Sustainable agriculture for the future

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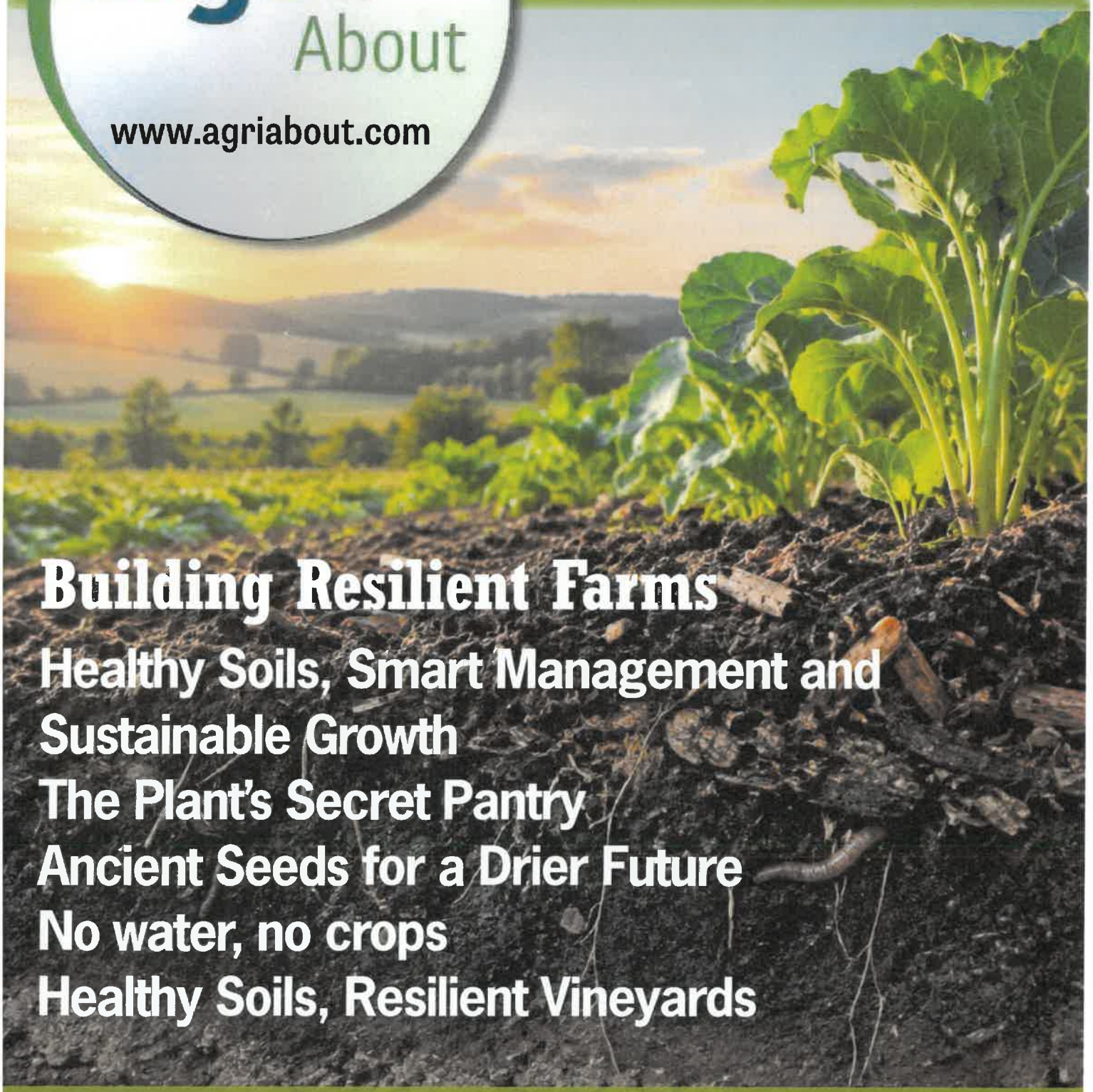

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The Secret Life of Soy: How a Humble Bean Becomes a Creamy Beverage

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Soymilk is the aqueous extract of soybeans. When first introduced to the Western World, it was not very popular due to the "beany" taste that traditional extraction methods imparted to the product. However, modern extraction techniques have substantially improved the flavour as well as the product yield, making it more economic for processors and producers alike.

