

DIETARY REQUIREMENTS FOR FERTILITY AND LACTATION: THE VITAMIN A CONTENT OF WHEAT OIL¹

By BARNETT SURE

Professor of Agricultural Chemistry, Arkansas Agricultural College

INTRODUCTION

The early work of McCollum, Simmonds, and Pitz on "The Nature of the Dietary Deficiencies of the Wheat Embryo" (3)² suggested a toxic factor in wheat oil, and possibly for this reason investigators have been discouraged from attempting a quantitative study of the vitamin-A content of this oil. The researches of Osborne and Mendel (5) and Voegtlin and Myers (13), however, did not disclose a toxic factor in the oil of the wheat embryo. In the reproduction studies of the writer during the past five years more than 12 gallons of wheat oil have been used, and the introduction of as much as 3 per cent of this oil in the diets of rats has not resulted in an impairment of growth, fertility, or lactation, even when the animals were carried as far as the fifth generation (10). Recently Simmonds, Becker, and McCollum (6) have reported the beneficial effects of wheat oil when added to a "so-called salt ophthalmia-producing ration." The toxicity theory of McCollum and his associates concerning wheat oil promulgated in 1916 can, therefore, be abandoned.

Last year Steenbock and Coward (7) developed a quantitative method for the determination of vitamin A, which method insures the provision of vitamin D by irradiating the ration, and with their technic these authors demonstrated that of the three cereals—oats, wheat, and corn—wheat is the most potent in vitamin A. They have not, however, studied the oil of the wheat embryo, which is the source of the fat-soluble vitamins of the wheat kernel.

Since wheat oil is at present used by a number of nutritional investigators as a source of vitamin E, any data concerning its content of additional vitamins should be of interest to these workers, and such information may also serve as a guide in constructing rations deficient in all known fat-soluble vitamins other than E. Simmonds, Becker, and McCollum (6) and Mattill (4) assume in their recently published papers that wheat oil is quite deficient in vitamin A, and this assumption undoubtedly influenced the interpretation of their experimental findings. In the present communication quantitative data are presented showing that wheat oil, the most potent source of vitamin E, contains appreciable amounts of vitamin A.

¹ Received for publication May 14, 1928; issued October, 1928. Research paper No. 64, Journal Series University of Arkansas. This report is the eighteenth of a series on dietary requirements for reproduction. (See footnote 1, p. 87.)

² Reference is made by number (italic) to "Literature cited," p. 98.

METHOD OF STUDY

Young nursing albino rats whose maternal diet was deficient in fat-soluble vitamins (12) were allowed to remain with the lactating mothers on the same ration for one to two weeks after weaning until unmistakable symptoms of ophthalmia developed, indicating a depletion of vitamin A. The composition of the fat-soluble-deficient diet (No. 1034) used in these experiments was as follows: Casein,³ 20 per cent; McCollum's salts No. 185, 4 per cent; yeast,⁴ 10 per cent; and dextrin, 66 per cent. The animals were from 5 to 6 weeks old at the time the experiments were started. The character of the eye lesions varied in intensity among the different individuals. Only one animal of the entire group showed no signs of ophthalmia at the beginning of the experiment. At the onset of ophthalmia all the animals had shown a complete cessation of growth. The curative method was then adopted, and wheat oil was daily administered separately from the ration to each animal in graduated amounts with a calibrated pipette. As controls, litter mates were employed which received comparable amounts of a cod-liver oil in use in this laboratory since 1921 (11). The wheat oil was prepared by percolating whole-wheat embryo with cold acetone by methods previously described (9), and was fed in dosages of 0.01 c. c., 0.05 c. c., and 0.1 c. c. per animal per day. The cod-liver oil was fed in dosages of 0.01 c. c., and 0.05 c. c. daily to each rat. Since it was believed that a daily allowance of 0.05 c. c. of cod-liver oil per animal would supply an optimum amount of vitamin A, the 0.1 c. c. cod-liver oil dosage was not tried. The animals were weighed twice a week (and in some cases when necessary three and four times a week) and food-consumption records (Table 1) were taken simultaneously with the records of body weight. The results of the feeding experiments are shown in Figures 1 to 3.

