

Soybean Processing & Products - Soyfood Home Preparation Methods

Dehulling Soybeans

Dry Method

1. Clean whole soybeans by removing damaged grains, dirt, and stones.
2. Heat the beans in oven or under the hot sun. Another way is to place the beans with little amount of corn meal in a saucepan and heat on a stove. The corn meal is used to prevent the beans from over being heated. Heating the beans on stove requires constant stirring.
3. Use a stone mill or hand grinder to split the beans and remove the hulls.
4. Winnow the hulls from the cotyledons.

Wet Method

1. Drop the whole soybeans into boiling water. Simmer the beans for 25-30 minutes.
2. Drain the blanch water and rinse the blanched beans well. Keep the beans in a bowl with cold water. Scrub the beans between two hands to force the hulls from the cotyledons. Drain the water with the hulls and repeat operation until most of the hulls are removed from the cotyledons.
3. These cotyledons can be directly used for preparing many soyfoods such as soymilk and tempeh. For the future use, they must be dried.

Blanching and Cooking Whole Dried Soybeans

Directions for blanching whole soybeans

Ingredients:

- 1 cup whole dry soybeans
- 1 pinch of baking soda (if available)
- 5 cups water for boiling (plus more water for rinsing)

Method:

- 1) Bring about 5 cups water to a boil.
- 2) Add 1 pinch of baking soda to the boiling water.
- 3) Drop the whole dry soybeans directly into boiling water.
- 4) Let the soybeans cook at a low boil for 5 minutes.
- 5) Drain off the boiling water and rinse the soybeans in cold water.

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Blanched soybeans are not ready to be eaten. They must be cooked before eating.

Directions for cooking whole soybeans

Ingredients:

5 cups water (plus additional as needed)

1 pinch baking soda (if available)

the blanched soybeans

Method:

- 1) Bring about 5 cups of water to a boil.

2) Add a pinch of baking soda to the boiling water.

3) Add the blanched soybeans and cook at a simmer for two to three hours. The time is approximate because factors such as the temperature of cooking and the age of the dry beans will affect cooking time. The beans will be firm but easily mashed when done.

4) Drain the beans to eat as is or to use in a recipe.

Cooked soybeans are perishable. They should be eaten the day they are cooked, or else stored in a refrigerator for up to several days.

Preparing Soymilk (INTSOY Method) and Okara

Ingredients:

9 cups (2000 g) water for blanching twice

1 1/4 cups (200 g) whole soybeans or cotyledons (dehulled soybeans)

1/2 tsp. baking soda (2.5 g) for first blanch

1/8 tsp. baking soda (0.5 g) for second blanch

9 cups (2000 g) water for grinding with blanched beans

Sugar as desired (usually about 3%)

Salt (0.2%)

Flavors as desired (vanilla or chocolate)

Method:

1) Clean whole soybeans or cotyledons by removing dirt and damaged soybeans.

2) Bring 4 1/2 cups (1,000 grams) water to boil on a stove. Add 1/2 tsp. (2.5 g) baking soda (0.25% of the blanch water by weight).

3) Add soybeans directly into boiling water and blanch for five minutes.

4) Drain and rinse with hot water.

5) Bring 4 1/2 cups (1,000 grams) water to boil on a stove. Add 1/8 tsp. (0.5 g) baking soda (0.05% of the blanch water by weight)

6) Add the blanched soybeans directly into the rapidly boiling water. Stir, return to boil, and cook for five minutes.

7) Drain and rinse with hot water.

8) Grind the blanched cotyledons or whole beans with 9 cups (2,000 grams) hot water for 3 minutes using blender setting at high speed.

9) Cool until warm to touch and filter through a cheese cloth by squeezing.

10) Simmer soymilk on a stove for 20 minutes, stirring occasionally. Add salt, sugar and flavors as desired. Refrigerate. Serve hot or cold.

