Role of Extruders in Food and Feed Industries

Presented at the "Feed to Food" Conference

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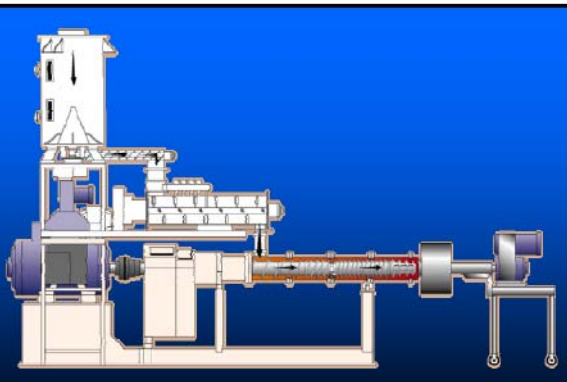
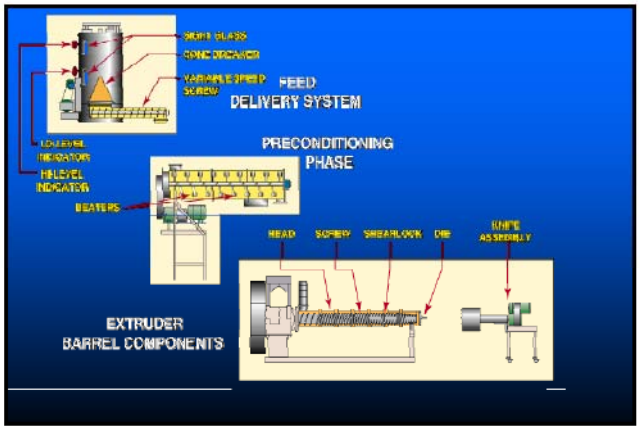
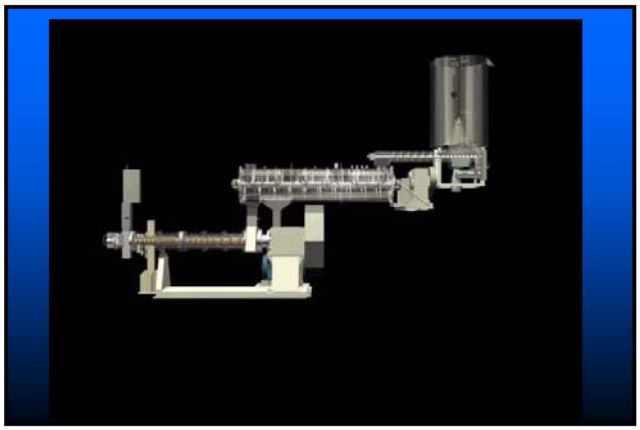
Extrusion A Processing Tool For Variety of Foods and Feed





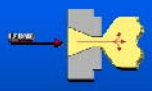


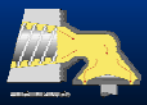
Presentation Overview

- What is Extrusion?
- Fundamentals of Extrusion
- Role of Extruder in Food and Feed Industries

What is Extrusion?

- Extrusion:
  - Process of Extruding
- Extrude:
  - to force, press, or push out: to shape by forcing through a die.





Definition of Extrusion Cooking

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

Definition of Extrusion Cooking

- A tool used to introduce thermal and mechanical energy to food and feed ingredients, forcing the basic components of the ingredients, such as starch and protein, to undergo chemical and physical changes. Meanwhile, forming a predetermined shape.

Functions That An Extruder Can Provide

- Texture Alteration
- Thermal Treatment
- Partial Dehydration
- Homogenization
- Protein Denaturing
- Gelatinization
- Grinding
- Hydration
- Expansion
- Shearing
- Mixing
- Shaping
- Destruction of micro-organisms and some toxic compounds

