stimulating tone and its frank acknowledgment of our ignorance in regard to many matters of fundamental importance. So valuable a work should have been printed on much better paper, but the exigencies of the war probably made this impossible. One could have wished also that the author had provided the volume with an index and had seen fit to give careful citations of the many interesting works to which he refers.

W. M. Wheeler

SPECIAL ARTICLES

ON THE PROTEIN CONTENT OF WHEAT

Wheats of the Pacific coast states are conspicuously low in protein, so much so that western millers are obliged to ship in large quantities of high protein wheat to mix with their domestic wheats in order to manufacture flour of good baking qualities. The cause of the low protein content of western wheats has been the object of considerable investigation on the part of interested agronomists and plant physiologists for the last two decades. Results obtained from these investigations have led to a rather common belief, that the cause of the low protein content of Pacific coast wheat is primarily attributable to peculiar influences of climate.

In an investigation by the writer on the effect of applications of certain forms of soluble nitrogen to plants at different growth phases, results obtained with wheat, one of the plants studied, throw new light upon this protein question. In this paper, only that part of the plan and the results that pertain to the subject under discussion, need be given. These are essentially as follows:

Glazed stone jars were filled with a soil very low in nitrogen. This soil, as taken from the field, had a very low crop-producing power when cereals were planted, but upon receiving a moderate application of soluble nitrogen salt would yield large crops. This soil was planted to a pure strain of White Australian Wheat. Two hundred and fifty milligrams of nitrogen per jar, that is, at the rate of 100 pounds of nitrogen per acre, were added in single applications to different jars, at different times during the growng period of the plants. The nitrogen was added in two forms, $NaNO_3$ and $(NH_4)_2SO_4$, respectively, for two different series that were tested. Every application was made in triplicate. The first application of nitrogen to the first set of triplicates of each of the two series was made at the time of planting, the second was made to other jars 17 days after planting and so on at intervals until the last sets in each of the $NaNO_3$ and $(NH_4)_2SO_4$ series received their nitrogen application 110 days after planting. Every application of nitrogen made to the several sets in the series was, therefore, made at different ages of the plants and obviously represents more or less different growth phases of the plants. The tabulated data for a $NaNO_3$ series will serve as an example of the plan of the investigation and gives the results obtained.

EFFECT OF $NaNO_3$ APPLICATIONS ON THE PROTEIN CONTENT OF SPRING WHEAT APPLIED AT DIFFERENT GROWTH PHASES OF THE PLANTS

Results Average of Triplicate Jars

Date of Planting	Date of Nitrogen Application	Days After Planting When Nitrogen was Applied	Yield of Grain Grams	Commercial Grade	Per Cent. Crude Protein
11/14/19.	11/14/19		9.4	2 Soft white	8.6
11/14/19.	12/1/19	17	10.6	2 " "	9.3
11/14/19.	12/16/19	33	21.0	1 " "	10.4
11/14/19.	1/1/20	48	19.9	2 Hard	11.8
11/14/19.	1/24/20	72	21.9	1 "	13.2
11/14/19.	3/2/20	110	13.1	1 "	15.2

It will be noted that the data show a decided increase (about 77 percent.) in the protein content of wheat obtained from the plants that received nitrogen when they were 110 days old over those that were treated with nitrate at the time of planting. The protein content of the wheat obtained from these two different treatments are respectively 15.2 per cent., and 8.6 per cent. The data show that for each of the different applications of nitrate made after the time of planting, there was a corresponding increase in the protein content of wheat. As these increases in the

protein content of wheat correspond with the length of the period of the different deferred applications of nitrate made after planting, this would indicate a significant relation between the state of development of the plant and when nitrate can be most effectively utilized by the plant in the production of high protein wheat. This emphasizes that the physiological status of the plant, as indicated in its different growth phases, is a factor of great importance in the utilization of plant food available to it.

Not only was the protein content of the wheat increased by all of the deferred applications of nitrogen, but the yield of produce, excepting that obtained by the latest application, was much larger from the plants that received nitrogen for the period of 33 to 72 days after planting than those that received nitrogen during the early growing period. The best quality wheat as determined by commercial grading was secured from the plants that received nitrogen 72 and 110 days after planting. This means that the high protein wheat berry was likewise plump and well filled.

A much fuller account of the investigation with ample analytical data and a critical review of other investigations relating to the subject will shortly appear. It is felt that the results obtained in this investigation do show that the low protein content of Pacific states wheats is not due primarily to the climate as such, but so far as the investigation with this one soil is concerned, is due to insufficiency of available nitrogen at certain growth periods of the plants. That climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it. That this availability is an important factor in affecting the composition of plant products is shown by the results of this investigation.

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THE VITAMINE REQUIREMENTS OF THE RAT ON DIETS RICH IN PROTEIN, CARBOHYDRATE, AND FAT RESPECTIVELY[1]

IN 1913, one of us (C.F.) showed that the onset of the symptoms of beriberi in pigeons could be hastened by increasing the amount of polished rice fed. This led to the conclusion that the anti-beriberi vitamine—vitamine B—plays an important rôle in carbohydrate metabolism. This observation was confirmed shortly afterwards by Braddon and Cooper and others, although Eijkman and Vedder have denied the validity of this finding.

In a second series of experiments, in which the diets varied as shown in Table I., it will be noticed that beriberi developed in the following order: starch, sugar, casein, and fat.

TABLE I

Diet	Starch, Per Cent.	Sugar, Per Cent.	Casein, Per Cent.	Fat, Per Cent.	Salts, Per Cent.	Onset of Beriberi, Days
Starch ...	60	12	12	12	4	24
Sugar....	12	60	12	12	4	28
Casein...	12	12	60	12	4	30
Fat.....	12	12	12	60	4	40

In order to check up the results obtained with pigeons in another class of animals, and also with the idea of attempting to throw some light on the prevailing view as to the importance of proteins of high biological value on the etiology of pellagra and war edema, analogous experiments have been carried out on rats. The composition of the diets and the results obtained are shown in Tables II. and III.

TABLE II

Diet[2]	Meat, Gm.	Sugar, Gm.	Starch, Gm.	Lard, Gm.	Salts, Gm.	Autolysed Yeast, Cc.	Orange, Cc.	Agar, Gm.	Cod-liver Oil, Cc.
Meat	49	12	12	12	3	4	3	3	5
Sugar	12	49	12	12	3	4	3	3	5
Starch	12	12	49	12	3	4	3	3	5
Lard.....	12	12	12	49	3	4	3	3	5

[1] From the Research Laboratory of H. A. Metz.

[2] The meat, sugar, starch, and lard were tested and found to be free from Vitamine B.