

**PROCESSING OF SOYBEAN WITH EXTRUSION TECHNOLOGY FOR
FOOD AND FEED APPLICATION**

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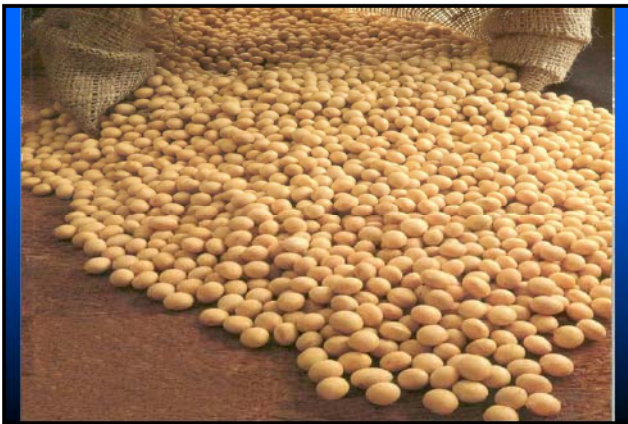
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Currently, the majority of soybeans processed use the solvent extraction process, which is very effective as it extracts most of the oil. The most common solvent used in this process (hexane) is declared a hazardous air pollutant by the EPA and a volatile organic compound which can contribute to ozone depletion. For a small or medium size oilseed processing facility building, a new solvent extraction facility requires major capital investment and technical skill to operate the extraction facility as well as knowledge to fulfill environmental regulations. On the other hand, extrusion processing of soybeans is becoming very popular because it requires a low investment and is environmentally friendly. In this process, soybeans are processed using extruders to rupture the oil cell. After this, oil is removed using an expeller or press. The resultant soybean cake contains 7-8% residual oil with an excellent nutritional quality. Currently, this method is being used to obtain food grade soybean flour, which can be used in baking and other food applications, as well as soy milk. If the soybeans are feed grade, mechanically expelled soybean meal, which can be used for feed application, can be obtained. The meal and soy flour from this process have shown remarkably excellent functional properties. In this presentation details about this process will be discussed.

Processing of Soybean with Extrusion Technology for Food and Feed Application

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History of Oilseed Processing

- Pressure is produced from a large screw/auger that turns inside a barrel
- Solvent extraction was introduced in 1930 for soybeans
- Beans are first flaked and cooked to denature cell tissue and allow for penetration of solvent

Current Oilseed Processing

Selection of process normally depends on the oil content of the seed

- Direct Extraction
- Direct Extraction with Expander
- Prepress/Solvent Extraction
- Full Press

Current Oilseed Processing

Direct Solvent Extraction

- Oilseed low in oil (<30%) seeds are solubilized by hexane
- Residual oil in meals is 0.5 – 1.0%

Current Oilseed Processing

Direct Extraction with Expander

Expand flaked material before extraction





Typical Soybean Collets



Current Oilseed Processing

Prepress- Solvent Extraction

- Oil contents of high-oil seeds is first reduced to 16-20% by screw press
- Cake is then crumbled and extracted with hexane to 0.75- 1.25% oil contents



Current Oilseed Processing

Full Pressing

- Oil in high (>30%) seeds is removed by continuous screw press or expellers
- Residual oil in seed cake is 4.5-7.5%

Alternative Method for Processing Soybeans

Solvent Extraction

- Most widely used method to extract oil from soybeans
- Soybeans are prepared by drying, tempering, cracking, dehulling, conditioning, and flaking
- Flakes are extracted using petroleum distillate high in *n*-hexane





Solvents

- N-Hexane is the worlds only solvent used for soy oil extraction
- Many other solvents used delisted due to toxicological concerns
- Aqueous extraction process had limited success
- Acetone worked very well as a solvent but need more work before using at commercial scale
- Isopropanol (IPA) is also not used because of its low oil recovery and high utilization of energy

Solvent Extraction: Process Attributes

- Large-scale operation
- Heavy investment
- High level of technology
- Operational hazards
- Negative environmental impact

Advantages of Solvent Extraction

- High extraction efficiency
- Residual oil in meal remains only 1-2%
- This technology is able to handle a large volume of crop