Some ways to use soymilk are:

- Soymilk makes a nutritious and refreshing drink. Drink it plain, or add sweeteners or other flavoring.
- Soymilk may be used in cooking to make cream sauces or soups.
- Use soymilk as the liquid in baking breads, cakes, or other baked goods.

After making soymilk, the solid residue that is left is called okara. For each cup of dry soybeans used to make soymilk, you will get a little less than two cups of okara. Okara contains high-quality protein and fiber and can be used in many different recipes. It should be used the same day the soymilk is made, or refrigerated or frozen for later use.

Some ways to use okara are:

- Add okara to soups, stews, mashed potatoes, and cream sauces.
- Mix okara with ground meat before preparing meatloaf, meatballs, sausages or burgers.
- Mix okara with cottage cheese and chopped vegetables and seasonings to make a spread for bread.
- Stir a little okara into porridge and weaning foods.
- Use okara in mashed vegetables and nshima.
- Add okara to bread dough.
- Use okara as a base for making patties.

Soymilk (Traditional method)

Please see the method for tofu and follow the step from 1-5, then cook the milk until boiling (do not add calcium sulfate).

Preparing Tofu

Ingredients

2 1/3 cups whole soybeans (400 g)

8 cups water for soaking

12 1/2 cups water for grinding

2-3 Tbsp. calcium sulfate (15 g) mixed with 1/2 cup (100 ml) water

Method

- 1) Clean whole soybeans by removing dirt and damaged soybeans.
- 2) Soak whole soybeans in tap water (3-4 times of the dry soybean weight, approximately 8 cups) overnight or at least eight hours at room temperature.
- 3) Drain and rinse with cold water (weight of the soaked soybean is about 800 g).
- 4) Grind the soaked soybeans into slurry in a blender in 12 1/2 cups (3000 g) water for three minutes at high speed. (Can divide bean and water mixture into 2 parts to blend if blender is too small to hold 12 1/2 cups (3000 g) water and bean).*
- 5) Filter through cheese cloth to remove fibrous materials (okara). Collect the liquid portion (about 3000 g).
- 6) Simmer the soymilk for 10 minutes. While cooking the soymilk, prepare coagulant solution by mixing 2-3 Tbsp. calcium sulfate (15 g) in 1/2 cup water (about 100 ml water).
- 7) Monitor the temperature of soymilk closely. Cool the cooked soymilk to 80C (176°F).
- 8) Add coagulant solution to the soymilk with agitation. Immediately stop stirring as the curd begins to form. Allow the curd to set without disturbing for 10 minutes.
- 9) Break the curd evenly with a spoon. Transfer coagulated dispersion into a tofu mold lined with cheese cloth.
- 10) Fold cloth, cover with tofu lid and press with a heavy object (ex: a pot of water) for 15 minutes.
- 11) Remove tofu lid, unfold the cloth and remove the tofu mold. Cut tofu into pieces and put in cold water.
- 12) Store the tofu in refrigerator and change soaking water daily.

*In general, the ratio of water for grinding is seven to ten times the dry bean by weight, and the amount of coagulant used is 0.25 to 0.5% of cooked soymilk by weight.

Preparing Soynuts

Ingredients

100 g dry, raw soy cotyledons (2/3 cup)

0.25 g baking soda (1/8 tsp., leveled)

Salt

Enough oil for shallow frying

Method

1. Blanch soy cotyledons for 10 minutes by dropping them directly into 500 ml boiling water containing 0.05% sodium bicarbonate (0.25 g NaHCO₃).
2. Drain the blanch water and spread cotyledons on paper towel to remove excess water.
3. Shallow fry blanched cotyledons in small quantities until brown and crispy.
4. Sprinkle powdered salt to taste.

Soybean Processing & Products - Soymilk and Dairy Analogs

Advantages of Soymilk Products

One of the simplest methods for converting soybeans to a high-quality food is to produce a beverage known as soymilk. This product contains virtually the same amount of protein as cow's milk and is free of cholesterol and lactose. Soymilk is especially important for people who are allergic to the lactose in cow's milk.

