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One of the varieties in the world collection.

Wheat Can Be Improved As Human Food

V. A. Johnson, D. A. Whited, P. J. Mattern and J. W. Schmidt

Wheat, which is the main food of an estimated 1 billion people in the world, needs both the quantity and quality of its protein improved.

Unlike animal protein, which has all eight essential amino acids in nearly perfect balance, the protein in wheat and other cereals lacks the amino acid balance needed to make the maximum protein useable by the human body.

Amino acids are the building blocks of protein and are needed by the human body for cell growth and tissue synthesis.

The human body can manufacture all but eight of the amino acids it needs. The eight it cannot manufacture are called the essential amino acids, meaning they must be included in the diet. A lack of a .y one of these essential amino acids can limit the ability of the body to use the others to the fullest.

Wheat is most deficient in lysine, methionine, and threonine.

Until 1956, wheat breeders had made no serious effort to improve the protein content of wheat. We have been working on the problem at Nebraska for 12 years, but have not had the funds to do the work on the scale the problem requires.

However, recent financial support from the Agency for International Development of the U.S. State Department has enabled the Agricultural Research Service and the University of Nebraska to start a cooperative intensified effort to improve the nutritional value of wheat.

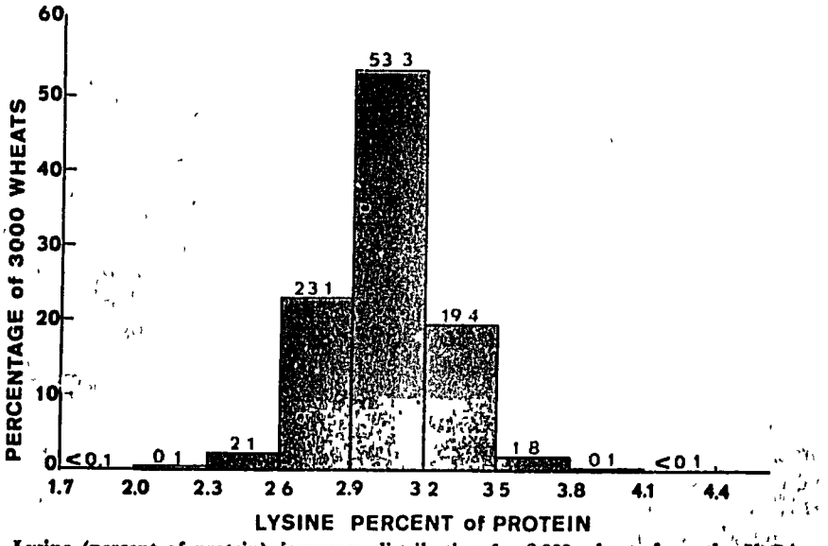
One of the key activities in this project is the screening of the world collection of wheats for high protein and lysine.

It appears that useable lysine differences exist in the World Collection of wheats. We are testing this collection in the laboratory and from data on the 3,000 lines analyzed so far we have reason to expect to find lines with lysine as high as 4 per cent as compared with an average value in current varieties of 3 per cent (Figure 1).

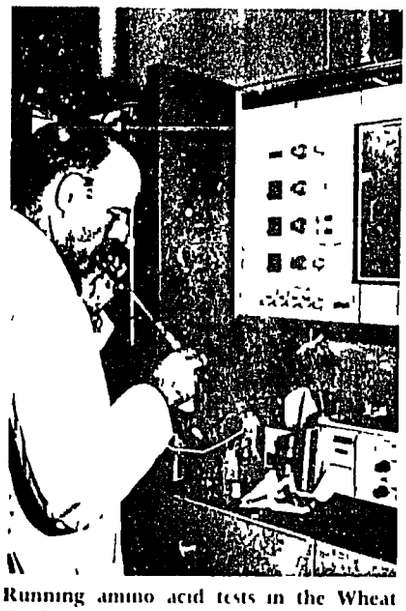
Our work so far on protein has led us to the following conclusions:

—High protein is a readily heritable, incompletely dominant trait.

—Some association of high protein with other traits has been found, such as close association of a high protein gene from Atlas 66 with adult leaf rust resistance. There also appears to be some association of high protein with low



Lysine (percent of protein) frequency distribution for 3,000 wheats from the USDA world wheat collection.



Running amino acid tests in the Wheat Quality Laboratory

Emasculating a head of wheat to prepare it for crossing with another variety.

adult resistance or tolerance to stem rust.

—The high protein trait expresses itself in several different environments, the complete range of which we have not yet determined

We also have discovered that expression of the high protein trait in the grain does not necessarily depend on excessively high nitrogen in the soil This indicates that the high protein trait can be expected to express itself in a range of environmental and soil conditions

Since increasing the protein in wheat would be less useful if the essential amino acid balance became more unfavorable as a result, we analyzed our high protein experimental lines (Table 1) and have concluded that it should be possible to select for improved protein without changing present amino acid balance (Table 2)

Whether or not the high lysine wheats we have identified from the World Collection have promise for breeding higher lysine wheat depends on whether the high lysine is a genetic trait

Little is known of the effect of environment on lysine level In an effort to gain some information on this, we planted 10 varieties of spring wheat from the World Col-

(continued on next page)

Table 1. Lysine, methionine, and threonine levels in selected high protein lines of Atlas 66 x Comanche

Variety	Protein[1] % DWB	Lysine % protein	Methionine % protein	Threonine % protein
Comanche	15 0	3 23	1 67	3.54
Atlas 66	18 0	3.33	1.11	3.35
All P6x Cmn 2507	17 7	3 72	1 74	2.62
" 2509	18 3	3.45	1 83	3.32
" 2501	17 9	3 38	1.14	3.69
" 2510	16 5	3 37	1.67	3.22
" 2499	18 2	3.29	1 68	3.10
" 2500	18 3	3 20	1.65	3 16

[1] Percent of total dry weight.

