

SWEET POTATO: The Versatile Vegetable

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It supports human populations and adds nourishment and variety to millions of diets. It provides starch and sweetening for the Japanese, it has been used as a replacement for wheat in making bread in the USA and Israel, and it has been fermented for alcoholic beverages and a number of commercial solvents. It has even been used for wallpaper paste. Chickens, pigs, and cows have been fed on its raw, ensiled and dehydrated roots and vines. It is *Ipomea batatas*, the sweet potato.

In view of the many possible uses of sweet potato, its potentialities have hardly been touched. For the most part, the sweet potato has been produced and used as a single purpose crop. In order to take advantage of its versatility, utilization systems must be devised to use the entire crop for many purposes and products. Old and recent technology suggest the use of sweet potatoes in many ways for a variety of products.

The sweet potato can grow continuously, utilizing agricultural land for any length of growing season. In the southeastern United States, it can grow for 180-200 days, fixing carbon by photosynthesis just as fast as a field of corn or a forest can. In doing this it takes minerals and water from the soil and, through infinitely complex chemical processes, combines them with the carbon to form sugars, starch, cellulose, protein, and the whole gamut of vitamins. Under ideal conditions there is no agricultural crop that can provide as much nutrition per acre in a growing season as the sweet potato. As the world's population grows, cities crowd out cornfields and super highways carve up vast plains of wheat, increased agricultural efficiency will be demanded. By adding the dimension of time to horticulture and by growing crops which will make maximum use of growing seasons, increased food can be made available, not using more land, but using it longer. The knowledge and technology to produce more are here. The limitation is the willingness and imagination to use what can be produced. Food scientists are now providing the imagination.

Recipes are available to every homemaker for preparing sweet potatoes for the table by baking, boiling, frying, casseroles, etc.; but sweet potatoes can be used in other ways. During World War I, the U.S. Department of Agriculture was searching for substitutes for wheat flour and found that sweet potatoes could be used to replace one-fourth of the wheat in a loaf of bread. After World War II, Israeli scientists used sweet potato in making bread and rolls because the sweet potato produced 6-8 times as much food as does wheat.

For many years Japan and Taiwan have found sweet potatoes to be the most economical source of starch for their countries. Considerable technology has been developed there for obtaining starch and converting it to sugar, but the starch industry in the Orient has wasted many valuable nutrients and fouled streams and bays with such waste. Japanese and Chinese scientists have developed methods for producing commercial alcohol, acetone, butanol, itaconic acid, citric acid by fermenting sweet potatoes. They have also devised methods of using sweet potato in soy sauce fermentation.

In several nations around the world, sweet potatoes have been used for animal feed. Swine and chickens do well on raw or dehydrated sweet potatoes. In the United States, similar experiments have been conducted showing that on the basis of dry matter sweet potato is equal to corn. Limited feeding trials with cattle have suggested that cattle can use the high energy value of sweet potato to convert commercial sources of nitrogen e.g. urea into milk and meat proteins. Such a system uses nitrogen as efficiently as applying nitrogen to the soil and harvesting the plant.

Various methods have been used to prepare sweet potatoes for feed. Since about two-thirds to three-fourths of a crisp sweet potato is water, swine and poultry handle dried meals better than raw sweet potato. Cattle do well with raw sweet potatoes, but raw sweet potatoes cannot be available all year unless preserved by some means. During World War II, scientists at North Carolina State University prepared sweet potato ensilage. The ensilage was good but was more watery than generally desired. Considering the ability of cattle to utilize "rough foods" in the presence of high energy foods, it is very probable that straw could be ground into the ensilage to take up the water, then be digested. This would constitute valuable disposal of an agricultural waste.

Thus far only use of the roots has been discussed. Recent estimates place the amount of foliage from the Centennial variety sweet potato at 38,000 lbs/acre, wet basis. This would amount to between 5000-6000 lbs of dry hay per acre in addition to the roots. This foliage contains between 20-40% protein, depending upon the stage of growth. Further research must be done to determine the optimum time to harvest the forage.

In the southeast, where most of the United States' sweet potatoes are grown, there is over a \$10,000,000 annual deficit of red meat, due mainly to the lack of feed. Much of the feed used is imported. Development of a high-grade feed from sweet potatoes would be a two-fold boon to this low-income area.

In the Orient sweet potato leaves are used for human food, but direct human consumption would use only a small part of the leaves available. Efficient means of extracting proteins from leaves have been devised. The process by itself is hardly economical; but in connection with other value uses of the crop, this source of protein could become important.