TABLE 1.—Weekly food-consumption records of ophthalmic rats on a diet containing wheat oil or cod-liver oil as sources of vitamin A

Animal No.	Number of grams of food consumed during—																										
	1st week	2d week	3d week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	13th week	14th week	15th week	16th week	17th week	18th week	19th week	20th week	21st week	22d week	23d week	24th week	25th week		
4751	10																										
4752	6																										
4757	34	38	45	38	38	35																					
4758	30	32	31	50	43	33																					
4749	47	64	100	100	95	96																					
4750	43	62	99	70	73	74																					
4763	32	48	63	64	64	40	78	100	93	88	95	99	100	98	102	67	77	85	47	52	53	19					
4764	24	43	54	41	56	51	68	79	41	64	65	70	67	69	65	56	65	70	51	68	79	70	69	71	64		
4761	50	77	68	95	103	96	90	79	89	78	75	80	80	100	97	81	78	88	80	86	84	65	67	73	70		
4762	45	72	81	72	86	85	68	85	81	73	75	79	67	89	83	66	70	76	70	72	67	69	60	63	75		
4753	3																										
4754	30	47	51	66	79	76																					
4765	50	75	65	63	46	60	83	103	98	93	94	96	45	100	108	83	85	93	86	92	77	56					
4766	47	65	44	52	42	47	75	92	85	68	87	90	55	86	90	65	78	81	67	76	94	65	43	40			

* Food consumption record for a 5-day period.

† Food consumption record for a 4-day period.

³ Purified by repeated extraction with hot 95 per cent alcohol.

⁴ Obtained from a commercial yeast manufacturing company.

EXPERIMENTAL RESULTS

It is quite clear from a study of Figure 1 that 0.01 c. c. wheat oil does not begin to compare with 0.01 c. c. cod-liver oil per animal per day as a source of vitamin A. Note, however, the response of

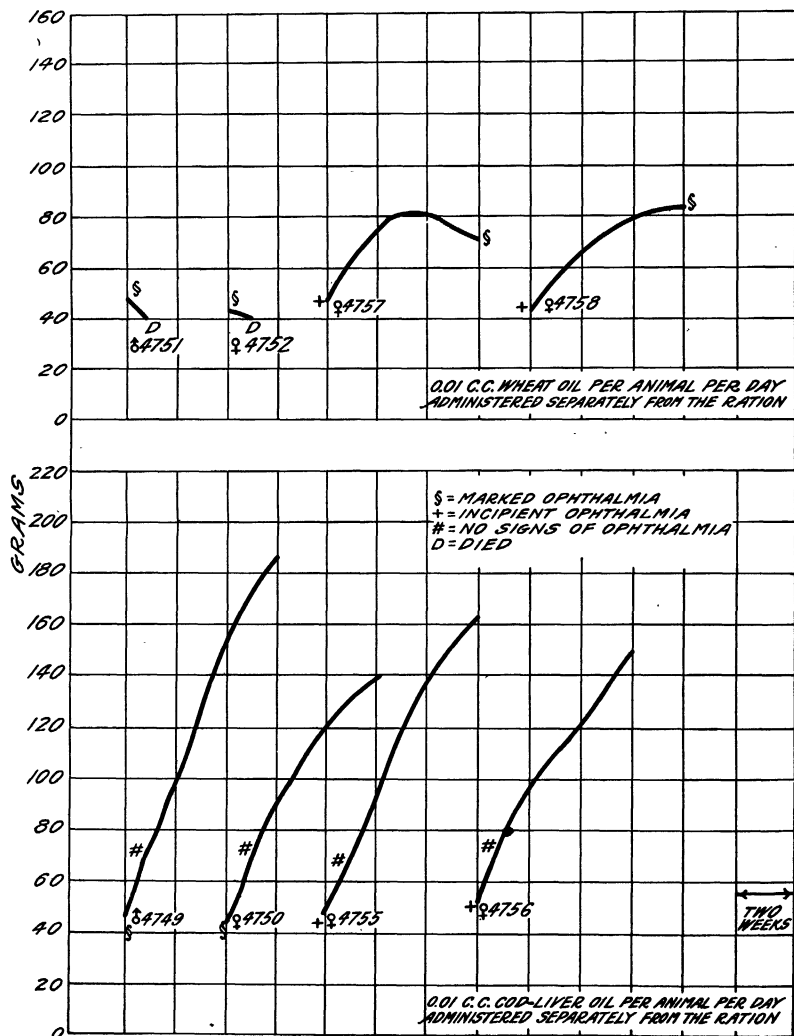


FIG. 1.—Comparative response of ophthalmic rats to vitamin A in wheat oil and in cod-liver oil when fed at low levels

animals 4757 and 4758 when taken in the incipient state of ophthalmia. Growth for two to four weeks is quite apparent.

