The Improvement of the Nutritional Properties of Cereal Proteins through Genetic Manipulation

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We are all aware of both the importance of cereal proteins and their nutritional limitations in human diets. The total world cereal production is currently more than 1,021,000,000 metric tons which contains more than 100,000,000 metric tons of proteins. This is more than five times the quantity of protein consumed in the form of animal proteins each year.

Cereals are the source of from 60 to 70 percent of the total protein intake in most of the underdeveloped or developing nations of the world. Animal proteins in most such countries are both expensive and scarce, and largely beyond the economic reach of much of the population.

All cereal diets when not fortified with animal proteins, protein supplements or synthetic amino-acids are deficient in one or more of the essential amino-acids. All cereal proteins are especially deficient in lysine.

It is possible to produce soybean flour, cottonseed flour, or fish flour, as well as synthetic lysine cheaply and to add small quantities of these supplements to cereal diets to correct their nutritional deficiencies. Nevertheless, there remains the large and difficult problem of getting these food supplements into the stomachs of the

low-income, rural peoples of the world, since they live largely outside of the commercial economy, on a subsistence agriculture.

Another new tool and approach to the protein nutritional problem now seems to be appearing. In late 1963 Mertz, Bates, Nelson and Vernon at Purdue University (U.S.A.) found that the gene Opaque-2 which had been known for 30 years as a genetic marker, influenced the L-lysine content in the maize endosperm. Grain with the Opaque-2 gene contained from 69 to 100 percent more lysine and 66 percent more triptophane than the protein of normal grain. Feeding studies conducted within the past years with young rats and recently-weaned pigs fed on Opaque-2 corn plus the essential minerals and vitamins, showed that they grew more than 3½ times as fast as similar animals fed on the same rations based on ordinary hybrid corn. Growth grains with both test animals were as good on the Opaque-2 - mineral-vitamin rations as on the ordinary hybrid corn-soybean ration of the same protein level. Feeding studies with adult pigs fed on Opaque-2 rations, showed that they gained twice as fast as those on normal corn rations.

Recently Dr. Ricardo Bressau (INCAP) concluded several nutritional studies with children, involving tortillas made with Opaque-2 and ordinary corn. He also found the nutritional value of Opaque-2 to be much higher than ordinary maize and about 90 percent as good as the protein quality of skim milk.

More recently, a second gene, known as Floury 2 has also been shown to produce high levels of lysine in maize. Undoubtedly still others exist.

The aforementioned discoveries have resulted in extensive research undertakings to produce high-yielding and hybrid-synthetic varieties of maize, with high levels of lysine. Within the next five years high yielding, high-lysine varieties of commercial maize will become widely available. These will be of special importance in Latin America, Africa and Asia.

Similar researches are either already underway or will be initiated soon to search for genes to increase the lysine levels in wheat, rye, Triticales, sorghum, millets and rice.

One of my Mexican colleagues has recently found potentially valuable variability in the lysine content in both rye and the man-made synthetic genus Triticale. We will initiate a breeding program to exploit these discoveries of the feeding studies already underway bear out the preliminary analytical information.

Although genes governing different levels of lysine and other essential amino-acids are likely to be found in all of the cereals, it will be more difficult to identify them and follow them in segregating populations of complex polyploid species such as bread wheat (Triticum vulgare), than in diploid species such as maize, sorghum and rice.

Once high yielding, high-lysine cereal varieties are grown by the peasant farmer, it will automatically lift his nutritional plateau to a new level. No additional costs will be involved beyond those he normally encounters in growing his crop, if synthetic varieties are used instead of hybrids.

Genes are also known in both maize and wheat which control high levels of total protein. These have not been exploited in commercial varieties up to the present time. In all probability it should now be possible to develop varieties combining high lysine and higher total protein levels.

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