Although less serious in the United States or Europe, the inability to digest the milk sugar lactose widely occurs in developing nations. Rates from 50 to almost 100 percent have been recorded among population groups in Asia, Africa and Latin America.

Because soymilk contains no lactose and is relatively inexpensive, it offers an attractive alternative to cow's milk for hundreds of millions of people in developing countries, as well as many people in developed countries.

Soymilk Acceptance Problems

Soymilk has been a staple in the Orient for many centuries. Traditionally, it is made by soaking the beans, grinding them with water, cooking the slurry, and then filtering to remove the sludge.

Unfortunately, the traditional soymilk has a distinctive beany flavor which is unacceptable to most consumers outside the Orient. This objectionable flavor results from the action of an enzyme when raw soybeans are ground and exposed to moisture.

The acceptability of soymilk further has been complicated by the unjustified tendency to compare it with cow's milk. Thus, in producing a widely acceptable soymilk, it is essential to carefully control a range of factors including flavor, color, viscosity and freshness.

Improved Soymilk Processes

Several of the problems associated with soymilk were solved as early as 1970 with a beverage developed by food scientists at the University of Illinois. The product is made by cooking and grinding the beans in a way that inactivates the enzyme responsible for causing the objectionable beany flavor.

The Illinois process used the whole soybean and produced a soy beverage with bland flavor, excellent suspension stability and good taste characteristics. Serious acceptance problems ensued, because the product tended to leave a chalky feeling in the mouth. Patent restrictions further limited the use of this process in many less developed areas.

INTSOY Home and Village Processing

Recently, INTSOY developed a new, inexpensive method to prepare soymilk at the home and village level. The following is a simplified form of this small-scale preparation process:

Drop whole, raw soybeans directly into boiling water containing a small amount of sodium bicarbonate and blanch for five minutes.

Drain the water, add the partially blanched beans to fresh boiling water containing sodium bicarbonate, and cook for five additional minutes.

Drain the blanch water and grind the beans along with the additional boiling water in an electric blender or hand grinder.

Stir the slurry well and filter with a finely woven, moist cheesecloth. Squeeze out as much milk as possible.

Simmer the filtrate for 20 minutes.

Add sugar and flavoring and pour into holding containers.

Heat treatment is the most important step. It is absolutely necessary to hydrate and thoroughly heat the raw soybeans before grinding into a slurry to prevent development of the typical beany flavor. This process adequately destroys the antinutritional Trypsin inhibitor.

Boiling times longer than recommended will reduce the amount of protein in the final product. The concentration of solids easily can be adjusted according to the final use of the soymilk.

New Commercial Process

Commercial soymilk processing equipment with an average capacity from 200 to 2,000 liters per hour is available for purchase with aseptic packaging from several sources at a cost of several million dollars.

A major focus of INTSOY research is on scaling up the improved soymilk processing techniques from the laboratory to the medium commercial scale. In simplified form, the process is as follows:

Clean and size whole soybeans.

Dry the beans by forced air in an oven.

Split the hot beans in a dehuller roller.

Separate the hulls and the cotyledons using an air blower.

Blanch the dehulled soybeans in a steam kettle.

Grind blanched beans on a continuous basis along with boiling water in a hammer mill.

Continuously extract the soymilk from the ground slurry using the roller extractor from an accepted tofu machine.

Pasteurize and homogenize the soymilk.

Long blanching times lower the recovery of nutrients. Very short cooking times are inadequate to destroy the enzyme that causes the beany flavor.

Making Dairy Analogs

The soymilk from this process is a bland product suitable for making a number of dairy analogs:

- Soy Yogurt

Yogurt is a tasty and nutritious product made by fermenting cow's milk to form an acidic gel. Soy yogurt is less acidic than regular yogurt and should have widespread consumer appeal. The steps for making soy yogurt are as follows:

Manufacture the soymilk.