Disadvantages of Solvent Extraction

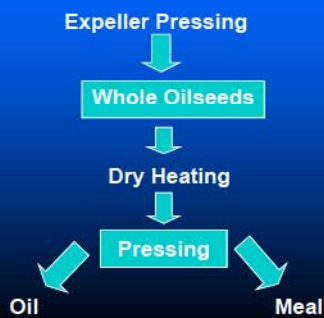
- Well suited for extremely large scale operations
- *Normal*-Hexane is used as solvent
N-Hexane is highly flammable
The 1990 Amendment to the Clean Air Act listed *n*-Hexane (CAS # 110534), a major (50-95%) constituent of commercial hexane, as a hazardous substance and has attracted increasing attentions to solvent plant emissions







Traditional Oil Extraction Methods



Disadvantages of Traditional Process

- Relatively low oil content
- Anti-nutritional factors
- Potential for off flavor development

Oilseed Processing With Extrusion-Expelling

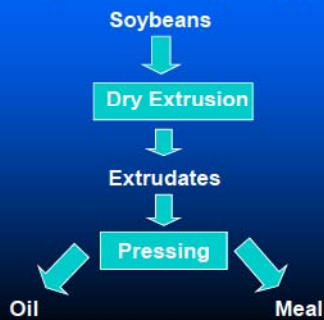
Dry Extrusion- Pressing

Oilseeds are first extruded

Pass through a press or expeller



New Technology (Extrusion-Expelling)



Dry Extrusion

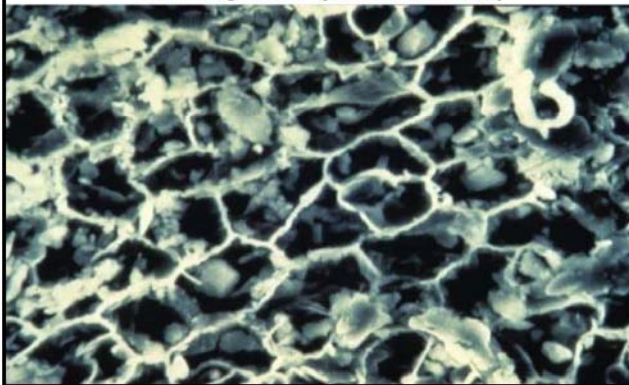
- Dry extrusion capitalizes on the heat generated through friction as the sole source of heat to cook and dehydrate the product

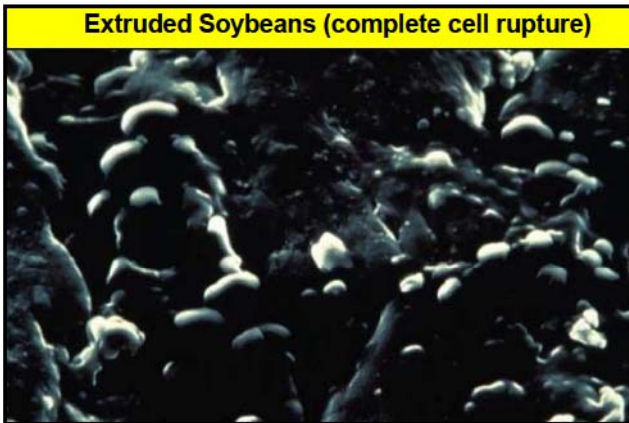
Dry Extrusion

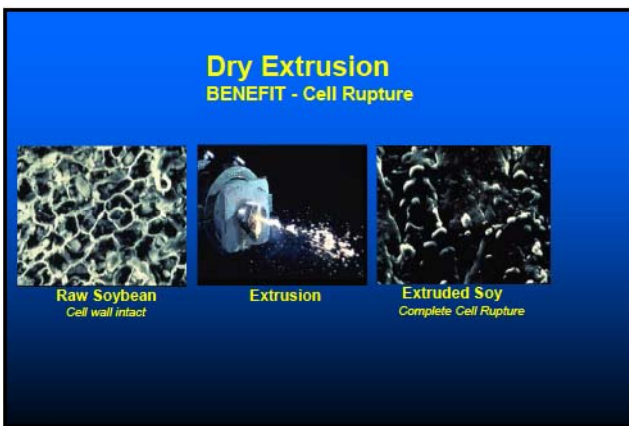
- The heat and pressure generated in the extruder barrel typically raise the temperature to 145-155 C
- This temperature and pressure is sufficient to denature the anti-nutritional factors in the soybeans and rupture the oil cells



