Core Course: 8

Unit: 3. Technology of Oilseeds

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Dear viewer's under the food technology let's learn about technology of oilseed.

Soybean, cottonseed, peanut, and sunflower are the major oilseeds grown in the world. Soybeans and peanuts are legumes, but are atypical because of their high oil contents and little or no starch. Soybeans, sunflowers, and particularly peanuts are consumed directly as foods, but the four oilseeds primarily serve as sources of edible oils and high-protein meals that are the mainstay of the animal feed industry. Of the four oilseeds, the soybean is the largely utilized as edible oil and edible protein products.

At present, palm oil accounts for 62 percent of India's edible oil imports. India's per capita edible oil consumption is currently estimated at 17.18 kg. Although, there is an increase in consumption, still, Indian vegetable oil consumption remains well under the world average of 24.86 kg.

We will learn the technology of oilseed under the following sections in this episode

- **Nutritional Properties of oil ,protein and meals from oilseed**
- **Processing of oilseed**
  Edible Oil Products
  Edible Protein Products
  Food Uses of oilseeds
- **Soy texurization**
- **Meat extenders**
- **Meat analogs**
- **Extrusion texturization**

Nutritional properties of oil, protein and meals from oilseed:

Nutritional properties of oil

Unhydrogeated and partially hydrogenated oils from cottonseed, peanuts, soybeans, and sunflowers are good sources of linoleic acid, an essential fatty acid. Hydrogenation of soybean oil is used to extend shelf life, and to give better flavor stability and physical and plastic properties. Such processing lowers the content of linoleic and linolenic acid but also causes formation of trans fats,as per the extensive studies reported by Erickson et al(1980) However,soybean oil is considered safe under normal cooking conditions.

Nutritional properties of Proteins and Meals:

Nutritional properties of the oilseed meals and derived protein products depends on their amino acid composition, presence biologically active proteins and a variety of nonprotein compounds that occur in the defatted meals. For example, phytic acid found in all four oilseeds has been implicated in preventing absorption of dietary zinc, calcium, magnesium, and iron as per the research by Reddy and his team.

Cottonseed

Cottonseed proteins are low in lysine, threonine, isoleucine, and leucine when compared with the Food Nutrition Board(FNB) ideal amino acid pattern (Table 1). On moist heating of cottonseed, the e-amino group of lysine reacts with the aldehyde groups of gossypol to form a derivative that makes the lysine unavailable during digestion, thus creating an imbalance with respect to lysine (Berardi and Glodblatt 1980).

Gossypol causes,discoloration of the yolks,. when fed to laying hens However, Gossypol toxicity is not a problem with ruminants unless large quantity is fed.

Peanuts:

Low levels of lysine, threonine, isoleucine, and leucine (Table 1) make peanut proteins lower in nutritional value than soybean proteins. Peanut proteins generally are better than wheat or corn proteins, inspite of trypsin inhibitor effect in raw form. The trypsin inhibitor is inactivated by moist heat.

Soybeans:

Methionine is the first limiting amino acid in soybean proteins. It is well known for many years that raw soybeans has poor nutritive value, but on cooking, the nutritional quality is greatly increased. Moist heat, however, destroys most of the inhibitor activity.

Sunflower Seed:

Sunflower proteins are deficient in lysine and leucine and borderline in threonine and isoleucine content as compared to the ideal protein for humans (Table 1). Heating the seed before extracting the oil improves the nutritional value of the

defatted meal (Amos et al. 1975). Although this result suggests the presence of heat-labile antinutritional factors, though it has not been clearly identified, so far.

<u>Processing of oilseed</u>

Oil and Meal:

Depending on the oil content of the seed, processing may consist of screw pressing, prepress solvent extraction, or direct solvent extraction. Pressing is used only with seeds having a high oil content. All three techniques are used in processing cottonseed (Fig 1).

The seed is cleaned (removal of sticks, stones, leaves, and other foreign materials), delinted (mechanical removal of cotton fibers remaining after ginning), dehulled, and flaked (passage between smooth rolls). Some processors extract the flakes directly; others cook the flakes and then screw press them or a combination of screw pressing followed by solvent extraction. Peanuts are processed by screw pressing or by screw pressing followed by solvent extracted, or prepress solvent extracted.