Male 4763 and female 4764 (fig. 2), which at the beginning of the experiment were severely affected by ophthalmia and had already ceased to grow, showed a marked response to the daily administra-

tion of 0.05 c. c. wheat oil. Not only did the severe eye lesions entirely clear up in less than four weeks, but excellent growth was obtained in male 4763 for 16 weeks and very good growth in female 4764 for a period of 10 weeks. Animal 4763 finally succumbed, dying totally blind in both eyes when both animals 4761 and 4762

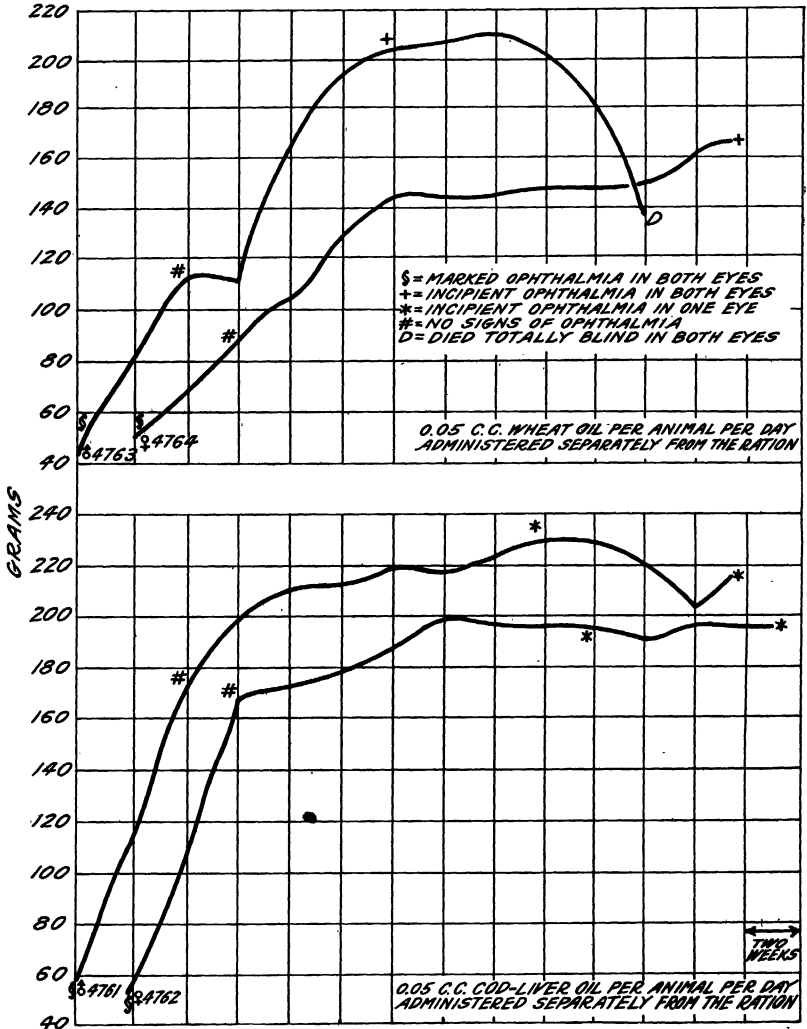


FIG. 2.—Comparative response of ophthalmic rats to vitamin A in wheat oil and in cod-liver oil when fed at levels higher than those represented in Fig. 1. The severity of the eye lesions in animals 4761 and 4762 was much greater than in animals 4763 and 4764. The former animals were almost blind in both eyes when the experiment began. This fact probably explains the longer period required for their eyes to heal

on an equivalent daily allowance of cod-liver oil were in excellent physical condition although showing incipient ophthalmia in one eye. From such results it is concluded that the optimum daily dosage of cod-liver oil for the adult rat is probably nearer 0.1 c. c. than 0.05 c. c. The ophthalmic condition of female 4764 on the 0.05 c. c.

wheat oil daily dosage was no worse than that of the two animals (4761 and 4762) receiving the equivalent cod-liver oil daily allowance, but the growth of No. 4764 was quite inferior. This experiment shows conclusively, then, the appreciable amounts of vitamin A in the oil of the wheat embryo.

