New technologies to develop superior grains can fight African malnutrition

by Carol Shaffer Cleary

Recently the problems posed by attempting to feed Africa have been very much in the news. Tremendous logistical bottlenecks exist, just in getting the 1,695,667 metric tons of Title II grain the United States is sending to drought-stricken African countries, inland to the starving humans caught by this immense tragedy. But qualitatively, this aid is also totally inadequate; it is not the right kind of food to keep these people alive. To keep a person healthy, the body needs not just calories, but also vitamins and minerals and, perhaps most important, complete proteins.

A complete protein is one which contains the essential amino acids in a ratio necessary for the healthy growth of muscles, nerves, and other tissues; for the healthy function of the immunological system which protects each of us from disease; and for the healthy development of human cognitive powers. Although the body can manufacture a few of the amino acids, a great number of them are what are called essential amino acids: They must be ingested for the human to survive. The best ratio of essential amino acids for healthy growth and development is found in animal proteins, such as milk protein, steak or eggs. Cereals contain plant proteins, but they are so deficient in some of the essential amino acids that a person surviving on a primarily cereal diet acquires a disease called kwashiorkor—a protein-deficiency disease.

Kwashiorkor, which commonly hits the weaning-age child in association with measles, diarrheal diseases, and in Africa, also malaria and parasitic problems, is characterized by edema—swelling or bloating of the limbs with excess body fluids, growth failure, including sometimes weight loss, muscular wasting as the body consumes itself in order to acquire some protein, anemia, dyspigmentation of hair, and psychomotor behavioral changes, including whining, apathetic lethargy or total miserable withdrawal.

Although the United States does ship some non-fat dry milk with these grain shipments, the quantity of dry milk shipped is inadequate to make up for the protein deficiency of such a large number of starving people. Milk is also not an ideal solution to the protein needs of these people, since a large number of Africans cannot digest lactose, a milk sugar, and react to the consumption of milk with bloating and diarrhea. Some dry milk should be shipped for those who can consume milk, but clearly any serious effort to keep the continent of Africa alive would include the shipment of other complete protein sources as well.

Recent developments in agricultural technology have made it possible to develop grains whose proteins are close enough to complete proteins to clinically allow for the recovery of a child suffering from kwashiorkor through the consumption of a diet of primarily these enriched grains.

Corn

A high-lysine corn has been developed and tested in Guatemala and Colombia, and shown to be quite effective in eliminating kwashiorkor. This high-lysine corn was developed by standard hybridization, or plant breeding techniques. Scientists studied the genetic control over the biochemical pathways in corn which convert simple sugar into starch and proteins. In the various varieties and hybrids of high-lysine corn, the synthesis of the usual lysine-poor corn protein is deliberately depressed, in favor of the synthesis of lysine and trytophan (another amino acid) rich glutulins.

Glutulins are a protein found in many grains, in fact the high-protein wheat flour used for bread, is a glutulin-rich wheat flour. Thus far, genetic modification to produce high-lysine corn has generally meant the production of a corn which is less resistent to disease and other crop stresses, such as drought; as well as a slight to large depression in the yield a farmer obtains by planting high-lysine corn. However, in the next 10 years, these problems will be eliminated by further crop breeding.

A similar breeding project is just beginning to develop high-lysine sorghums. Sorghum is a grain grown in very dry areas, particularly in Africa and Asia.

Wheat

Although it has not been possible, utilizing these same plant-breeding techniques, to develop a high-lysine wheat, scientists have begun to use cell tissue culture, specifically, the culture of the wheat-callus, the growth area of the wheat plant, to breed a high-lysine wheat. While ordinary plant-breeding techniques take a large amount of space and roughly 10 years to develop a new plant variety, cell tissue culture allows researchers to screen millions of potential wheat plants for a desired trait in a very small area, and to develop a new plant variety over a period of five years or less. By adding a chemical, S-2-aminoethylcysteine (AEC), which mimics the chemical action of lysine in the wheat's biochemical pathways, researchers are able to screen for plants that have extra biochemical pathways and unusually great production of lysine.