Table 2. Protein and essential amino acid balance in Atlas 66 x Comanche Selection 2509.

Percent higher or lower than Comanche in	
Total protein	+22
Lysine (g/100g protein)	+7
Methionine "	+10
Threonine "	−9
Histidine "	+10
Valine "	+2
Isoleucine "	0
Leucine "	+2
Phenylalanine "	−2
Tryptophan	not analyzed

Table 3. Lysine content of selected spring wheat varieties from the World Collection grown at 3 locations in the U.S.A.

Entry No.	Source	Lysine content (% of protein)					
		Minot	Bozeman	Aberdeen		4-test average	
				Non fert	Fert	Unadjusted	Adjusted
31	England	3 33	3 28	3 47	3.20	3 31	3.50
37	Russia	3 12	3 36	3 88	3 29	3 41	3 30
38	China	2 98	3 23	3.24	3 21	3 17	3 27
[illegible]	U.S.A	2 99	2 76	3 56	3 79	3.28	3 35
Justin	U.S.A	2.74	2 96	3.01	2 95	2 92	3 10
[illegible]	40 entries	2 93	3 09	3 31	3 26	3.15	3 15

(continued from page 5)

lection at Minot, N D , Bozeman, Mont., and Aberdeen, Idaho.

The limited data we received indicates that environment does influence lysine level Most of the effect is associated with the influence of environment on protein itself We believe that this is not an insurmountable problem (Table 3)

We have limited indication from analysis of these 40 spring varieties that some high lysine varieties will maintain their lysine superiority in an array of environments

Data from 60 high lysine winter wheats being grown at four widely separated locations in the United States in 1968 may help to substantiate this

It may be possible eventually to combine high protein in wheat with improved balance of essential amino acids by the breeding approach.

This will be a difficult task because of the interrelation of yield, protein, and amino acid composition of the protein It must be attacked on a broad front with equal attention paid to productivity, protein quantity, and protein composition, because any gain in one of these that is offset by losses in the others cuts down the net gain

The task is further complicated by the need for relying on highly sophisticated analytical laboratory equipment for amino acid determinations A more rapid reliable test for measuring lysine and other limiting essential amino acids is needed

Information from this intensified research project during the short time it has been in progress leads us to be optimistic We believe that this information will enable wheat breeders to eventually improve the nutritional quality of wheat varieties For the 1 billion people who rely upon wheat as their main food, this will mean improved diets and improved health

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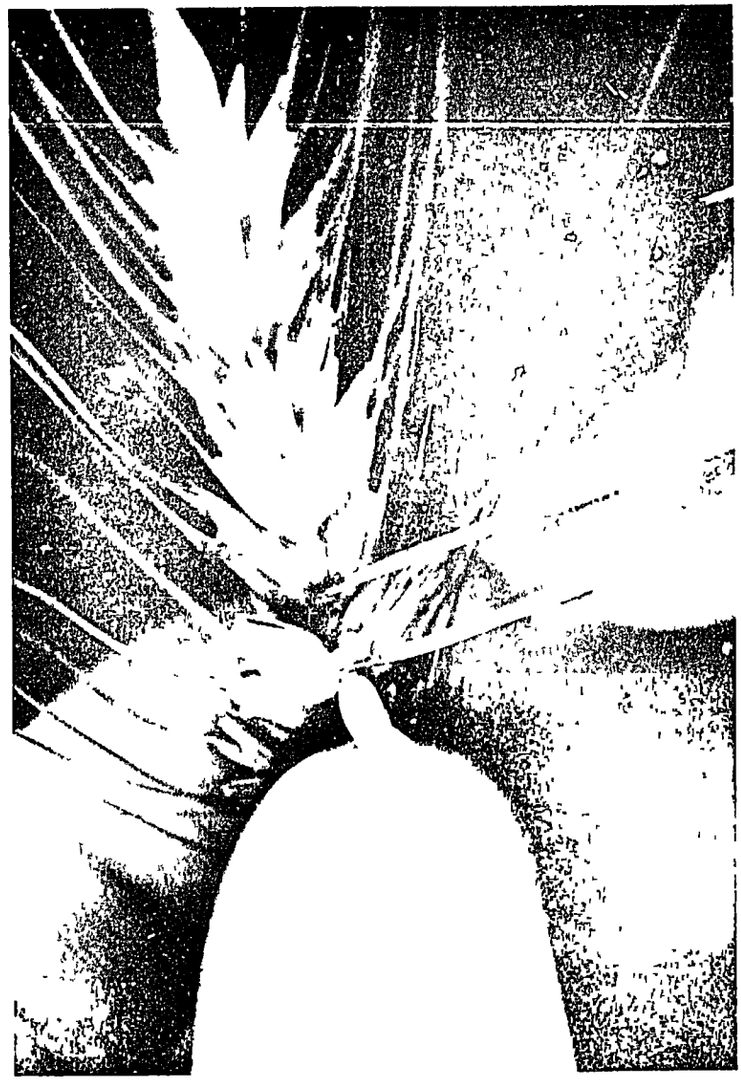

Tweezers reveal seat of reproductive organs

Reproductive parts compared in size to a dime Male organ is at right, female organ at left.