Because soybeans contain only about 20% oil, virtually all are processed by direct solvent extraction (Fig. 2). Soybeans are cleaned and dried, if necessary, and then stored. After storage, they are cleaned further, cracked to loosen the hulls, dehulled, and conditioned to 10-11% moisture for flaking.

<u>Edible Oil Products</u>

Crude oils obtained from oilseeds are processed further into salad and cooking oils, shortenings, and margarines as exemplified by soybean oil (Fig. 3).

Phosphatides and gums are removed first by degumming to yield crude lecithin, which is further refined or back to the defatted flakes just before the desolventizing-toasting step. Free fatty acids, color bodies, and metallic prooxidants are removed by the alkali refining. Activated earth in the blanching step removes additional color bodies, and soaps. The deodorization process decomposes peroxides and removes odors and residual free fatty acids. Hardened fats are obtained by partial hydrogenation and may be utilized directly or blended with other vegetable oils or animal fats for use as shortening and margarine. Blends of oils of varying melting points are used to obtain desired mouth feel and plastic melting ranges and the most economical formulation.

<u>Edible Protein Products</u>:

At present, only defatted soybean flakes are processed into edible protein products. Until about 1986, peanut flour and grits were prepared from prepress hexane-extracted flakes and used as food ingredients, however, production has since been discontinued. Partially defatted peanut flours made by hydraulic pressing are still available commercially. Soybeans, on the other hand, are converted into defatted flours and grits, concentrates, and isolates; their preparation is described below.

a) Defatted Soybean Flours and Grits:

Edible-grade, defatted soybean flakes are manufactured as shown in Fig. 2. After desolventizing, the defatted flakes are ground and classified by screening. Grits have particle sizes larger than 100 mesh, whereas flours are 100 mesh or finer in particle size. Varying degrees of heat treatment are given to grits and flours to inactivate enzymes and to improve flavor and nutritional quality.

Extent of heat treatment is measured by determining the Nitrogen Solubility Index (NSI) or the Protein Dispersibility Index (PDI), which estimate the amounts of undenatured protein that remains dispersible in water under conditions of the tests (American Oil Chemists Society 1976). Defatted flours and grits have a minimum protein content of 50% on a dry basis as illustrated by the compositional data for commercial products (Table 2). Essential amino acid contents are summarized in (Table 3).

b) Soybean Protein Concentreates

These products are made from defatted soybean flakes or flours by removing the soluble sugars and other low-molecular-weight constituents. Three basic processes have been used to prepare protein concentrates (Fig. 4). The first method employs aqueous ethanol to dissolve the sugars; the proteins and polysaccharides which are insoluble in alcohol and make up the concentrate after the solvent is removed (Mustakas et al. 1962).

In the second process, defatted flakes (or flour) are extracted with dilute acid at pH insoluble; after neutralizing and drying, the protein and insoluble polysaccharides constitute the second type of protein concentrate (Sair 1959). In the third process, the flakes or flour are first toasted to heat-denature and insolubilize the proteins

Protein concentrates by definition contains a minimum protein content of 70% on a dry basis. A typical composition is given in Table 2.

Essential amino acid content acid content for a concentrate prepared by alcohol washing is shown in Table 3.

c) Soybean Protein Isolates:

Isolates are the most refined form of soybean proteins available. They are processed one step beyond the protein concentrates by removing both the water-insoluble polysaccharides and the water-soluble sugars (Fig .5). Defatted flakes with a high protein solubility (high NSI or PDI) are extracted with dilute alkali (pH 7-9) at 50 – 55 C. The extract is adjusted to pH 4.5, the isoelectric point where the bulk of the proteins are insoluble and precipitate as a curd. The curd is then washed and may be spray-dried to obtain the isoelectric (water-insoluble) form of the protein. The proteinates are water-dispersible and thus easier to incorporate into wet food systems.

An isolate contains a minimum of 90% protein on a dry basis, and a typical composition is given in Table 2. Essential amino acid content for an isolate is listed in Table 3.

<u>Food Uses of oilseeds</u> : The Food use of oilseeds has increased by five percent to 2.5 MMT, driven by steady demand for value-added food products made from oilseeds, particularly nuggets, snacks, curries, and sauces made from soy, rapeseed, mustard, sesame, peanuts, and other oilseeds.