Raw Soybeans (cell wall intact)

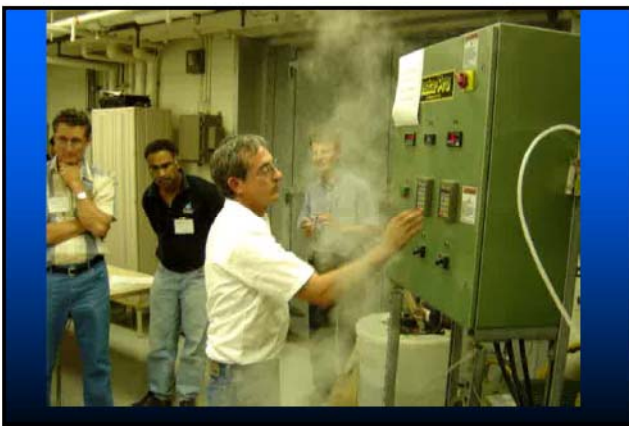










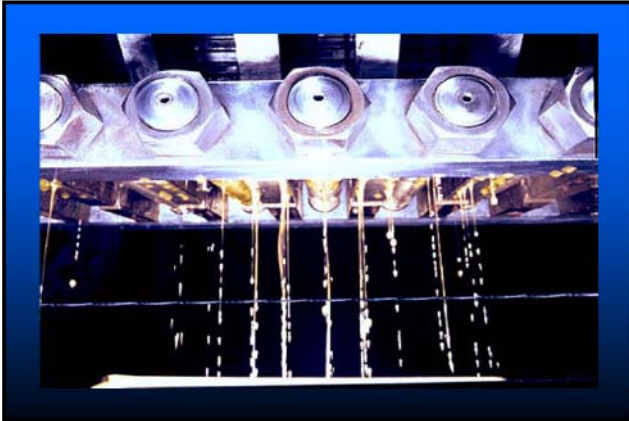






















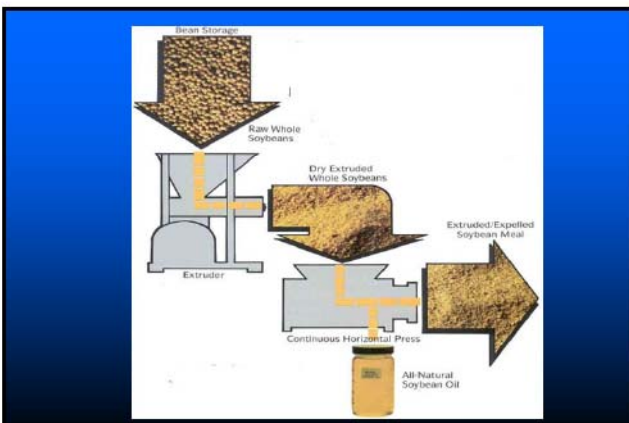












The Extruding/Expelling Process

- Preferred to as mini-mills in literature – small scale oil refinery machines
Extruders are scaled up and commercialized a version of the mini mill
- Extrusion-Expelling System
Used to extract oil from soybeans, cotton, sunflower seeds and canola

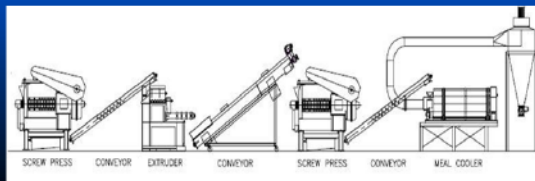
Current Oilseed Processing

Press/Dry Extrusion/Press

Oilseeds are first pressed

Extruded

Again pressed



The Extruding/Expelling Process

Oilseed	Raw Oil contents (%)	Raw Protein contents (%)	Oil Removal Efficiency (%)	Extruding Temperature °F	Expelled Meal oil Contents (%)	Expelled Meal Protein contents (%)
Soybean	18-22	36-40	65-67	290-315	6-9	42-46
Cotton	20-22	24-27	65-70	280-300	6-8	26-30
Canola	35-40	22-26	72-75	250-260	8-11	32-37
Sunflower	35-45	16-22	72-75	240-260	10-13	22-27