Texture Alteration

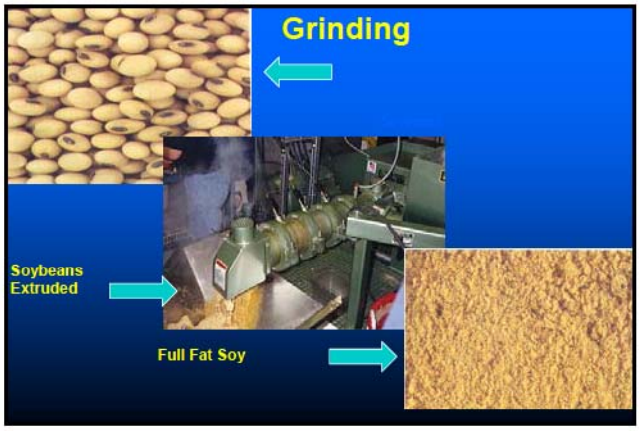
Thermal Treatment

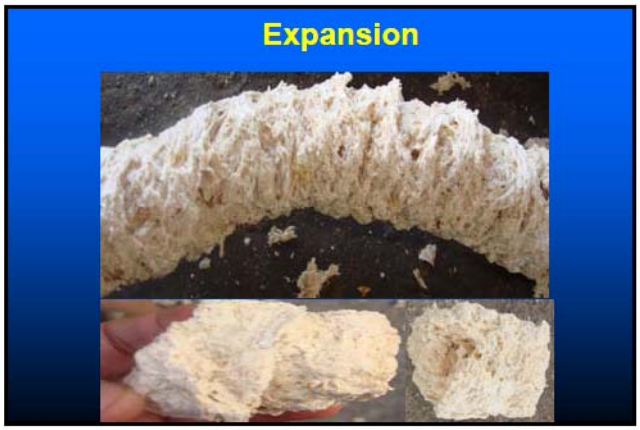
- Heat generated in conjunction with pressure and moisture achieves cooking, deactivation of anti-nutritional factors, protein denaturing and starch gelatinization

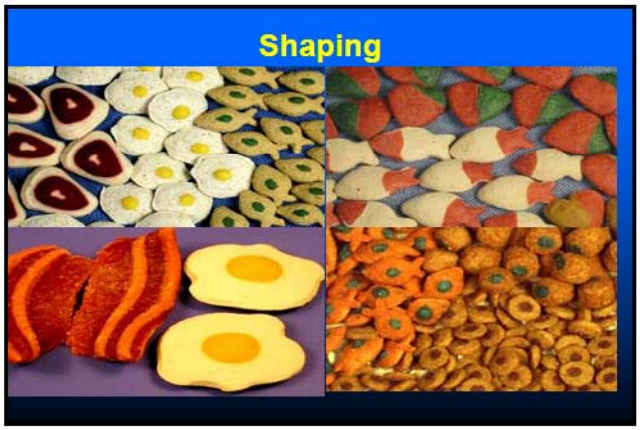
Partial Dehydration

Mixing & Homogenization

Gelatinization


Grinding
Soybeans
Extruded
Full Fat Soy


Expansion


Shaping

Advantages of Extrusion Cooking

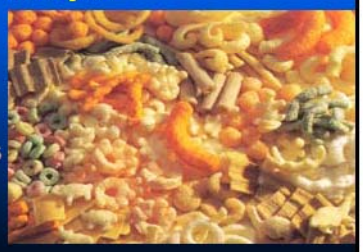
Adaptability

- Ample variety of foods are feasible
- Only changing the ingredients
- Operation conditions of the extruder
- Extrusion process is remarkably adaptable to accommodate the demand by consumers for new food products

Product Characteristics

A variety of

- Shapes
- Texture
- Color
- Appearances



Energy Efficient

Extruders operate at relatively low moisture while cooking food products, so less re-drying is required.

Low Cost

Extrusion has lower processing cost:

- 19% raw material
- 14% labor
- 44% capital investment.

Extrusion processing also need less space per unit of operation

New foods/feeds

Extrusion can modify

- Protein (vegetable and animal)
- Starches (all sources)
- Other food material to produce a variety of new and unique food products

High Productivity & Automated Control

- An extruder provides a continuous high-throughput
- Fully automated controls extruders

High Product Quality

- Extrusion is HTST heating process, minimizes degradation of food nutrients
- Improving the digestibility of proteins (by denaturing) and starches (by gelatinizing).

Quality -- Continue

Extrusion cooking at high temperature destroy the antinutritional compound,

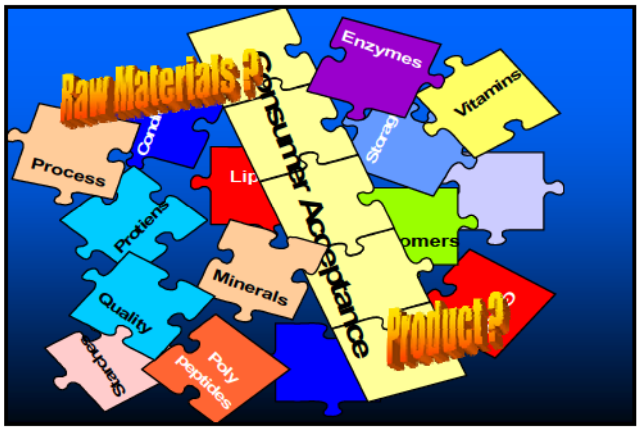
- Trypsin inhibitors
- Gossypol,
- Hemagglutinings,
- Undesirable enzymes, (lipases, lipoxidase and microorganisms