India annually exports high-value HPS peanuts, soybean, sesame, niger seed, cottonseed, safflower seed, rapeseed, and mustard valued at upwards of $1.5 billion.

Now lets understand food uses of few oilseeds

Cottonseed:

Glandless (Lacking the pigment glands which contains gossypol) cottonseed is produced on a commercial scale. The roasted kernels are used in breads and confectionary items. Glanded cottonseed is processed into oil and meal. The oil is refined and used for salad and cooking oils, shortenings, and margarines.

The meal is utilized for animal feeds, primarily for beef and dairy cattle. A prepressed-hexane extracted cottonseed flour has been used since the 1960s in Latin America in the form of blend with corn flour, sorghum flour, and torula yeast; the blend is known as Incaparina.

Peanuts:

About one-half of the peanut crop is processed into edible products in U.S. peanut butter is the main edible form and others include peanut candy, salted nuts, and roasted in-the-shell items. Peanut butter is made by shelling the peanuts, dry-roasting the kernels, removing the skins, and then grinding finely. The ground peanuts are then mixed with salt, and other ingredients that may include hydrogenated fat, dextrose, corn syrup solids, lecithin, and antioxidants.

Soybeans:

Soybean flours are used in breads and other baked goods, breakfast cereals, infant foods, and dietary foods/ soy flours are also texturized by thermoplastic extrusion. Such texturized flours are used as extenders for ground meats (especially beef) and as meat analogs. Small amounts of soybeans are roasted and sold as snacks, canned in tomato sauce, and converted into soy milk-based infant formulas. Larger amounts of soybeans are converted into oriental foods which include tofu, miso, and tempeh. Soy sauce is a well-known condiment whose consumption has increased in the last two decades.

Sunflower Seeds

Processing of sunflower yields a high-quality edible oil and a high-protein meal that is used for animal feeds. Direct food use of sunflower consists of roasting both in the shell and in the dehulled form. Roasted nutmeats are utilized in candies, cookies, snack items, spreads, and cakes.

<u>Soy texurization</u>

The process for the production of textured soy products containing spun protein fibres was first described in a 1954 patent issued to Boyer. The basic flow-diagram of the process is shown in Fig. 6. Applied to soy protein products, the terms "texturization or texturing" mean the development of a physical structure which will provide, when eaten, a sensation of eating meat.

The soy product texturization can be classified in two categories. The first approach tries to assemble a heterogeneous structure comprising a certain amount of protein fibres within a matrix of binding material.

The second approach converts the soy material into a hydratable, laminar, chewy mass without true fibres .The starting material for spun fibres is isolated soybean protein. In contrast, extrusion or steam texturized soy products can be made from flour, concentrate or isolated protein.

Meat extenders

The principal use of texturized soy protein products is as a meat extender in comminuted meat product such as patties, fillings, meat sauces, meat balls etc. In such products, as much as 30% of the meat can be replaced by hydrated texturized soy products without loss of eating quality. Further, textured soy products offer not only economic savings but also product improvement. Their ability to absorb water and fat results in increased product juiciness.

Meat analogs

Chunks of extrusion texturized soy protein products and spun fibre based preparations are marketed as "imitation meat" or "meat analogs". Recently there is a marked trend to reduce the consumption of red meat, associated with the demand for low-cholesterol foods. At the same time, the industry has been successful in developing more attractive meat analogs made from rehydrated textured soy proteins, alone or in combination with wheat gluten. The present marketing strategy for meat analogs is to present them as new, high quality products, and not as inexpensive substitutes for meat.

Extrusion texturization

Mc Anelly in 1964 described a process for the production of spongy, elastic particles from soy flour. A mixture of defatted flour and water was extruded. The extruded strands were heat-set in an autoclave, chopped, leached with hot water and dried. Although, this invention can be considered as the forerunner of the extrusion texturization processes, the breakthrough in this field was the disclosure of a continuous cooking-extrusion process, for which a patent was awarded to Atkinson in 1970. In this process, defatted soy flour containing a certain amount of water is passed through a high-pressure extruder-cooker to produce an expanded, porous, somewhat oriented structure described as "pleximellar". Although devoid of true

fibres, the product possessed the textural characteristics of chewiness and elasticity, and was deemed to imitate meat in this respect. Extrusion texturized soy flour soon became an established food ingredient known as TVP (Textured Vegetable Protein) or TSP (Textured Soy Protein).