Soymilk is consumed in much the same way as dairy milk. It has also found an important market as an alternative food source for babies who are allergic to dairy milk. It can be formulated and fortified to be consumed as a beverage or food supplement. Soymilk can also be concentrated by evaporation or spray drying and can serve as substrate to prepare dairy analogues such as tofu, soy yoghurt, and soy ice cream.

Modern soymilk extraction methods seek to eliminate the development of undesirable elements and improve the flavour of the final product. To do this successfully and understanding of the chemistry of the "beany" flavour formation is required. The characteristic flavour of soymilk results mainly from reactions catalysed by an enzyme known as lipoxygenase. These enzymes need to be released to come into contact with its target-chemicals, in the presence of water. All these conditions are met when soybeans are ground and mixed with water to form a slurry. The temperature of the soy-slurry has a great effect on the rate of flavour development. As the temperature increases, so the number and volume of volatiles decrease. The enzymes are inactivated at 80°C and therefore it is critical that the slurry be heated to 80°C or above as soon as possible after, or even during, wet grinding. As an alternative, the dehulled beans can be blanched prior to grinding. Most commercial soymilk plants employ a combination of these techniques, or variations of the traditional means of producing soymilk. Regardless of the variation I process, the basic steps and principles of soymilk extraction are essentially the same.

Raw Material Selection
The selection of the right variety of soybeans is essential to successful soymilk production. Not only does it influence the quality of the product, but also the economy of the process. High yield and protein extraction is desired from the cultivar. The typical soybean used for milk extraction should yield 80% or more protein and between 55-65% total solids.

Cleaning of Soybeans
The first step in preparing the soybeans for processing is to remove foreign materials, including plant rests, stones, and dust. Cleaning is performed by a series of vibrating screens followed by aspirators and cyclone separators.

Dehulling for Milk Extraction
Most manufacturers choose not to remove the hull of the soybeans prior to extraction, because dehulling can damage the cotyledon and released oxidative enzymes that cause off-flavours. There are various arguments for and against dehulling.

If the manufacturer does preform dehulling, they need to keep a few key points in mind:

- It should be done in-line with grinding, with no residence time in between.
- It must be dome with minimum heating/ heat-hold time.
- It must be done in the absence of water.
- It must be done with a little as possible damage to cotyledons.

Soaking
There are several ways of incorporating water with the beans to obtain an aqueous extract. Soaking is one of these ways. Traditionally it was done overnight in cold water, but the soaking time can be greatly reduced by increasing the temperature of the soak water. The beans can increase in weight 2-2.3 times during soaking. The benefits include:

- Reduced power input requirements for grinding.
- Less erosion of millstones/blades.
- Reduced blanching/cooking requirements.
- Increased dispersion of "milk" solids.
- Increased yield.

Blanching
Blanching is done to inactivate the enzymes that are responsible for off-flavours and reduces the surface microbial load of the soybeans. Anti-nutritional factors such as trypsin inhibitors are also partially deactivated, and the beans are hydrated if the soaking step was not performed. Blanching is done as a two-step process with or without the addition of sodium bicarbonate.

Step 1: The beans are heated for 5 minutes in boiling water containing 0.25% sodium bicarbonate.
Step 2: the beans are drained, rinsed, and boiled again for 5 minutes in water containing 0.05% sodium bicarbonate. The addition of sodium bicarbonate to the blanching water is optional, but has several advantages:

- If the beans were not dehulled, it softens the hulls and tenderises the beans.
- Shortens the blanching time.
- Reduces the energy input required during grinding and homogenisation.
- Raises the pH, making soy proteins more soluble and increasing protein and solid recovery.