If cattle can ferment sweet potato in the presence of nitrogen to make protein, why can't chemists do the same thing in fermentation vats? Preliminary work at North Carolina State University suggests it can be done. Sweet potato puree fermented in the presence of yeast and ammonium salts as a nitrogen source yields a paste with enhanced sweet potato aroma and a slightly yeasty taste. Although not considered delightful, few people have found the taste offensive. Perhaps home economists can turn it into a delicacy. After using up some of the carbohydrates and making new protein, the end product contains over 30% protein on the dry basis. This would provide more protein per calorie than many meats.

Shortly after World War II, USDA scientists studied the production of starch from sweet potatoes. The technology which was developed provided for complete use of the sweet potato with no wastes to cause pollution. The project was terminated, because the cost of sweet potatoes was too high; and they were available for too short a time. Rapid increases in the yield of sweet potatoes in North Carolina has dropped field costs of sweet potato solids to about that of corn solids, and yields are still increasing. However, before sweet potatoes can compete with corn on a cost basis, the cost of harvesting, handling and storage must be considerably decreased. Development of improved systems in these areas is essential before industrial utilization can grow. Imminent developments in harvesting and handling promise drastic reductions in cost, and foreseeable developments in storage will increase the time that sweet potatoes are available for processing.

Previous technology considered starch as the only profitable product, but newer technology and changing demands offer the possibility of multiple products. In the previous plan, sweet potatoes were finely ground with water to form a liquid phase and a fibrous residue. The residue was mostly cellulose which at the time had only slight feed value. Recent waste disposal research has developed methods of converting cellulose waste such as paper into high quality feed by fermentation. If this cellulose can be disposed of in the same way, would it not be profitable to convert it into paper and use it before such disposal?

The milky liquid phase obtained contained starch, protein, sugars and minerals. The starch can be removed by settling tables, and there is nothing lacking in methods for subsequent handling. Previously the remaining liquid was slightly acidified and heated above 180°F to form a coagulum containing the protein, fats and residual starch. When dried, it contained 50-60% protein and was considered an excellent animal feed. At that time either the world was not so protein hungry or was not aware of wide spread deficiency. Now far better uses of the protein can be visualized and slight modification of procedures provide a means of obtaining better separation of the protein.

When the liquid remaining after removal of starch is heated to 150°F and small amounts of calcium are added a coagulum forms which contains nearly all the fats, the residual starch and some of the protein. This coagulum can be removed as a paste containing 20-30% protein and if obtained from orange sweet potatoes it also contains tens of millions of units of vitamin A potency per pound. In the northern United States and Canada, milk production and livestock reproduction are hindered in late winter by a deficiency of vitamin A. Since this material is a feed supplement rather than a feed, it may find a ready market in the northern livestock industry.

A nearly pure protein can be obtained from the defatted liquid phase. Upon heating the liquid to near boiling, a massive protein curd is formed. The dried curd is a light gray powder containing over 90% protein and is practically tasteless. The chemical composition, i. e. amino acid distribution, is such that this protein is an excellent supplement to grains, soybeans, and many other plant proteins.

This product would rank very closely in quality to the much publicized fish protein concentrate. As an example of its use, if 10 grams were added to a 1 lb. loaf of whole wheat bread, it would increase the total protein from about 9% to about 11%; but it would increase the biological protein value from about 5.6% to 9.5%, a 69% increase.

The one fraction left is the sugars dissolved in the water. This can be concentrated into a molasses and disposed of as a low grade feed. USDA scientists devised a continuous fermentation system to reduce the sugar and harvest a crop of yeast. Later Japanese scientists added nitrogen to this solution as a nutrient for the yeast. This decreases the amount of sugar in such wastes to the point that it is no longer considered a source of pollution, and increases the yield of protein.

It will be a long time before it will be profitable to process sweet potatoes just for the starch, or just for the protein, or just for the Vitamin A value; but if profitable markets can be found for each of the three products, then all three would help pay a reasonable cost for raw material and processing. No new industry can start unless it can show that pollution of air and water can be controlled. As visualized, all of the sweet potato and the entire crop can be used without causing a new source of pollution. Industrial utilization of sweet potatoes should be welcome wherever sweet potatoes can be grown. It would provide increased use of an agricultural product, provide industrial jobs and revenue, and provide products which would be greatly useful in providing better nutrition.

Scientists alone cannot bring about better and more economical nutrition for this nation or the world. No group alone can do any more. Agriculture must be willing to produce a high-volume, lower-profit crop, but total income will increase. Industry must have the faith to venture into enterprises not yet established. Consumer advocates must freely endorse new products which offer promise of improved nutrition at lower cost.

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