The extruder consists basically of a sturdy screw or worm rotating inside a cylindrical barrel (Fig. 7). The barrel can be smooth or grooved. A narrow orifice or "die" is fitted at the exit end of the barrel. The shape of the die opening determines the shape of the extruded product.The flour-water mixture is next fed into the extruder and picked up by the screw. As it advances along the barrel, it is rapidly heated by the action of friction as well as the energy supplied by the heating elements around the barrel. The high pressures attained through the compression mechanism explained above permits heating to 150-180°C. This rapid "pressure cooking" process transforms the mass into a thermoplastic "melt", hence the name of "themoplastic extrusion".

Extrusion texturized soy flour has been called "the first generation TVP".

Conclusion

Unhydrogeated and partially hydrogenated oils from cottonseed, peanuts, soybeans, and sunflowers are good sources of linoleic acid, an essential fatty acid. Hydrogenation of soybean oil is used to extend shelf life, and to give better flavor stability and physical and plastic properties

Nutritional properties of the oilseed meals and derived protein products depends on their amino acid composition, presence of biologically active proteins and a variety of nonprotein compounds. For example, phytic acid found in all four oilseeds has been implicated in preventing absorption of dietary zinc, calcium, magnesium, and iron as per the research.
In the recent time soy protein texurization has resulted in variety of products like meat extenders, meat analogues. Large number of snack items has been designed and widely accepted due to extrusion texturization.

Table 1. Amino Acid Composition (g/16 g N) of Defatted Oilseed Meals

Amino acid	Cottonseed *a*	Peanut *b*	Soybean *c*	Sunflower *d*	FNB pattern *e*
Lysine	4.4	3.4	6.4	3.8	5.1
Histidine	2.7	2.4	2.6	2.5	1.7
Ammonia	2.1	1.7	1.9	2.2	1.7
Arginine	11.6	12.0	7.3	8.9	-
Aspartic acid	9.2	13.0	11.8	8.7	-
Threonine	3.0	2.5	3.9	3.2	3.5
Serine	4.2	5.2	5.5	3.9	-
Glutamic acid	21.7	20.6	18.6	21.0	-
Praline	3.6	5.1	5.5	5.0	-
Glycine	4.1	6.6	4.3	5.1	-
Alanine	3.9	3.8	4.3	4.1	-
Valine	4.5	3.1	4.6	4.8	4.8
Cystine	2.6	2.5	1.4	1.8 }	2.6
Methionine	1.5	1.1	1.1	1.9 }	
Isoleucine	3.1	2.3	4.6	4.0	4.2
Leucine	5.8	6.2	7.8	6.1	7.0
Tyrosine	3.1	3.6	3.8	2.7 }	7.3
Phenylalanine	5.4	5.0	5.0	4.7 }	
Tryptophan	1.2	1.0	1.4	1.1	1.1

- **a Means for eight glanded seed varieties (Lawhon et al. 1977).**
- **b Means for 16 varieties (Young et al 1973), except for tryptophan (Lusas 1979).**

- **c Means based on 32 hydrolyzates except for praline, cystine, and tryptophan (Cavins et al. 1972).**
- **d Means for seven varieties (Earle et al. 1968).**
- **e Food and Nutrition Board pattern for high-quality protein for human (NAS 1980).**

Table 2. Typical Compositions of Soybean Protein Products

Constituent	Defatted flours and grits	Protein	
		Concentrates	Isolates
Protein (N X6.25)	56.0	72.0	96.0
Fat	1.0	1.0	0.1
Fiber	3.5	4.5	0.1
Ash	6.0	5.0	3.5
Soluble	14.0	2.5	0
Insoluble carbohydrates	19.5	15.0	0.3

Analytical values on a moisture-free basis (Horan 1974).

