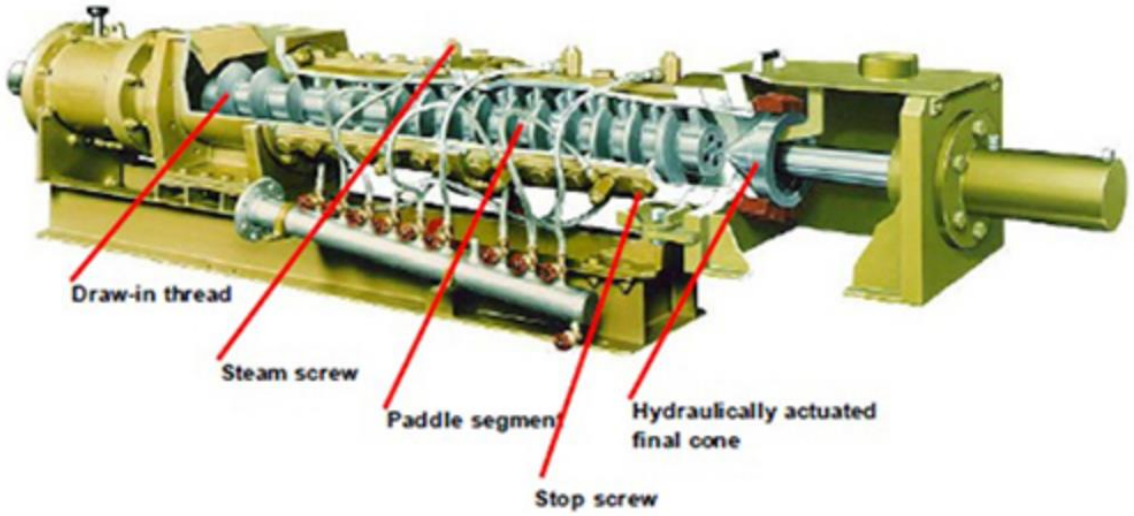
Aldrich et al., 1997



Source: Slide of Carlos M. Campabadal, PhD

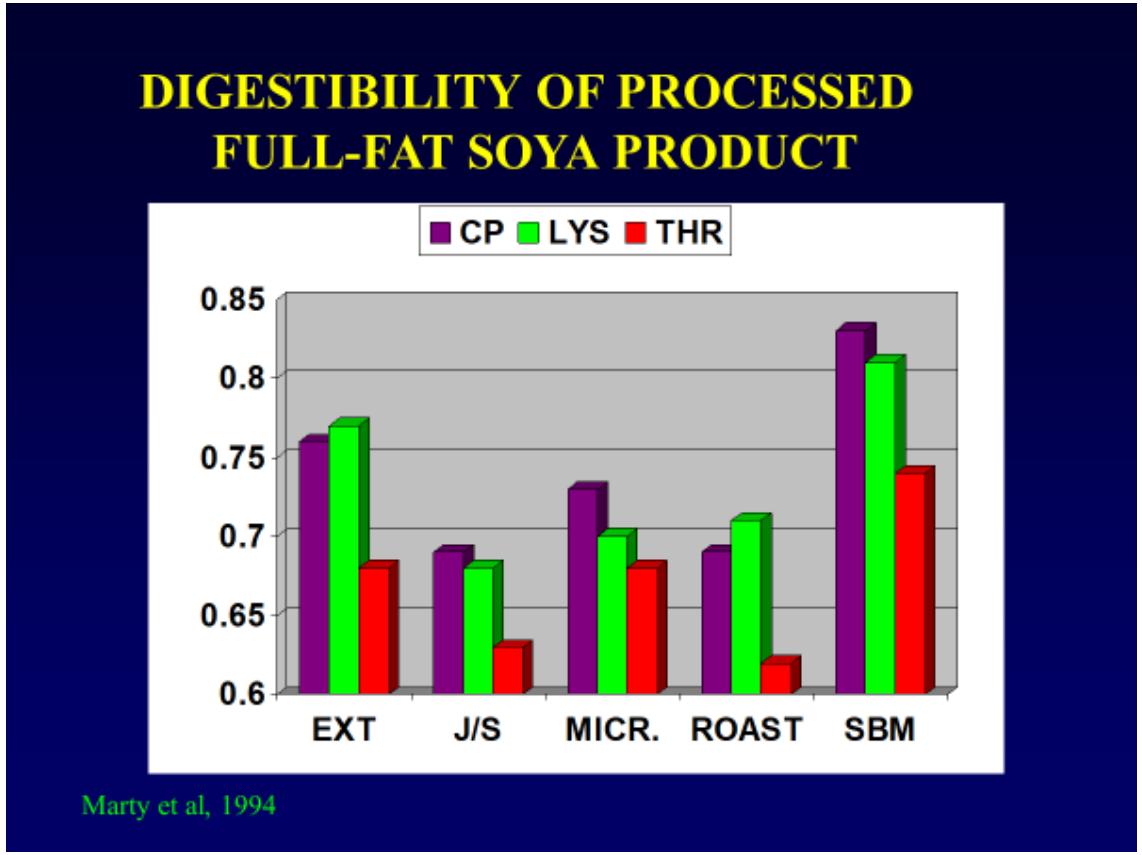
Expanders

- Temperatures between 70 °C to 170°C for short times 5 to 15 seconds.
- Add water, pressure and steam.
- Uses less energy than an extruder and outlet has a conic shape valve.
- More expensive than extruders.