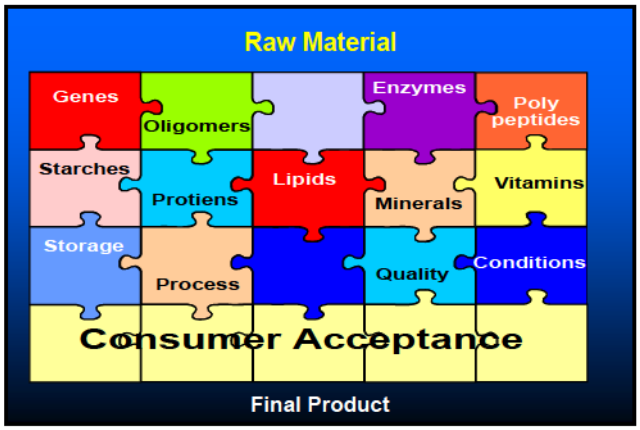
No effluent

Very few process effluent produced

Fundamentals of Extrusion Processing

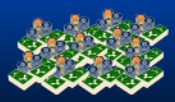
- Formulation (Recipe)
- Hardware
- Software
- Product Specifications





Raw Materials Cost Effect on Profits

- 1% Savings
- Raw Materials Cost



is worth 16 X more in profits

- 1% Savings
- Utility Cost

Know Your Raw Materials!

They may be your best friend,

OR BECOME YOUR WORST NIGHTMARE!

Formulation

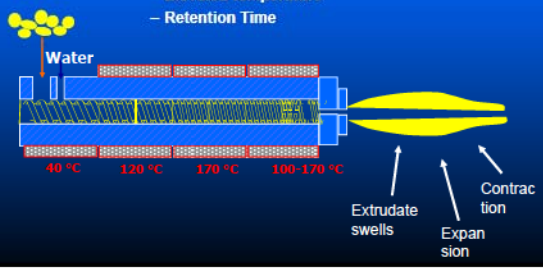
- Carbohydrate
- Protein
- Lipids
- Minor Ingredients

Carbohydrates

- Starch
- Fiber
- Hydrocolloids (gums)
- Sugars

Starch Gelatinization

- Requires
  - Moisture
  - Elevated temperature
  - Retention Time

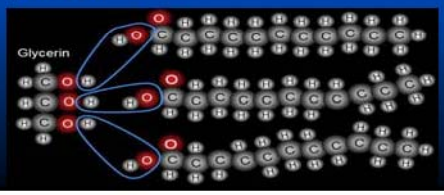


Proteins

- Denature when heat treated
  - Lose solubility
  - Lose enzymatic activity
  - Improves digestion
- Level of heat treatment
  - Affects "functionality"
  - Affects processing characteristics

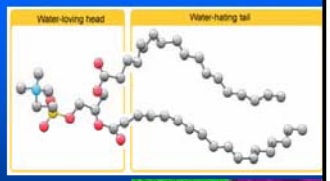
Lipids

- Level of indigenous or added lipids affects:
  - Binding and texture of product
  - Quantity of energy mechanically added to product