Table 3. Essential Amino Acid Composition (g/16 g N) of Soybean Flour, Concentrate and Isolate

Amino acid	Defatted flour	Concentrate	Isolate
Lysine	6.3	6.3	5.7
Methionine	1.3	1.3	0.9
Cystine	1.6	1.5	1.2
Tryptophan	1.4	1.5	1.1
Isoleucine	4.4	4.6	4.6
Leucine	7.7	7.9	7.8
Phenylalanine	5.1	5.1	5.2
Valine	4.8	4.8	4.5

Source: Technical Service Manuals, Central Soya Co., Fort Wayne, IN.

Table 4. India: Oilmeal Exports, In Thousand MTs

	Soybean meal	Rapeseed meal	Peanut meal	Sunflower meal	Total
Oct-15	**4,237**	**3,079**	**0**	**0**	**7,316**
Nov-15	**8,909**	**12,845**	**0**	**0**	**21,754**
Dec-15	**5,667**	**16,855**	**0**	**0**	**22,522**
Jan-16	**7,707**	**1,990**	**0**	**0**	**9,697**
Feb-16	**1,127**	**9,803**	**496**	**0**	**11,426**

Source: Solvent Extractors' Association of India

Table – 5 Characteristics of textured soy products

Characteristic	Product based on:		
	Soy flour	Soy concentrate	Soy isolate

Flavour	**Moderate to high**	**Low**	**Low**
Retort stable	**Yes**	**Yes**	**Yes**
Flavour development on retorting	**High**	**Low**	**Low**
Flatulence	**Yes**	**No**	**No**
Form/shape	**Granules or chunks**	**Granules or chunks**	**Fibres**
Cost (dry basis)	**Low**	**Low**	**High**
Recommended hydration level	**2:1**	**3:1**	**4:1**
Cost of hydrated protein	**Low**	**Low**	**High**
Fat retention	**Moderate**	**High**	**Moderate**
Optimum usage level in meat extension (% hydrated level)	**15-20**	**30-50**	**35-50**

Source: Campbell (1981)

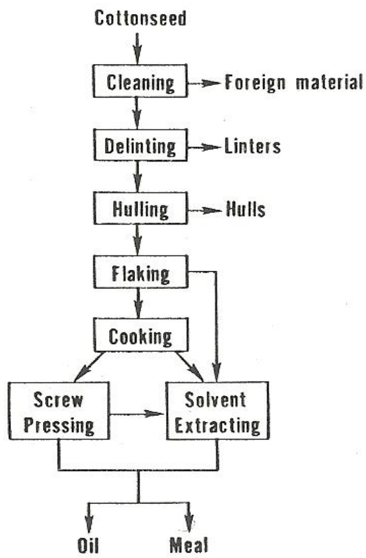

Fig. 1. Outline for processing cottonseed into oil and meal.