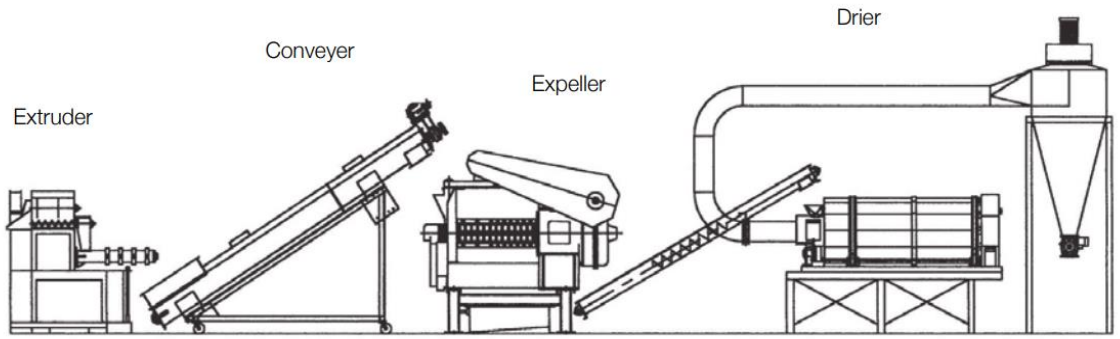


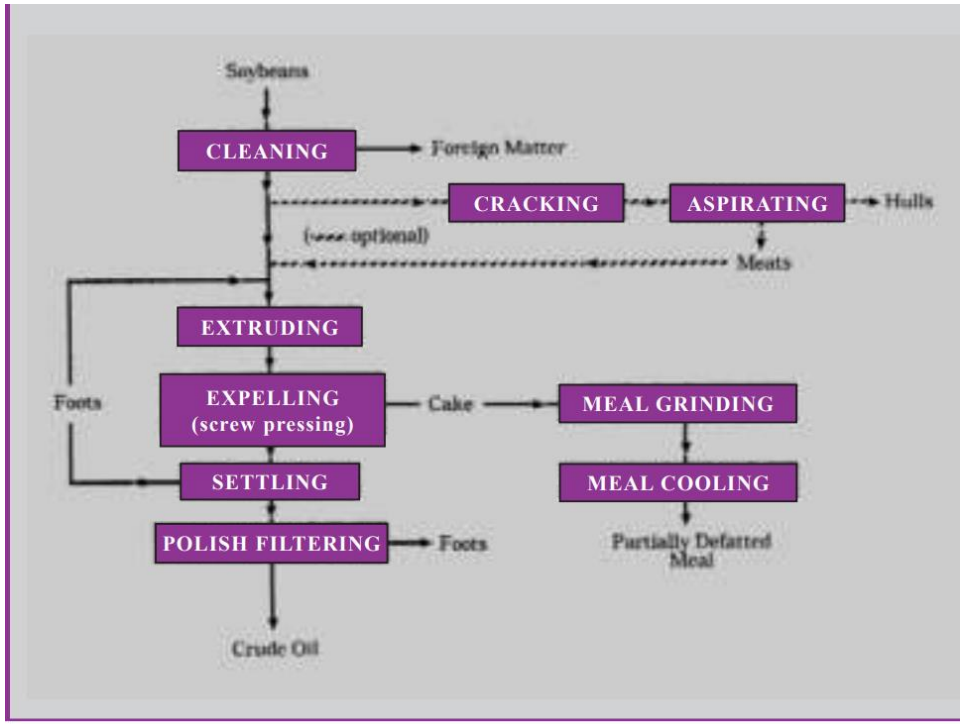
Amino Acid Digestibility

- Ext = Extrusion
- J/S = Jet Sploding
- MICR = Micronizing
- ROAST = Roasting
- SBM = soybean meal solvent extraction
- CP = Protein
- LYS = Lysine
- THR = Threonine



Mechanical Press





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Thank you!