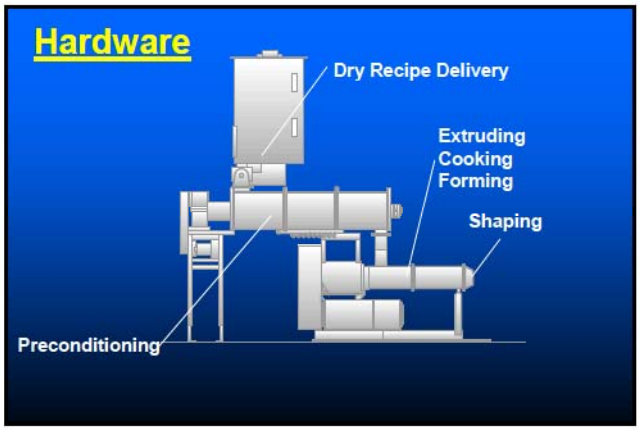


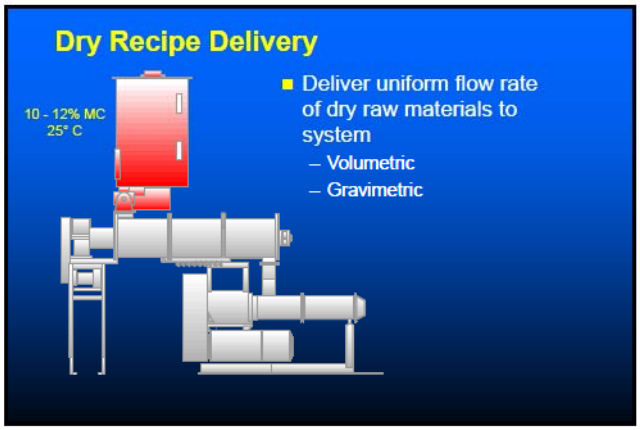
Minor Ingredients

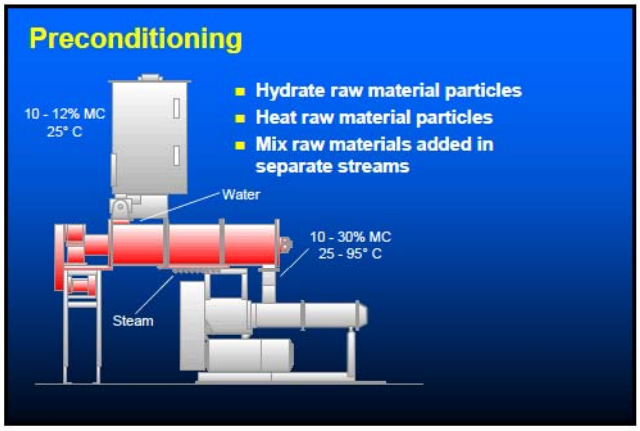
- Minerals
- Vitamins
- Pigments
- Flavors
- Processing Aids

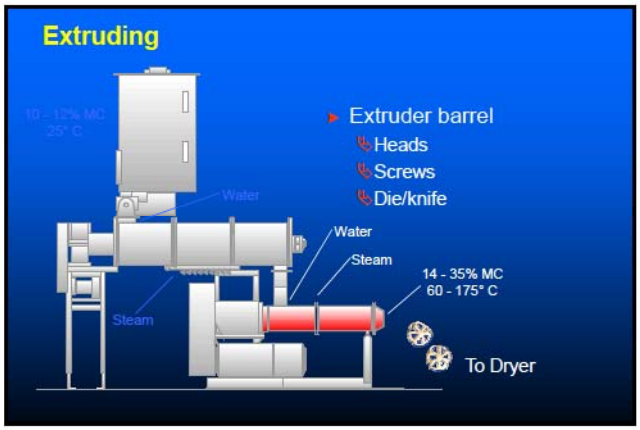


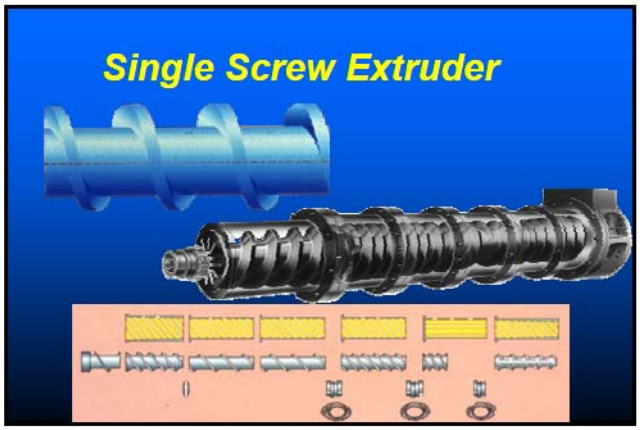
Note: Vitamin, Pigment, and Flavor Potency is effected by energy (in the form of heat), moisture, and retention time in the process.