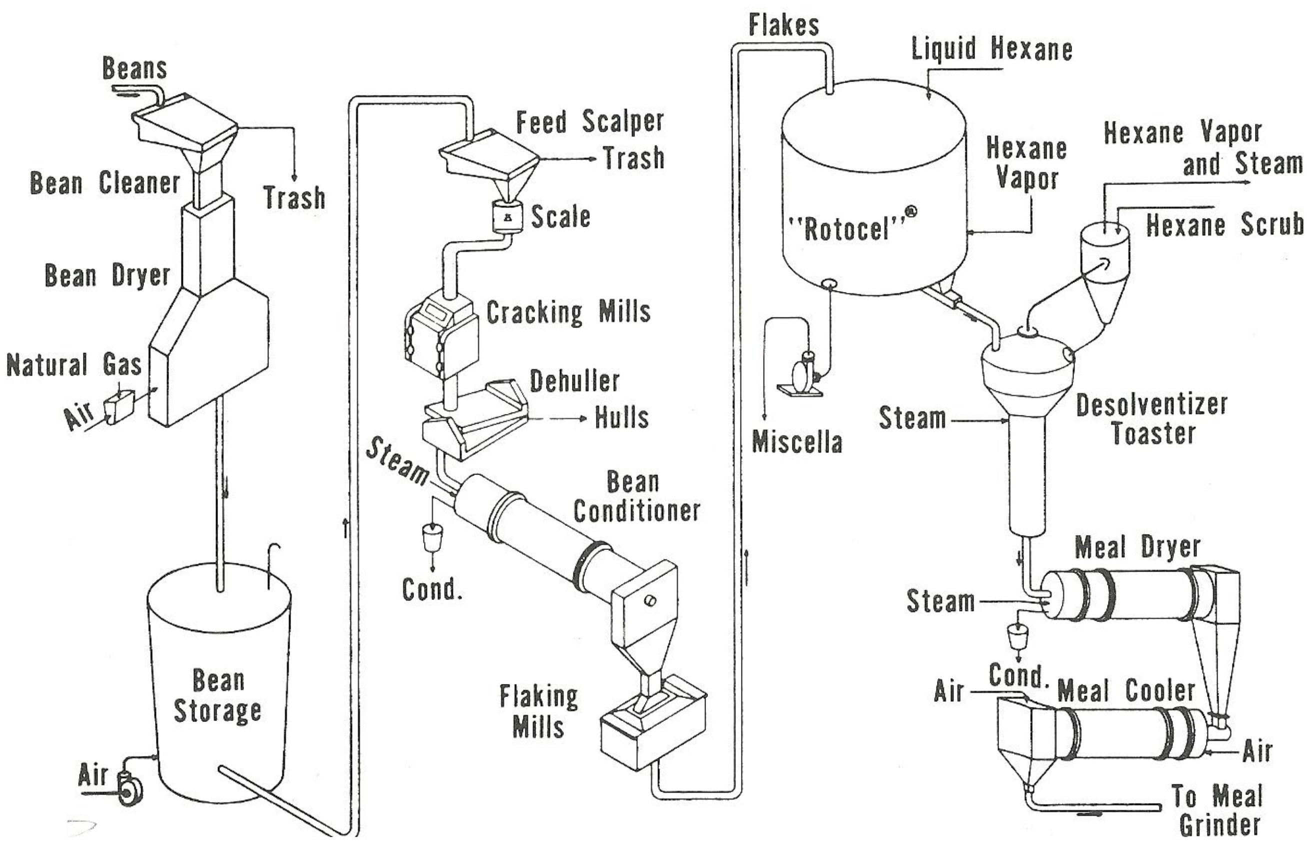

Fig. 2. Outline for processing soybeans into oil and meal by hexane extraction. Courtesy Dravo Corporation.

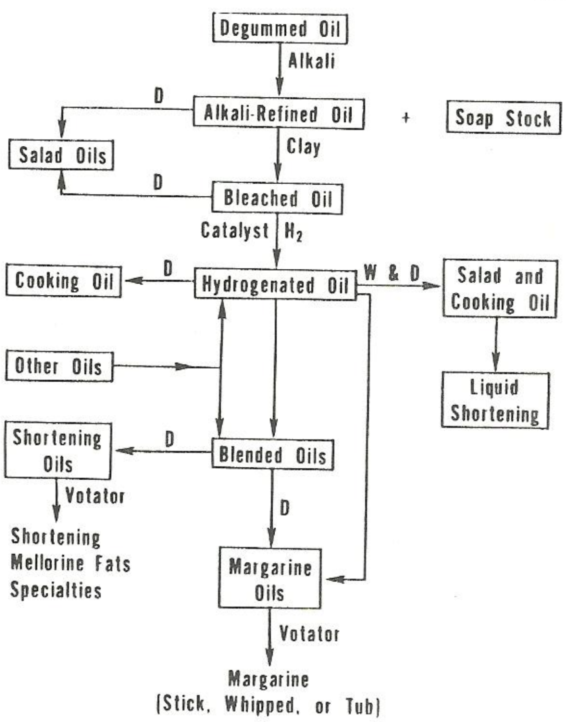

Fig. 3. Outline for manufacture of edible soybean oil products. D, deodorization; W, winterization; Votator, heat exchange equipment for solidification of fats. Source: Erickson et al. (1980), country of the American Soybean Association and the American Oil Chemists' Society.

