SOYMILK PROCESS

BACKGROUND OF THE INVENTION

The ever enlarging gap between world food supply and world demand for high quality food products continues, and has in the recent past and will continue in the future to force shifts from animal to vegetable sources of protein for human nutrition. Soy-based milk analogs are known in the prior art and have been shown to have potential in improving world-wide nutrition, particularly in less well developed countries. In this country, soybeans have been grown primarily for their oil content, the meal residue being used as livestock feed; only 3 to 5 percent of the annual domestic soybean crop is used for direct human nutrition. The largest domestic market for direct human use has been for milk substitutes for infants allergic or hypersensitive to bovine milk. Soy products are also currently used in a variety of applications including protein fortification and enhancement of functional properties in baked products, texturized imitation food products, the extension of comminuted meat products, and the fortification of breakfast cereals and beverages.

FLAVOR PROBLEMS

Although the functional and nutritional benefits of soy products have been demonstrated in numerous human food applications, the utilization of soybeans in non-Oriental food consumption patterns has been limited due to the presence in those soy products of biologically active components of the soybean and enzymes which catalyze the oxidation of fatty acids having conjugated carbon-carbon double bonds. The latter enzyme causes rapid flavor deterioration when raw soy flour is slurried or when soybeans are ground in water. It is largely this flavor problem which has precluded the extensive use of soy products outside the Orient. Numerous methods have been devised to reduce this off-flavor development; however these methods also reduce yields of soymilk, dispersable endogenous protein content and the functional properties of the protein generally, and the nutritional qualities of the soymilk occasionally. These processes have the further disadvantage of requiring large amounts of installed energy-intensive capital and a great deal of technical expertise in operation, and generate large amounts of waste water having high biological or chemical oxygen demand.

The extent to which undesirable flavor components are inherent in the soybean itself and the extent to which such flavors are produced during processing has not yet been fully defined. It is generally accepted, however, that comminution of the intact soybean during processing does in fact generate significant off-flavors, particularly when previously nonheat-treated soy particles contact water.

It is now generally recognized that the typical raw soybean flavor which results upon maceration of the bean is decreased by either moist or dry heat application preceding maceration, and this because the enzyme lipoxygenase (linoleate oxygen oxidoreductase, EC 1.13.11.12) is heat sensitive. Primary oxidation products of both lipoxygenase-catalyzed reactions and autoxidation are thought to involve the formation of nine- and thirteen-hydroperoxide isomers of linoleic acid, in which the hydroperoxide oxygen derives from the gaseous phase. These hydroperoxides in turn undergo a variety of enzymatic and nonenzymatic reactions to produce volatile carbonyls and organic acids which have very low flavor thresholds. Once the off-flavor is produced it is not currently possible to eliminate it entirely or to mask it. It has been further reported that the off-flavor caused by lipoxygenase activity, which results when the cell tissue of soybean cotyledons is disrupted in the presence of even a small amount of moisture, develops almost instantaneously. It is generally assumed that this enzymatic activity is minimal at the usual moisture content of dry merchantable soybeans before grinding or comminution.

Soymilk has been prepared for hundreds of years in the Orient by a traditional water-extraction method which involves soaking the soybeans in water for several hours, draining, grinding with additional water, filtering to remove the insoluble residue and cooking the filtrate for about thirty minutes. This process continues to be practiced today although it produces a soymilk which has a flavor to which Occidentals have not become accustomed. All efforts to transplant this process to developing third world cultures have failed largely as a result of the unacceptable flavor of this liquid product. It is generally recognized that the traditional Oriental method allows extensive lipid oxidation by lipoxygenase; grinding the bean in water produces ideal conditions for lipoxygenase activity (hydration, increased surface area for water contact, fat dispersion, abundance of oxygen, and optimum pH and temperature for enzyme activity). The filtered water extract is heat treated to pasteurize the extract and to partially reduce the off-flavor produced; it is only in this latter step that lipoxygenase is inactivated, far too late to preclude off-flavor development. In addition, some soluble protein is insolubilized by the heat, forming a surface scum or a precipitate which must be removed before bottling.

Dry-heat roasting of the whole unbroken soybean has been used to inactivate lipoxygenase and trypsin inhibitor prior to processing soybeans into numerous derivative products.

It was found that while dry heat at 200° F. for thirty minutes greatly reduced enzyme activity, protein extractability yield is also greatly reduced, a nutty flavor distinguishable from that of lipid oxidation products develops, a chalky texture in the extract is produced and the color darkens, all of which are undesirable.

The traditional soaking of whole soybeans at ambient temperature prior to wet grinding presumably tenderizes the beans, facilitates comminution or grinding and enhances extraction of solids. Yet, despite the fact that soaking is nearly always used, there is no clear demonstrated advantage to this pretreatment. In fact, lipoxygenase activity has been shown to occur, although at a low level, during this period even though soybean seed coat remains intact; at a very minimum, the soaking process brings the soybean lipoxygenase to a potentially active state from which the enzyme becomes instantly active once the soybean seed coat is disrupted.

Blanching of whole soybeans prior to grinding very severely and permanently "sets" the protein bodies therein, and denatures protein and therefore prevents solubilization of the soy proteins, allowing a yield of soybean solids including lipid and protein in the aqueous extract only much lower than soymilks prepared by other methods when centrifuged at 1000 g.