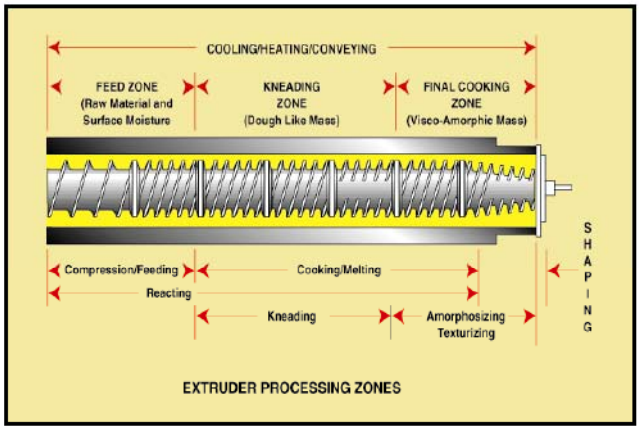

Hardware
Dry Recipe Delivery
Extruding
Cooking
Forming
Shaping
Preconditioning

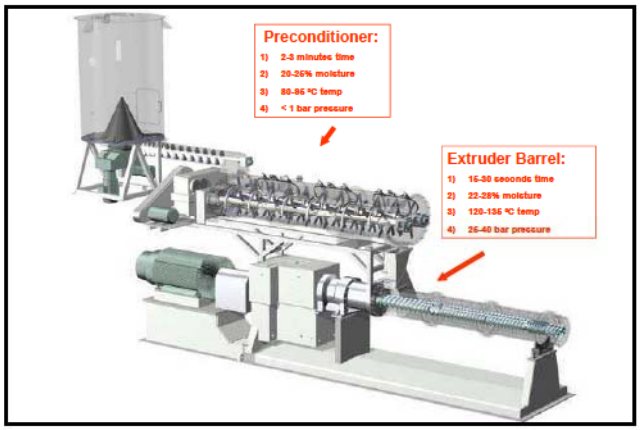

Dry Recipe Delivery
10 - 12% MC
25° C
Deliver uniform flow rate of dry raw materials to system
– Volumetric
– Gravimetric

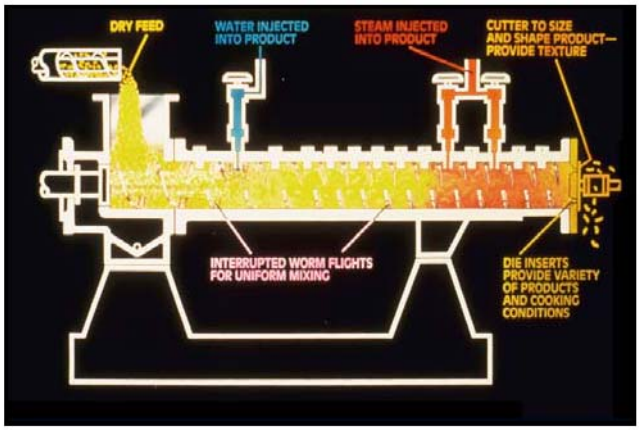

Preconditioning
10 - 12% MC
25° C
Hydrate raw material particles
Heat raw material particles
Mix raw materials added in separate streams
Water
10 - 30% MC
25 - 95° C
Steam

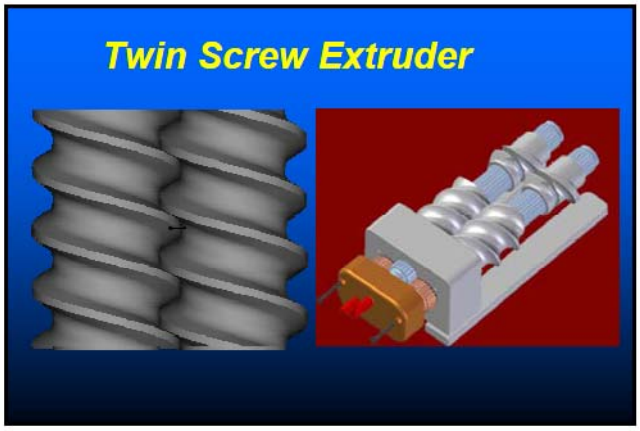

Extruding
Extruder barrel
Heads
Screws
Die/knife
Water
Water
Steam
14 - 35% MC
60 - 175° C
Steam
To Dryer

