

Taming of the Golden Bean

Rajendra P. Gupta
ProSoya Inc.
2-5310 Canotek Road, Ottawa, Canada K1J 9N5

For time immemorial, soybean has been known as the best source of plant protein and is rich in nutritive minerals and dietary fiber. Recently, nutraceutical aspects of the bean have become well recognized even in the western world. Foods derived from soybean have been shown to selectively lower the bad cholesterol and aid in reducing the chances of developing cancer. In women, soyfoods consumption minimizes the menopause symptoms. For this reason and because of its color, soybean is aptly referred as the Golden Bean.

The use of soybean in foods has been rather limited outside the Orient, mainly due to the rancid-oil-like taste problem of such foods, especially those derived from soymilk. This bad taste is imparted by the catalytic action of lipoxygenase enzyme in synthesizing off-flavor causing volatiles from lipids in the bean in the presence of water and oxygen. Until recently, the only successful way of combating the off-flavor problem was to kill the lipoxygenase enzyme, such as by thermal and/or chemical treatment. However, killing the enzyme is like treating cancer; for the process also adversely affects a lot of good protein cells, making the extraction of soluble protein in water very difficult.

The Golden Bean was finally tamed with the invention of a natural process in which the soybeans are ground in water in the absence of air at a temperature that is too low to adversely affect the lipoxygenase enzyme and the proteins. This air-less cold-grind process permits the soluble solids in soybean to easily dissolve or make a colloid in water. Any heat treatment necessary to make the product digestible is performed only after air-less cold-grind step. It results in clean tasting soymilk without the characteristic chalkiness imparted by alternate methods.

The new patented invention has been developed into a technology that has been used to produce good tasting dairy-like soyfoods and beverages at all levels. Commercial and industrial scale equipment for producing soymilk using this technology, in capacities ranging from 50 L/H to 10,000 L/H of finished soy beverages, are currently operational in various parts of the world, including Canada, the USA, UK, Russia, and India. A household soymilk appliance is under development and has recently been tested by NASA for their manned mission to Mars.

There are four basic methods of producing soymilk. These methods are compared in Table 1.

Method >	Traditional	Hot-Grind	Hot-Blanch	Airless Cold-Grind
Soybeans	Whole Any Type	Whole or Dehulled High Quality	Whole or Dehulled Good Quality	Whole or Dehulled Any Type
Processing Chemicals	Not Required	NaHCO ₃ , NaOH, HCl,...	NaHCO ₃ , NaOH, HCl,...	Not Required
Bean Soaking	Yes	Optional	Hot Blanch	Preferred
Process	Cold Grind in Water Cook/Filter Or Filter/Cook	Hot Grind in Water Cook / Vacuum / Filter	Hot Grind in Water Cook and High Pressure Homogenize	Airless Cold Grind in Water Cook/Vacuum / Filter Or Airless Filter Cook /Vacuum
Soymilk	Dissolved Solids	Partly Dissolved Solids	Mostly Suspended Solid	Dissolved Solids
Odor	Rancid	Less Rancid	Roasted Nuts	Cereal
Flavoring	Very Difficult	Difficult	Easy	Easy
Mouthfeel	Smooth	Chalky	Very Chalky	Smooth
Protein Yield	70-90%	60-80%	Up to 98%	70-90%
Basic Plant Cost	Low	Medium to Very High	High	Low to Medium
Soymilk Plant Available From	Sato Kawanishi Kurihara Takai, etc.	Alfa-Laval Kibun Mitsubishi APV-DTD	INTSOY Kibun Pant Nagar	ProSoya ASSOY SSP

The age old Chinese and Japanese method (traditional method) uses cold grinding of well soaked and rinsed soybean in a stone mill with water. The resulting puree is mixed with additional water and cooked in an open caldron or in a pressure cooker for an adequate time to make it digestible. The cooked slurry is filtered through a filter bag to extract soymilk. The okara (residue in the bag) is pressed to squeeze out more soymilk. The squeezed okara is mixed with water and filtered and pressed again to obtain thin soymilk. This thin soymilk is either mixed with the soymilk already extracted or used in place of water in the stone mill when grinding soybean in order to improve soymilk yield. This method gives soymilk with excellent mouth-feel and good yield. However, the soymilk has very high level of the rancid-oil-like smell which is rather repulsive, especially when soymilk is consumed as a cold beverage rather than as a hot drink.

The other most commonly used method is the hot-grind method in its variety of proprietary and sometimes patented forms. Essentially, it involves grinding soybeans (with hulls or without, soaked or dry) with hot, almost boiling water,

sometimes accompanied with steam injection, to make ground soybean slurry. Most hot-grind methods use sodium bicarbonate or caustic soda to increase the pH of the water to make it significantly alkaline. High temperature and pH substantially inactivate the lipoxygenase enzyme and reduce the rancid-oil-like taste in soymilk. Once the soymilk is extracted, its alkalinity is neutralized by adding hydrochloric or some other acid. Soymilk extracted with this method has significantly less rancid-oil-like off-flavor but suffers from a chalky mouth-feel resulting from the adverse affect of heat on the protein solubility.

