High Lysine Corn — What Lies Ahead? ¹

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ABSTRACT

This paper reviews the worldwide impact, now and in the future, of the 1963 discovery by Purdue researchers that the protein of the opaque-2 mutant contained more lysine and tryptophan than normal corn protein. Agricultural breeding, growing, harvesting, storage and distribution aspects are delineated and economics reviewed. Physical and chemical differences are discussed in relation to the foregoing aspects and implications concerning processing. Present and future roles of high lysine corn in human nutrition, particularly in lesser developed countries are discussed. Potential impact on the animal feeding industry is considered.

Discovery of the potential nutritional value of the opaque-2 gene has been told and retold (1-4). Its development into a commercial crop; (b) agronomic aspects of seeds and crops; (c) the composition of high lysine corn as compared with normal corn and its relation to nutritional qualities, processing and its use in products; (d) uses in foods; (e) economics of uses in animal feeding; (f) factors which appear likely to motivate consumption of high lysine corn in different parts of the world.

Discussion of what lies ahead logically will follow the same pattern.

BACKGROUND OF DEVELOPMENT INTO A COMMERCIAL CROP

In the 50's, the United Nations and other groups were striving to highlight the major nutritional deficiencies of the diets of large segments of the populations of the developing nations, and particularly those in the tropical belt around the world. They stressed the need for improvement in diets as a major step toward increasing the capacity of those peoples for improving their economic status. An increasing awareness of the importance of protein quantity and quality in diets was emerging then. It became apparent that protein deficiency was far more widespread than caloric deficiency. Supplies of animal-based foods were inadequate and were too expensive for those who most needed proteins. All of the widely consumed cereal grains lacked sufficient amounts of some of the essential amino acids. One approach was to change the protein genetically so as to obtain a more balanced amino acid profile. Corn, deficient in lysine and tryptophan, was a staple food in many countries. Improvements of its protein quality could offer hope for millions of people.

After analyzing hundreds of corn varieties in mutant types from samples obtained from all over the world, Drs. Mertz and Nelson discovered one which had almost an ideal amino acid profile. By cross-breeding this mutant with local varieties they were able to grow experimental quantities of high lysine corn at Purdue. Seed from this corn was planted at a number of locations to obtain stocks for further agronomic development. Notable among these was the work of the Rockefeller Foundation in Colombia (13).

AGRONOMIC ASPECTS

Opaque-2 modified hybrids seem to germinate less readily than normal hybrids. Repeated growing tests indicate that this poses no problem since the high lysine corn can be harvested at about the same time after planting as normal hybrids. Planting and cultivating practices do not differ. However, care must be exercised to provide reasonable isolation of the two types of corn when they grow in the same field. This can be done either by physical separation or by delaying planting of the high lysine corn sufficiently to assure that normal corn in the area will have pollinated by the time the high lysine corn silks. Moisture levels at harvest are higher than those of normal hybrids but the opaque-2 corn dries faster. All methods of harvesting from husking the ear to the most modern picker-shellers have been used effectively. There has been no evidence of significant rot, and no unusual problems as fungus in storage have been observed.

There is, and will probably remain, a yield difference between the two types of corn. After enough cycles of genetic manipulation have been accomplished involving back-crosses of the opaque-2 gene into the hybrid to establish the hybrid identity, the volume of corn produced per acre is about the same. This was established in practical tests conducted by Funk Bros. Seed Co. on over 50 farms in the USA in the 1969 growing season. However, the bulk

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FIG. 1. Cross section of corn kernel.
density of opaque-2 corn is lower-52 to 53 lb per bushel vs. 56 lb per bushel for normal hybrids. This means a yield penalty of 5% to 7% and a consequent higher price.

In those countries having a commodity distribution system for corn, a further price penalty can be expected. The special handling required, including isolation in the field, in transportation and in storage, coupled with the probable need for contracting quantities required with farmers and distributors, can add another 15 cents to 25 cents per bushel until the quantity grown becomes great enough to establish high lysine corn as a commodity. In countries having no commodity distribution system, the penalty will be lower.

**COMPOSITION**

Figure 1 shows the major portions of the corn kernel: hull, endosperm and germ (or embryo). The hull is chiefly indigestible fiber. The endosperm contains most of the carbohydrate in the kernel and much of the protein; the germ is chiefly protein and fat. The carbohydrate is starch and the fat is corn oil.

A comparison of normal and high lysine corns, Figure 2, shows that normal corn has a relatively large, horny endosperm as indicated by the cross section inside the hull. High lysine corn is more chalky and softer than normal corn. High lysine corn has a larger germ as will be seen by comparing the darkened sections at the bottom of the two kernels.

A comparison of the composition of samples of normal corn and high lysine corn, Table I, shows differences in all of the components. While protein content is a little higher, carbohydrate content is lower. The larger germ yields some additional oil.

Interest chiefly centers around the improved protein quality. Assuming egg has the correct distribution of amino acids for human nutrition and assigning 100 as the level of each amino acid in egg, Figure 3 shows how human breast milk, cow's milk, beef, normal corn and soybeans compare with egg for each of the four limiting amino acids. It is evident that cow's milk and beef are rich in lysine but slightly lacking in methionine and deficient in cystine. Normal corn is deficient in all of these essential amino acids. Comparatively, high lysine corn appears to have a nearly ideal distribution of these amino acids.

The real test of any nutrient is its usefulness to human beings. Helen Clark (14), at Purdue University found that the protein and essential amino acid requirements of five young adults were satisfied when they received between 250 and 300 g of high lysine corn daily. One large man required 350 g. However, from other work it is known that 600 g of normal corn would not have been similarly sufficient.

In studies with children in Guatemala, Ricardo Bressani (15) found that the quality of high lysine corn protein was about 90% of that of skim milk.

Much more rigorous tests of the value of high lysine corn were conducted by Arturo Pradilla (16) of the Universidad del Valle in Cali, Colombia. He gave high lysine corn as the only source of protein to children severely ill with

![Figure 2. Photograph of cross sections of normal and high lysine corns.](image)

![Figure 3. Relationship of limiting amino acids in common foods.](image)