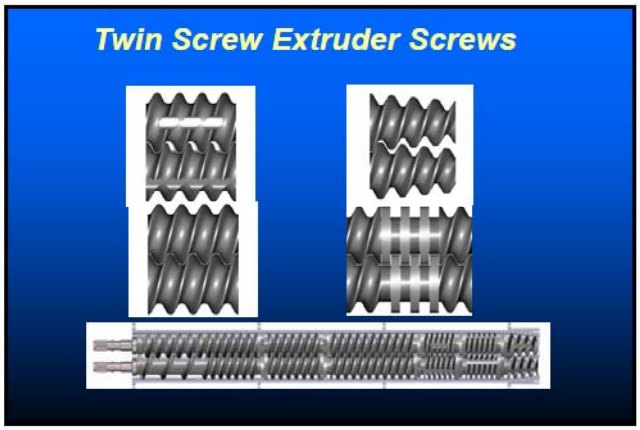

Single Screw Extruder

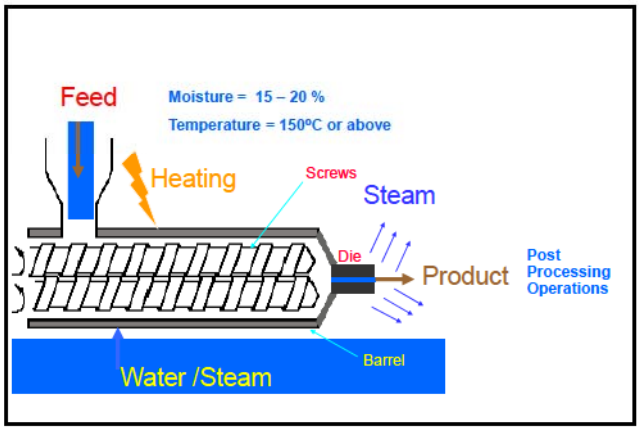

COOLING/HEATING/CONVEYING
FEED ZONE (Raw Material and Surface Moisture
KNEADING ZONE (Dough Like Mass)
FINAL COOKING ZONE (Visco-Amorphic Mass)
Compression/Feeding
Cooking/Melting
Reacting
Kneading
Amorphosizing Texturizing
SHAPING
EXTRUDER PROCESSING ZONES


Preconditioner:
1) 2-3 minutes time
2) 20-25% moisture
3) 80-95 °C temp
4) < 1 bar pressure
Extruder Barrel:
1) 15-30 seconds time
2) 22-28% moisture
3) 120-135 °C temp
4) 25-40 bar pressure


DRY FEED
WATER INJECTED INTO PRODUCT
STEAM INJECTED INTO PRODUCT
CUTTER TO SIZE AND SHAPE PRODUCT— PROVIDE TEXTURE
INTERRUPTED WORM FLIGHTS FOR UNIFORM MIXING
DIE INSERTS PROVIDE VARIETY OF PRODUCTS AND COOKING CONDITIONS


Twin Screw Extruder


Twin Screw Extruder Screws


Feed
Moisture = 15 – 20 %
Temperature = 150°C or above
Heating
Screws
Steam
Die
Product
Post Processing Operations
Barrel
Water /Steam

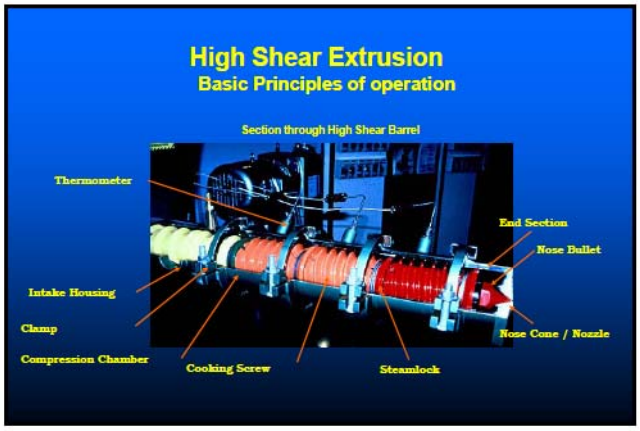
Twin screw vs. Single Screw

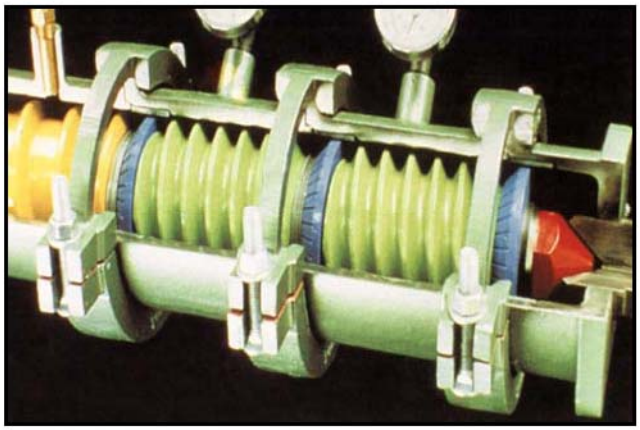
Single Screw Extruder

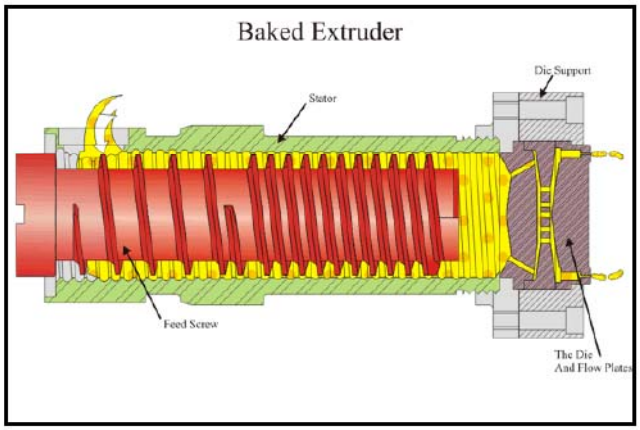
Twin Screw Extruder

Operating Range

Moisture Level
Lipid Level
Fiber Level
Protein Level
Mechanical Energy Input
Product capabilities
Wear tolerance