The Extruding/Expelling Process

■ Benefits of extrusion expelling system

■ Oil Production

- Attractive color and odor
- Can be used as a cooking oil with little or no refining
- Enables Identity Preservation
- Operates on a smaller scale therefore can preserve the identity of different varieties of oilseed
- Important for specialty, natural and organic market

Optimal Values for Proper Processing as Compared with Solvent Extracted SBM

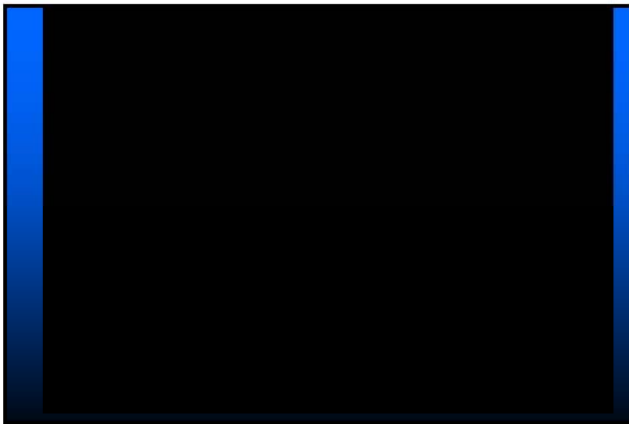
	Raw <u>Soybeans</u>	Solvent Extracted <u>Soybean Meal</u>	Extruded/Expelled <u>Soybean Meal</u>
Urease Activity			
PH rise	2.00	0.02 - 0.20	0.02 - 0.06
TIA (TIU/gm)	40,000 - 60,000	4,000 - 10,000	< 10,000
(mg/gm)	34	< 4.4	< 4.4
PDI%	80	20 - 40	9 - 14
NSI%	75	18 - 37	8.5 - 13
KOH Solubility %	> 85	71-85	71 - 85

Advantages of This Process

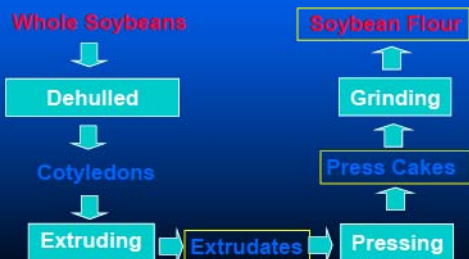
Single pass through press
Protein in meal up to 46% - 50%
Oil in meal down to 6%
Meal can be used as feed or food

Alternative Process for Food Application

- Clean soybeans
- Dehull
- Extrude to free oil
- Screw press to 7-8% residual oil
- Grind
- Sieve



Preparation of Mechanically Expelled Soy Flour







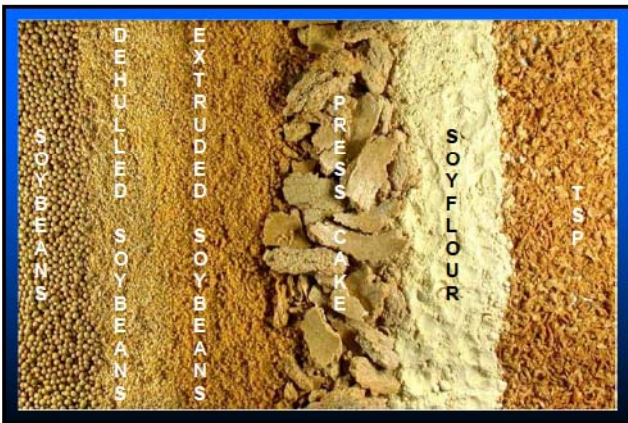
Specification of Mechanically Expelled Soy Flour

- This flour usually contain
- Protein 46-48%
- Oil 6-9 % oil
- Crude Fiber 3-4%
- PDI 25-30

Application of Mechanically Expelled Soy Flour

- This flour is used for making textured soy protein
- Bakery products
- Also used for protein fortification in different food application like, tortilla breads, etc





Advantages

- Relatively bland products
- Solvent extraction avoided
- Relative low entry cost/ Modest investment
- Processing can be decentralized
- Can palletize for fast shipment, setup
- Steam boiler not required
- Extruder, press, can be run by tractor PTO

Advantages

- Flexible scale of operation
- Simple technology
- No chemicals used
- Identity preservation feasible
- Environmentally friendly