Formulate the soymilk with sucrose and dextrose.

Pasteurize and homogenize.

Inoculate and incubate.

The culture must be carefully maintained. The temperature and time of incubation should be carefully controlled. The soymilk must be properly pasteurized to prevent contamination. A small amount of added sugar promotes the fermentation. The use of different sugars or sugar mixtures produce somewhat different flavors in the final product.

- Soy Ice Cream

This product is prepared from the soymilk and added vegetable oil. It is formulated and manufactured as in the conventional dairy ice cream process. The soy ice cream stores well and has good melt-down characteristics.

Developing Commercial Products

An excellent soymilk containing more than five percent protein can be prepared using this scaled-up method. At that concentration, about 10 kilograms of dehulled soybeans are needed to produce about 50 kilograms of soymilk.

This product contains from 7 to 10 percent total solids. That compares to cow's milk which has 10 to 12 percent solids, including about four percent protein. This soymilk should be nearly ideal as a base for commercial soft-serve ice cream products.

The okara or residue from the commercial process can be used immediately in baking or dried for later use as a high-fiber flour. The okara contains about eight percent protein on a wet basis or about 40 percent on a dry basis.

Benefits

The equipment used in this research is relatively inexpensive and widely available. It easily could be linked to a commercial soymilk operation with a volume of 100 to 200 liters per hour. With a larger roller extractor, the capacity could be expanded to as much as 600 to 800 liters per hour.

The new commercial-scale process being developed by INTSOY represents a major step towards effectively meeting the huge worldwide need for soymilk. The benefits should include the following:

A soymilk plant producing 100 to 800 liters per hour would be much less expensive than the available turn-key operations.

Smaller processing plants that prepare pasteurized products for local rather than nationwide distribution would not need costly aseptic packaging equipment.

The moderate cost for this type of operation could be particularly important for promoting soymilk in areas where there is a strong need for a high-protein beverage with only a limited of investment capital.

Soybean Processing & Products - Extrusion Cooking & Oil Expelling

Limitations of Standard Processing

In recent years, large-scale solvent extraction facilities have replaced mechanical oil extraction equipment for processing soybeans. The solvent process, in which oil is leached from flakes using hexane, a petroleum product, can easily remove at least 99 percent of the available oil from soybeans. The protein meal by-product provides large quantities of cheap animal feed and the base for numerous food and industrial uses.

However, this technology has proved to be generally unsuitable for individual farmers and entrepreneurs in the United States and many smaller developing countries. A large solvent extraction plant costs approximately \$20 million to build. Anything less than a daily volume of 200 tons of soybeans is considered uneconomical for even the smallest facility.

Mechanical Expeller Alternative

On the other hand, a mechanical screw press expeller costs from \$5000 to \$50,000, depending on its size, and can operate efficiently using the smaller quantities of soybeans available on individual farms and in developing countries. However, use of this alternative processing technique has been limited by several technical problems.

Because soybeans have a relatively low oil content compared to other sources such as peanuts, coconuts or palm kernels, conventional methods of expelling produce low oil yields. Running the soybeans through the expeller several times increases oil yields, but also causes overheating of the meal or cake, resulting in a brown color and scorched flavor. It also produces darkening and deterioration of the oil.

The Extruder as an Aid to Expelling

According to recent research at INTSOY, these problems can be overcome using relatively small-scale extrusion cooking equipment to condition the soybeans before expelling. The extruder produces heat by friction under pressure. A screw transports the ingredients through a series of restrictions within a cylindrical chamber, finally forcing the material through a die.