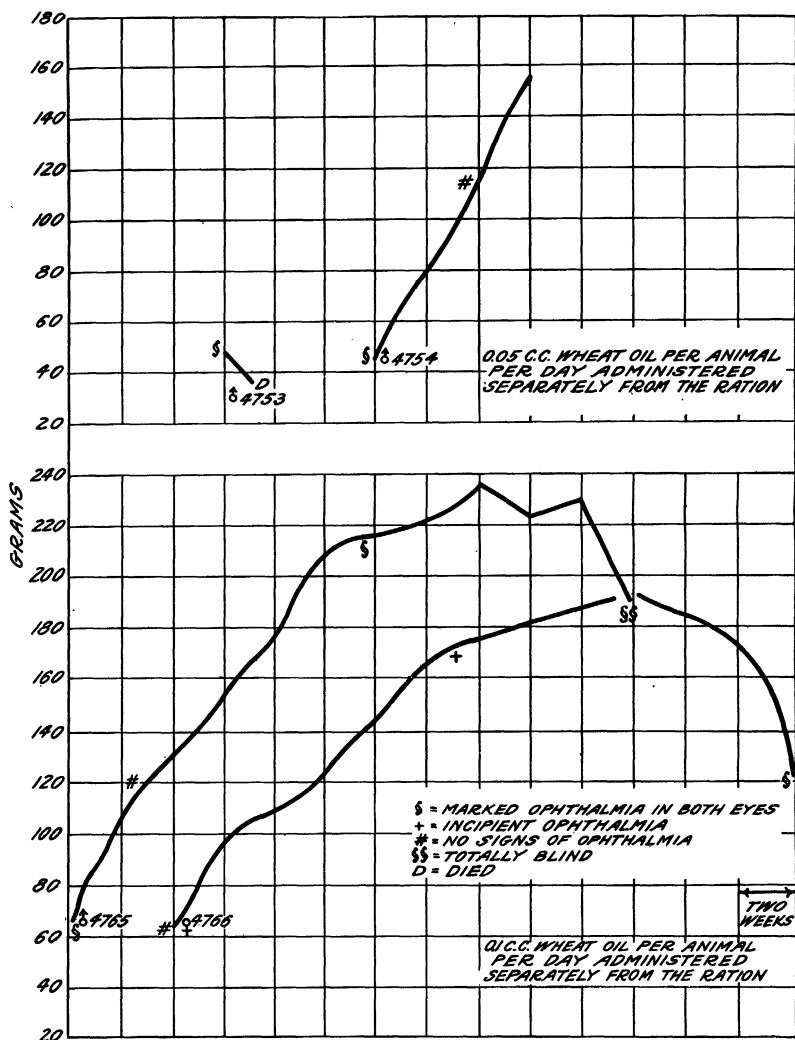


FIG. 3.—Comparative response of ophthalmic rats to vitamin A in wheat oil when fed at high levels

A daily dosage of 0.05 c. c. of wheat oil administered to male 4754 (fig. 3), started on the experiment in the incipient stage of ophthalmia and at a period of maintenance of growth, resulted in rapid growth, which was continuous for a period of six weeks. All signs of eye lesions completely disappeared in less than four weeks. The same daily dosage of wheat oil was ineffectual, however, as a thera-

peutic measure in curing a case of severe ophthalmia (male 4753). A daily dosage of 0.1 c. c. of wheat oil was potent to the extent of entirely clearing up an advanced stage of ophthalmia in 17 days. On such a daily dosage excellent growth was produced for four months, after which period the animals gradually declined in growth and finally collapsed.

Table 1 shows that variations in growth of the individuals can very well be ascribed to variations in food consumption. The point that this table brings out is that before failure on the wheat-oil administrations sets in when the severe ophthalmia manifests itself, showing unmistakably a deficiency of vitamin A, there is a marked reduction of the food intake, until at the very last stage of the avitaminosis complete inanition occurs. Animal 4763 (fig. 2) ate only 1 gm. of food during the last four days of the experiment and animal 4766 ate absolutely nothing during the last three days of the experiment and only 4 gm. during the preceding two days. These findings have considerable significance in the etiology of anorexia, or loss of appetite. For some time it has been known that vitamin B has a controlling effect on food consumption (1, 2) and recent work from this laboratory has demonstrated that as little as 5 mgm. of a highly concentrated vitamin B preparation from yeast can bring about a resumption of appetite at a state of complete inanition in 24 hours, but from the work reported in this paper it seems that a deficiency of fat-soluble vitamin A also plays a determining rôle in inanition. To be sure, in this series of experiments ample provision has not been made for the D vitamin, but since this vitamin, according to Steenbock and Nelson (8), is also essential for growth, the animals on ration 1034, deficient in fat-soluble vitamins, must have been deriving considerable vitamin D during the four months of their excellent growth from the supplementary daily administration of wheat oil. It would seem, then, that wheat oil also contains appreciable amounts of vitamin D. Work in progress shows that in cases of uncomplicated vitamin A deficiency, the D vitamin having been provided by the irradiated ration, a gradual reduction in food consumption occurs.