Thus far, utilizing this technique, researchers were able to increase lysine production in the local wheat strain they used 100%. Currently, they are beginning to use the same technique on a specific high-yield spring wheat that is widely adapted to climatic conditions globally, and expect over the coming five years, to bring this wheat up close to the Food and Agricultural Organization standard of 5.3% lysine. A similar cell tissue culture project is beginning to increase the methionine (another amino acid) content of rice.

In the meantime, the somewhat more expensive synthetic lysine, such as that now produced in Japan, could be added to wheat when it is milled, in the same way that U.S. wheat flour is enriched with B vitamins.

Potato

A separate group of scientists is utilizing a still newer technology, recombinant DNA or "genetic engineering," to produce a complete-protein, high-protein potato. This group is simultaneously working on white potatoes, sweet potatoes, yams, and cassava. Cassava is a starchy root which grows under very poor conditions, but unfortunately, has no nutritional value, except in providing calories. Cassava is widely grown in impoverished developing countries, where agriculture is very primitive.

This research group has inserted a small section of deoxyribonucleic acid (DNA)—the chemical genetic material is made of—into potato leaf tissue. This small section of DNA includes the gene for protein storage found naturally in corn, but modified to make it a complete protein, plus a "promoter" gene, which tells the plant to produce this stored protein in the tuberous root only. This small section of DNA is inserted into the potato leaf tissue by infecting the tissue with a agrobacterium which has been genetically modified to include this DNA segment.

This is the same family of agrobacterium that infects the root tissue of legumes, like soybeans, and makes these infected root nodules fix free nitrogen from the air. The infected potato leaf tissue is then regenerated by cell culture techniques, to produce a whole potato plant, which can then be propagated by the "eyes"—the potato callus area that produces green potato plant sprouts when potatoes are left too long in warm, moist storage areas. Since white potatoes, sweet potatoes, yams, and cassava are all very closely related genetically, the same technique is used for each crop. These scientists expect to have high-protein, complete-protein potatoes, sweet potatoes, yams, and cassava in a year or so.

Right now, *if* economic policies were changed, U.S. farmers who are being driven into foreclosure, could be growing high-lysine corn to keep starving Africans alive. Also, farmers in Mexico, Brazil and Argentina could be growing for export varieties of high-lysine corn developed by CIMMYT in Mexico. The Rio de la Plata could be developed on a crash basis to feed starving humans globally. And, in a short time, these same farm areas could be growing high-lysine wheat.

Since wheat is a higher protein grain, the export of high-lysine wheat as soon as it is developed to feed starving Africans would be superior nutritionally, to the export of high-lysine corn.

Beyond the emergency value of these grains and root crops in keeping alive countless humans—who would otherwise die of kwashiorkor and related medical problems—this technology will have a major long-term impact on global agricultural production. Farmers in the United States are already growing primarily high-lysine, rather than regular corn.

This high-lysine corn is fed to cattle and pigs. Livestock, when fed this superior protein-quality grain, produce more growth hormone, and therefore reach slaughter size much more quickly. Younger animals require much less feed to put on the same slaughter weight, than older animals. Therefore the farmer achieves a healthier, slaughter-size animal not just more quickly, but with a tremendous savings in grain and economy of production, and he achieves this without employing any chemical additives, whose medical impact on the consumer of the slaughtered meat might be questioned.

For developing countries, like these 22 drought-stricken African countries, superior animal feed, vaccines, and any other technology which can help produce healthier livestock more rapidly, are of inestimable importance for developing the kind of herds which will enable all humans, whereever they live, to enjoy the full nutritional benefits of animal proteins.

TABLE 1
High-lysine grains compared to regular grains

	Percent protein	Protein digestibility	Lysine g/100g protein
WHEAT			
Purdue 4930 high protein	17.3	85.5	2.9
regular	12.1	85.5	3.0
MAIZE			
high lysine	10.5	85.8	4.6
regular	10.6	85.8	2.7
SORGHUM			
high lysine	18.5	60	3.3
regular	13.1	60	1.8
RICE			
SP 1761 high protein	15.4	83.8	3.4
regular	6.9	83.8	3.7