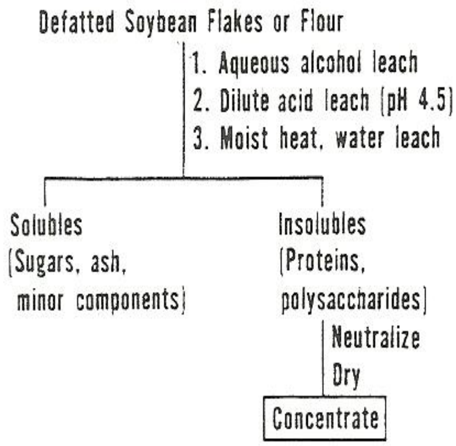

Fig. 4. Outline of processes for preparing soybean protein concentrates. Initial extraction is made by one of the three solvents, as described in the text.

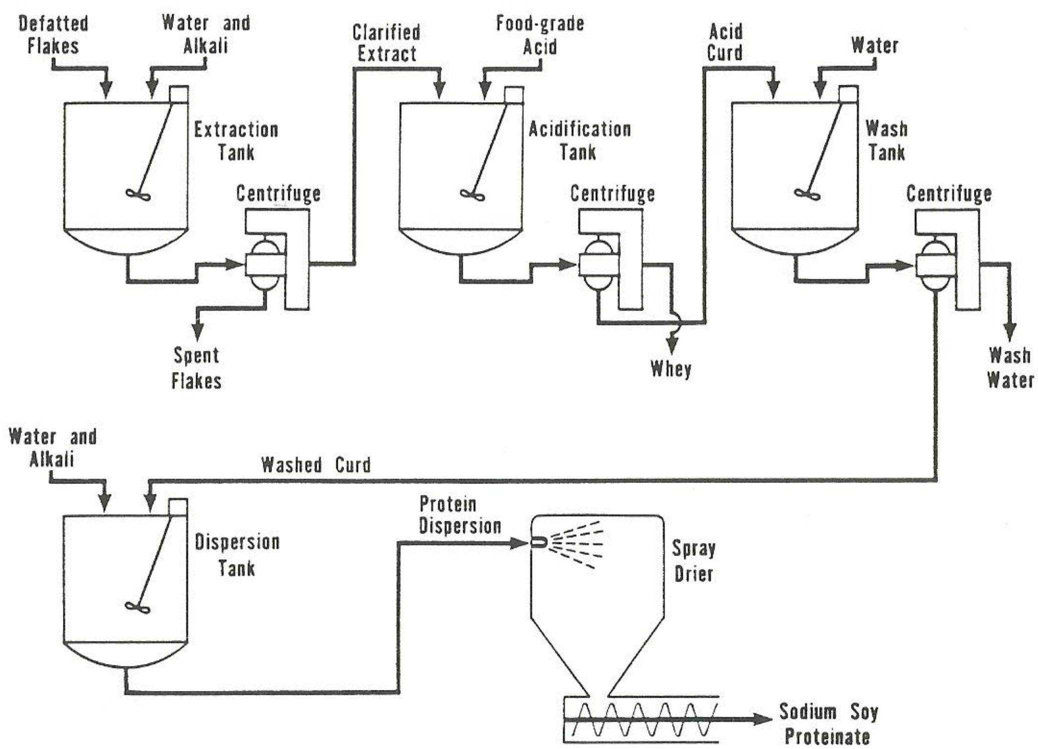

Fig. 5. Outline of process for commercial production of soy protein isolates.