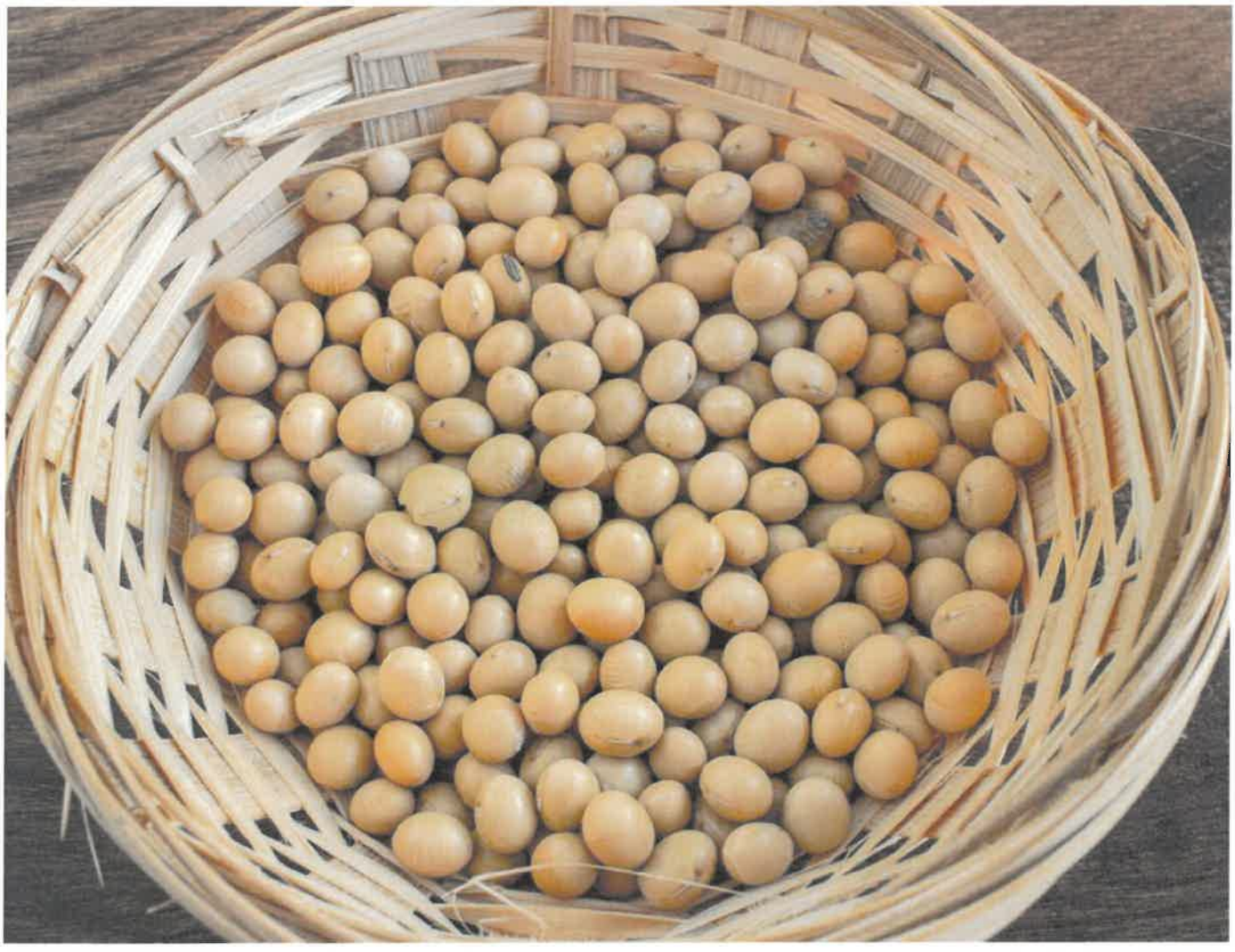
The disadvantages include:

- The possible addition of acid to neutralise the pH.
- The destruction of some key nutrients'
- The possibility of a soapy after taste.

Grinding

The purpose of grinding is to disrupt the tissues and release proteins, lipids and other solids for solubilisation and suspension in water. The method used depends largely on the preceding hydration and preparation steps. Grinding may be performed dry or wet, with hot or cold water:

- Dry grinding: This method is used by some processors to bypass soaking and blanching. The dry flour is mixed with water to form a slurry.
- Cold, wet grinding: Soaked soybeans were traditionally ground at ambient temperatures.
- Hot, wet grinding: This is the most used method. Grinding and hydration is performed in one step. Hot water and controlled conditions are required to coincide with grinding to prevent off-flavour development. The air may be saturated with steam to reduce the available oxygen and inactivate lipoxygenase enzymes.



Grinding equipment include the traditional stone mills, large blenders, hammer mills, pill milks and large commercial grinders.