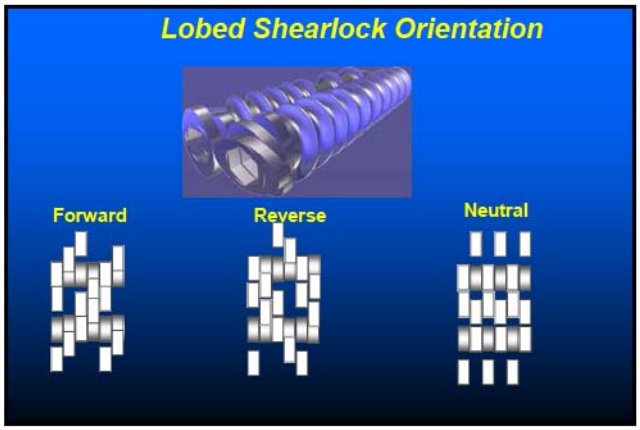

High Shear Extrusion
Basic Principles of operation
Section through High Shear Barrel
Thermometer
End Section
Nose Bullet
Intake Housing
Clamp
Nose Cone / Nozzle
Compression Chamber
Cooking Screw
Steamlock

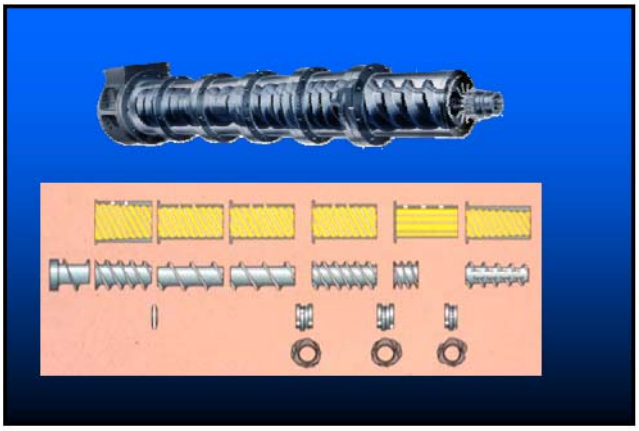



Baked Extruder
Die Support
Stator
Feed Screw
The Die
And Flow Plate


Extruder Screws

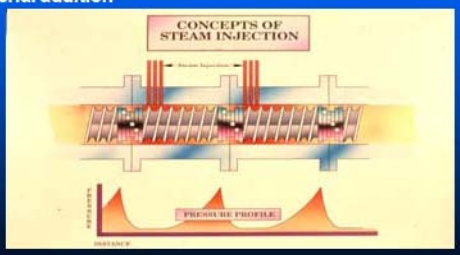

Single Screw Screws


Lobed Shearlock Orientation
Forward
Reverse
Neutral



Configuring the extruder

Mixing
Pressure Development
Venting
Material addition




Multiple Color / Multiple Shaped Products
✓Twin Screw
✓Single Screw


Color Mixing Head
✓Bi-colored Single Shape


Co-Extruded Petfood

Applications in Food

- Breading
  - A broad range of products with various shapes and particle sizes

Product Properties

- Bulk density
- Particle size and shape
- Oil absorption

- Breakfast Cereals
  - Direct expanded
  - Flakes

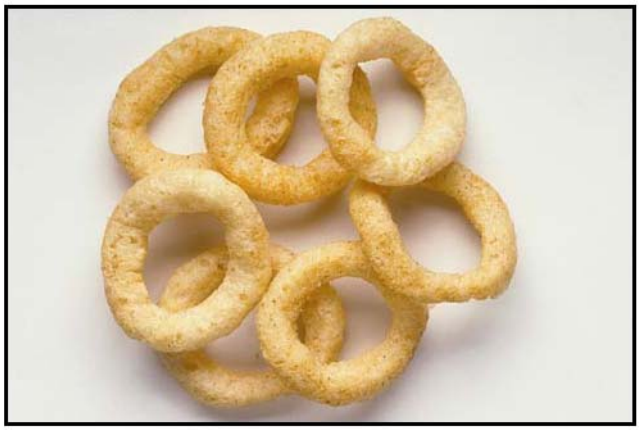
- Texture
- Flavor
- Bowl life
- Nutritional quality
- Bulk Density