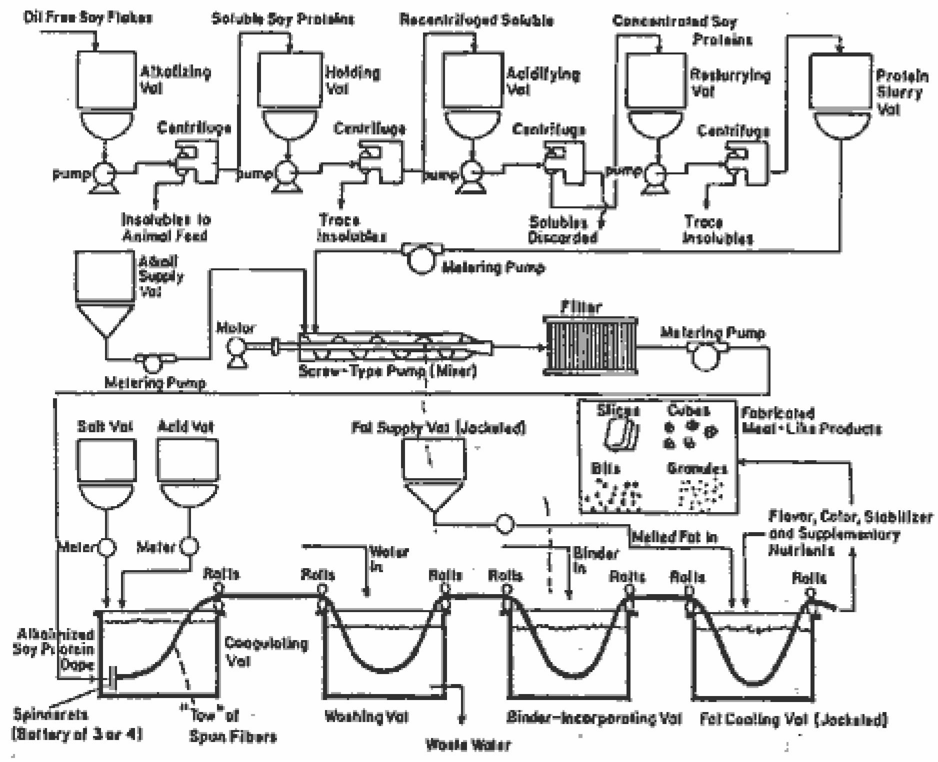

Figure 6: Production of Spun Fibers from Soy Protein Source: Horan 1974)

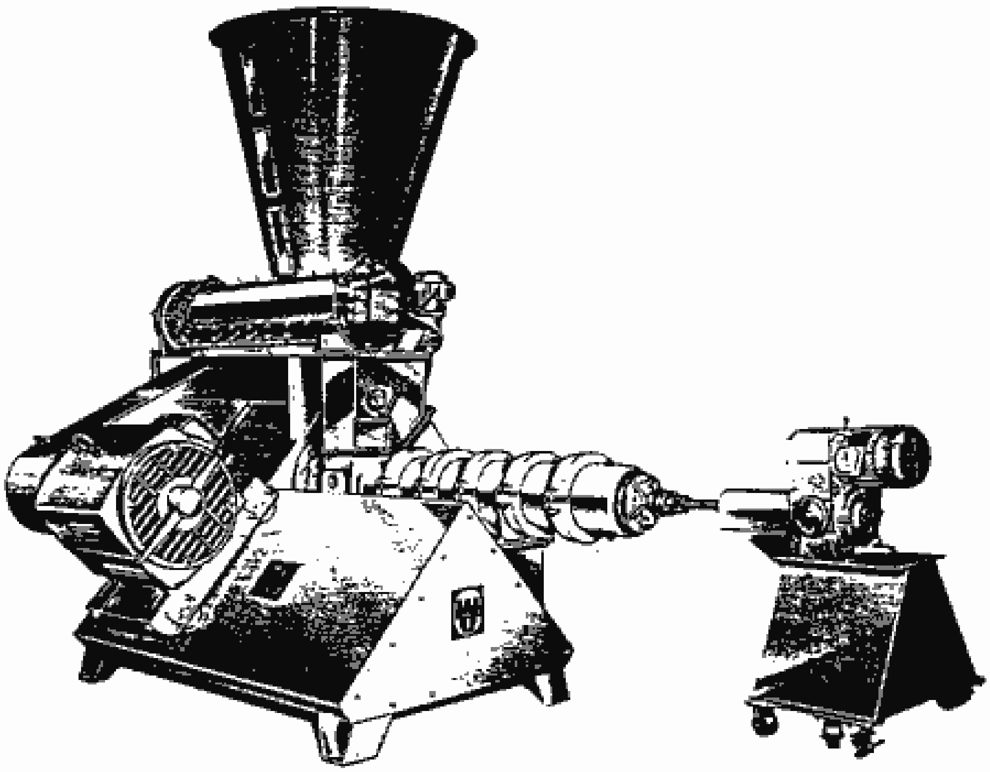

Figure 7: Cooker-extruder used for texturing soy flour (Courtesy: Wenger Manufacturing Co.)