SUMMARY

A dosage of 0.05 c. c. of wheat oil per animal per day furnishes enough vitamin A for excellent growth for a period of 10 to 16 weeks. Such a dosage also serves as a potent therapeutic agent for curing severe eye lesions in animals produced by previous depletion of vitamin A.

The depletion of vitamin A is accompanied by inanition, a symptom heretofore associated only with vitamin B deficiency.

LITERATURE CITED

- (1) COWGILL, G. R., DEUEL, H. J., Jr., and SMITH, A. H.
1925. STUDIES IN THE PHYSIOLOGY OF VITAMINS. XXX.—QUANTITATIVE ASPECTS OF THE RELATION BETWEEN VITAMIN B AND APPETITE IN THE DOG. *Amer. Jour. Physiol.* 73: 106-126. illus.
- (2) KARR, W. G.
1920. SOME EFFECTS OF WATER-SOLUBLE VITAMINE UPON NUTRITION. *Jour. Biol. Chem.* 44: 255-276, illus.
- (3) MCCOLLUM, E. V., SIMMONDS, N., and FITZ, W.
1916. THE NATURE OF THE DIETARY DEFICIENCIES OF THE WHEAT EMBRYO. *Jour. Biol. Chem.* 25: 105-131, illus.

- (4) MATTILL, H. A.
1927. THE OXIDATIVE DESTRUCTION OF VITAMINS A AND E AND THE PROTECTIVE ACTION OF CERTAIN VEGETABLE OILS. *Jour. Amer. Med. Assoc.* 89: 1505-1508.
- (5) OSBORNE, T. B., and MENDEL, L. B.
1919. THE NUTRITIVE VALUE OF THE WHEAT KERNEL AND ITS MILLING PRODUCTS. *Jour. Biol. Chem.* 37: 557-601, illus.
- (6) SIMMONDS, N., BECKER, J. E., and McCOLLUM, E. V.
1927. THE RELATION OF VITAMIN E TO IRON ASSIMILATION. *Jour. Amer. Med. Assoc.* 88: [1047]-1050, illus.
- (7) STEENBOCK, H., and COWARD, K. H.
1927. FAT-SOLUBLE VITAMINS. XXVII. THE QUANTITATIVE DETERMINATION OF VITAMIN A. *Jour. Biol. Chem.* 72: 765-779, illus.
- (8) ——— and NELSON, E. M.
1923. FAT-SOLUBLE VITAMINS. XIII. LIGHT IN ITS RELATION TO OPHTHALMIA AND GROWTH. *Jour. Biol. Chem.* 56: 355-373, illus.
- (9) SURE, B.
1926. DIETARY REQUIREMENTS FOR REPRODUCTION. V. THE RÔLE OF VARIOUS VEGETABLE AND FRUIT OILS IN FERTILITY AND LACTATION. *Jour. Biol. Chem.* 69: 29-40.
- (10) ———
1926. DIETARY REQUIREMENTS FOR REPRODUCTION. VI. TYPES OF STERILITY PRODUCED ON A SKIMMED MILK POWDER REPRODUCTION-DEFICIENT DIET. *Jour. Biol. Chem.* 69: 41-51, illus.
- (11) ———
1927. DIETARY REQUIREMENTS FOR REPRODUCTION. IX. COD-LIVER OIL VERSUS WHEAT OIL AS SOURCES OF VITAMIN E. *Jour. Biol. Chem.* 74: 45-53.
- (12) ———
1928. DIETARY REQUIREMENTS FOR FERTILITY AND LACTATION. XIII. STORAGE OF FAT-SOLUBLE VITAMINS FOR LACTATION, WITH SOME OBSERVATIONS ON THE COD-LIVER OIL REQUIREMENTS OF NURSING YOUNG. *Jour. Biol. Chem.* 76: 659-671.
- (13) VOEGTLIN, C., and MYERS, C. N.
1918. THE GROWTH-PROMOTING PROPERTIES OF FOODS DERIVED FROM CORN AND WHEAT. *Pub. Health Rpts.* [U. S.] 33 (22), p. 843-868, illus.