Breakfast Cereal

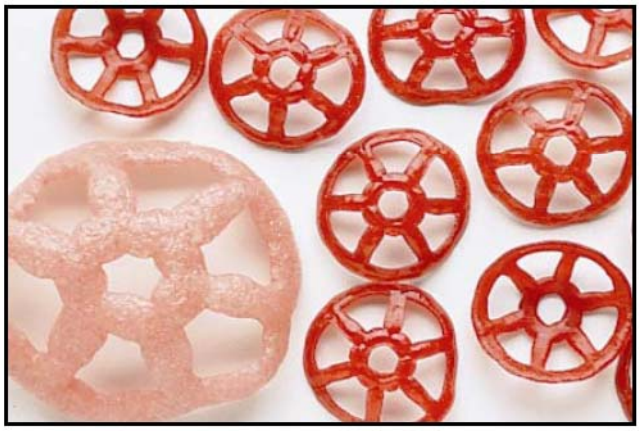
- Snacks
  - Expanded snacks (2nd generation)
  - Snack pellets (3rd generation)

Product Properties
- Texture
- Flavor
- Nutritional quality
- Bulk density


CONCEPT
SNACK




3-G Snacks



- Pasta
  - Traditional
  - Precooked
  - Instant

Product Properties

- Texture
  - Firmness
  - Stickiness
- Rehydration time


Pasta Noodles

Precooked Pasta

Product Properties

- Textured proteins
  - Meat analogs
  - Meat extenders

Co-extruded Products

Co-Extrusion

Application in Feeds

- Aquatic Feeds
  - Floating
    - Catfish
    - Carp
  - Slow Sinking
    - Salmon
    - Trout
  - Fast Sinking
    - Shrimp

- Pet foods
  - Dry expanded
  - Soft expanded
  - Semi-moist
  - Snacks and treats


Cow Feed

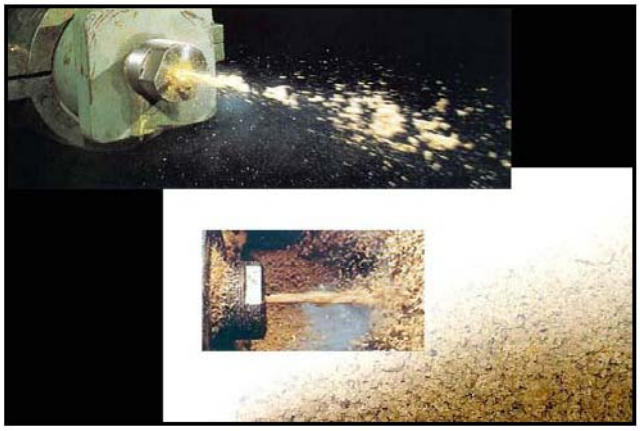

Semi-Moist Feeds

Applications in Oilseeds

Sterilization & Detoxification

Destruction of antinutritional factor

- » Urease
- » Proteases (Trypsin Inhibitor)
- » Gossypol



Enhance Solvent Extraction

- Extrusion will rupture the cell
- Porous collets
- Better extraction
- More yield

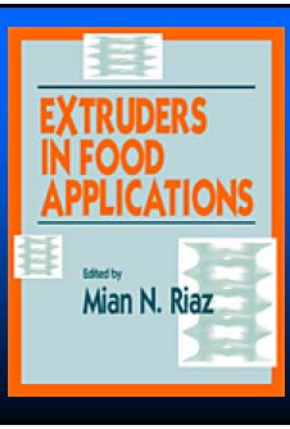
Stabilization

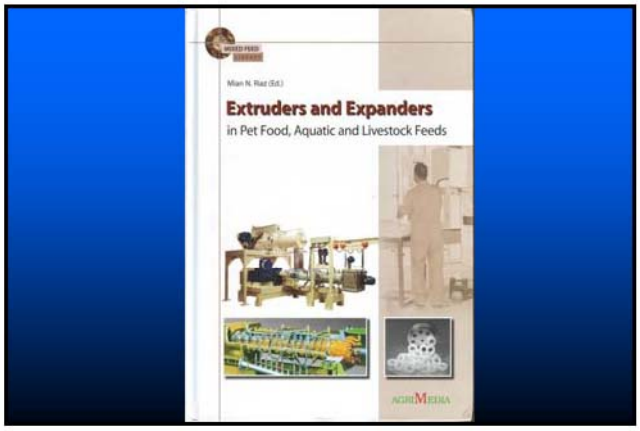
Rice Bran:

- To inactivate the enzymes
- Improve the oil quality
- To get better extraction

Extrusion cooking is…

a very flexible processing tool that using the proper raw materials, hardware, and processing techniques can produce a wide range of food and feed products

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Extruders and Expanders
in Pet Food, Aquatic and Livestock Feeds
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