Some researchers decided to take the hot-grind method a step further by thoroughly blanching the soybean by boiling it in water or alkaline solution for a duration that is long enough to completely inactivate the lipoxygenase enzyme.. This hot-blanch method eliminates the rancid-oil-like flavor completely at the cost of adding roasted nut flavor to the product and making the protein almost completely insoluble in water. The blanched soybeans are ground very fine in water, usually in a colloid mill, and the resulting fine slurry is passed through a high pressure homogenizer. The soymilk thus obtained is a suspension of fine soybean particles in water and in spite of its pleasant taste has very chalky mouth-feel. When alkaline solution is used, the soymilk is neutralized with an acid to achieve a pH of 6.7 to 7.2.

The airless cold-grind method has been developed to keep the virtue of the traditional cold grind method (the smooth mouth-feel) while eliminating its curse (the rancid oil like off-flavor) in the making of soymilk from soybeans. In this method, the culprit enzyme lipoxygenase is unable to catalyze the reaction among the reactants (oxygen, water, and oil) to produce off-flavor volatiles like aldehyde, keytones, furans, etc., for one of the reactant (oxygen) is kept out of the reaction volume. No heat treatment is required to partially or fully inactivate the enzyme for controlling or eliminating the off-flavor. Any heat treatment to improve the protein efficiency ratio (PER) and to inactivate the trypsin inhibitor enzyme is differed until soy protein and other solubles are already in the water. Such heat treatment in the later stage of processing is desirable to make the product digestible and to denature any antinutritional factors. The chalky taste is thus eliminated without compromising the mouth-feel. No chemicals are at all are required in this method.

For good mouth-feel of soymilk, the rule is to avoid heat treating soybeans above 50 °C prior to or during the grinding process.

ProSoya Inc. offers soymilk equipment and plants in various sizes suitable for production requirement from cottage industry scale to large scale.

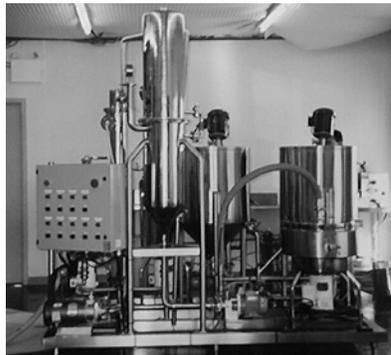
VS30/40 is a low budget soymilk system in a table-top configuration (*Picture 1*). It comprises a grinder-cooker unit, a mechanical filter press, and either a fuel-fired or an electric steam generator and a tofu forming box. Priced about US\$6,000, it is suitable for laboratory use, restaurants, hospitals, volunteer help groups, and other small volume production requirements. Depending on the steam generator, it can

produce 30 to 40 L/h of soymilk base or up to 80 L/h of soy beverages or 10 to 12 kg/h of tofu. Several hundred such systems are currently in operation throughout the world.



VS40 System shown complete with electric boiler, filter press and tofu box

VS200 produces 200 L/H of soymilk base or up to 400 L/H of soy beverages in a compact skid mounted configuration (*Picture 2*). Costing under US\$40,000, it is the smallest system that includes vacuum deodorization. It also has a one stage centrifugal extractor to continuously separate soymilk from okara, the fibrous residue. This system has recently been developed for those who wish to produce soy beverages and foods using the airless cold grinding process without paying production royalties and for whom the smaller VS30/40 SoyaCow system is inadequate. Four systems have already been sold.



VS200 system show skid mounted with optional soy beverage blending tanks

VS2000 produces 2000 L/H of soymilk base or up to 5000 L/H of soy beverages (*Picture 3*). It is a continuous system right from the grinding of soybeans to the point of storage of soymilk in the bulk tank or for its further processing. A VS2000 system used solely for making powdered products may be assembled without the vacuum flash tank to minimize the plant cost, for extensive deodorization takes place in the evaporator and dryer. The system is mounted on one or more skids depending upon the options desired. 10 such systems have been built for customers in Russia and Canada. The system price starts at US\$250,000 (for the unautomated system without vacuum flashing operation).



Basic VS2000 system less the flash tank for deodorization

VS4000 is essentially a scaled up VS2000. It can produce up to 4000 L/H of soymilk base or up to 10,000 L/H of soy beverages. The systems are mounted on one or more skids depending upon the options desired. A VS4000 system is currently operational in Scotland.

SoNice™ is the most well known brand of beverages (*Picture 4*) and other soyfoods which use the airless cold-grinding process under license from ProSoya. SoNice is currently available in the US, Canada, and the UK at many supermarkets and most healthfood stores. SoNice is produced in several formulations including Natural, Original, Vanilla, Chocolate, Cappuccino, and Strawberry flavors, and may be fortified with vitamins and minerals. The packagings currently offered are 1 L and 2 L in the refrigerated extended shelf-life gable top format and 200 mL, 250 mL and 1 L in the room temperature shelf-stable long shelf-life UHT Tetra and Combie formats. Sizes are slightly different in the US to accommodate the US gallon based measure.



SoNice beverages in refrigerated gable-top format

It should be made clear that soyfoods and beverages made by any process do not taste like dairy based foods and beverages to most consumers. Nevertheless, soyfoods and beverages made using the airless cold-grind process do have their own good cereal taste. SoNice formulations developed for the process are liked by most people including those of European, Asian, and African descents. For this reason, SoNice customers include a large number of mainstream consumers. As a result, the total market of beverages has greatly expanded and is continuing to expand at a rapid rate.