The extruder offers a convenient way of cooking the beans and breaking down the oil-bearing tissues in a fraction of the time required for conventional conditioning methods. The beans remain in the extruder system for less than 30 seconds at a temperature of approximately 275 degrees F. The short cooking time at high temperature is:

- Adequate to satisfactorily destroy anti-nutritional agents such as the trypsin inhibitor
- Not so long as to damage important nutritional components such as protein

INTSOY Research

The results of INTSOY research clearly indicate that expeller efficiency can be greatly enhanced by using hot extruded material in a nearly fluid state. High temperatures in the extruder release the oil, producing a semi-fluid state. At temperatures higher than 300 degrees F, the material tends to scorch.

At approximately 275 degrees F, there is a clear increase in the oil recovery rate when the extruded material is immediately fed into the expeller. As the extrudate cools, there is a drastic reduction in oil recovery regardless of the original extrusion temperature.

Advantages of Extrusion-Expelling

The results of combining the extruder and expeller into a single operation include:

- Oil yields approaching 75 percent with only a single pass through the expeller
- Production of a high quality, natural oil
- Large increases in the rated capacity of expellers
- Production of a partially defatted, protein-rich meal

Food Products from Extrusion-Expelling

A major objective of INTSOY's research effort is to produce low-fat cake or meal suitable for food uses. Results indicate that the combination of extrusion and expelling produces both a natural, edible oil and a high-quality meal with a color close to that of the raw material. The meal can be used in a number of food products including:

- A partially-defatted soy flour suitable for breads and tortillas
- Weaning foods
- Beverages
- Products for general protein fortification

Processing Advantages

This method also makes the milling process easier. For example, whole soybeans cannot be readily ground into flour by conventional milling equipment such as plate and hammer mills because of the high oil content, thereby limiting the production of full-fat soy flour in most developing countries. The partially defatted cake produced by the combination of extrusion and expelling grinds very well in conventional hammer mills.

This method further produces a high-quality, natural oil requiring little further processing. Oil from the expeller is:

- Passed while still hot through a screen to entrap the coarse sediments
- Allowed to stand overnight for cooling and sedimentation
- Decanted, leaving the sludge behind

The clear, light-colored oil is free of any off-flavor and is generally comparable to refined and partially hydrogenated oil in stability. It would be suitable for use in developing countries where there is little or no refining of vegetable oils used for human consumption. The oil also could be an important natural product for the U.S. health food industry.

Omega-3 in Soybean Oil

A number of recent reports indicate that dietary Omega-3 fatty acids have a beneficial effect on cardiovascular diseases. Raw soybean oil contains an average of 7 to 8 percent naturally-occurring Omega-3 in the form of alfa-linolenic acid. In most cases, the Omega-3 is partially destroyed during the normal refining process. The exact amount that is lost depends upon the degree of refining.

The highly stable oil resulting from extrusion-expelling retains virtually all the Omega-3 found in raw soybeans. The content in soybeans is much higher than in corn, coconuts, palm kernels and sunflowers, all of which have less than one percent.

The only common food crop that has more Omega-3 than soybeans is rapeseed, which has 10 percent. On the other hand, fish oil averages approximately 20 percent Omega-3.

Increasing Omega-3

University of Illinois germplasm experts already have identified several soybean varieties with Omega-3 contents in the 12-13 percent range. Through genetic engineering, it may be possible to develop new varieties with an Omega-3 content equal to or higher than that of fish oil.

The soybean oil from the extrusion-expelling process easily could be made into salad dressing and mayonnaise. Therefore, the relatively high Omega-3 content of soybeans creates tremendous potential for marketing the oil made using this new concept.

Benefits

This new combination of extrusion and expelling technology has tremendous potential for:

- Developing value-added products with high market potential as health foods
- Increasing decentralized processing of soybeans in regions where production is as small as 3,000 to 5,000 hectares
- Opening up soybean processing to many individual farmers and entrepreneurs interested in marketing high-quality, edible oil, along with animal feed and protein-rich soyfoods
- Promoting new economic activity which should result in both improved human nutrition and higher demand for soybeans and processed soy products.