Filtration and Milk Extraction
The efficiency of extraction directly determines soymilk yield. Soymilk is extracted from the slurry by:

- Filtration through cloth or vibrating screens.
- Pressing sacks.
- Centrifugation.

Extraction methods can be repeated or combined to improve extraction efficiency. The insoluble solid residue (soy pulp/okara) still contains some protein and other solids. To maximise the yield, the okara is often washed with hot water and filtered again. Filtration is omitted all together in certain cases to produce a soymilk with 100 % solids content. This naturally delivers a product with the highest yield but requires proper homogenisation and may have an unusual "chalky" mouthfeel.

***PLEASE NOTE**: The following processing steps (Cooking, Deodorization, Formulation, Fortification, Homogenisation), are optional depending on the intended final product, but are highly beneficial and as such is encouraged.*

Cooking
Cooking the soymilk increases its storage life by inactivating microorganisms and enzymes that cause spoilage. It improves the flavour of the product by inactivating the enzymes responsible for off-flavour development, improves the nutritional value by inactivating anti-nutritional factors such as trypsin inhibitors and lectins, and denatures the soy proteins, making them more easily digestible. Heating at 85-87°C for 20 minutes is common, but overheating should be avoided to prevent Maillard browning, loss of vitamins, and the development of a cooked flavour.

Deodorization
Soymilk can be deodorized to improve the flavour, or to remove off-flavours that formed during the production. This is done in a vacuum pan at high temperatures and high vacuum conditions (115°C, 0.526mm/HG). It is a very expensive process but strips the milk of all volatiles and produces a very bland product.

Formulation
Formulation involves the addition of sweeteners and flavours to soymilk to produce a more acceptable product for drinking. Ingredients that are commonly added include honey, maple syrup, sugar, vanilla extract, cocoa powder, orange juice, malt, coffee, almond extract, oil, and lecithin.

Fortification
Fortification aims to improve the nutritional profile of a food product by adding nutrients such as vitamins and minerals. Soymilk intended for baby formulas in typically fortified with calcium, B-vitamins, and essential amino acids like methionine and lysine.

Homogenisation
Homogenisation is the process whereby a liquid is forced through a very narrow opening under high pressure with the aim of breaking up fat globules, reducing them in size and ensuring they remain suspended throughout the liquid. Homogenisation prevents the separation of the fat and aqueous phases, producing a stable emulsion.

Soymilk contains aqueous and fat phases as well as large solids and added-in ingredients that need to be thoroughly mixed to form a stable food system. This is usually done at 2000-3500psi at a temperature of 90°C. The homogenised product has a smooth, creamy mouthfeel, and whiter appearance. *Homogenisation is essential for unfiltered milk and milk formulations.*

Stabilisation and Packaging
Soymilk is a highly nutritional food product and the ideal growth medium for bacteria. Commercial soymilk requires a heat stabilisation treatment such as pasteurisation or sterilisation to make it safe for consumption and the extend the shelf life. The heat stabilisation treatment is given just before or just after packaging or can even be part of the packaging process as in the case of aseptic packaging.

There are 3 basic processing options:

- Pasteurisation involves heating the milk to 75°C for 15 seconds in a heat exchanger to ensure that all vegetative bacteria that cause spoilage is destroyed. The pasteurised product is packed in glass bottles, plastic pouches, or gable-top cartons. It has a shelf life of 7 days and requires refrigerated storage. It is the best method of preservation for nutrients and original flavour.
- Sterilisation involves heating the milk to 121°C for 20 minutes in an autoclave to ensure that all forms of bacteria and their spores are destroyed. The milk is filled and sealed into cans, glass bottles, or retort pouches prior to sterilisation. The sterilised product has a shelf life of 2 years and does not require refrigerated storage. However, the high temperatures and long processing time involved causes signification vitamin loss, browning, and flavour deterioration.
- UHT processing involves heating the milk to 140-150° for 2-8 seconds in as aseptic system followed by flash cooling in a vacuum system prior to aseptic packaging in laminated box cartons, plastic bottles, or pouches. The process destroys all vegetative bacteria and their spores with minimal thermal damage to the product. The product has a shelf life of 6-8 months and requires no refrigerated storage. An added advantages of the process for unflavoured milk is the deodorisation that takes place during flash cooling.

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