The experiments presented thus far show clearly that in normal and hypophysectomized rats the blood sugar response to anoxia is modified by the prevailing blood sugar level. The higher the latter the less is the s.a. response. This phenomenon can be due either to an increased s.a. response or to a decreased v.i. response with falling blood sugar level or to a combination of both factors. Experiments on adreno-demedullated rats shown in Fig. 2, B, do not give any indication that the v.i. response is dependent on the level of the blood sugar. This experiment was repeated on another group of adreno-demedullated rats with similar results. It is therefore necessary to conclude from the experiments presented in this paper that in unanesthetized rats relatively slight changes in the blood sugar level resulting from different lengths of the fasting time significantly alter the reactivity of the autonomic blood sugar regulating centers. The balance existing between the v.i. and s.a. systems is altered in favor of the s.a. response with falling blood sugar level since no evidence could be obtained for a relation between the responsiveness of centers of the v.i. system to anoxia and the blood sugar level. The experiments show again the great stability of the centers of the v.i. system. Alterations in central autonomic balance induced by such diversified conditions as thyroxinization,[7] different age level,[3] and variations in the blood sugar concentration as the result of fasting seem to be due to the actions of these factors on the centers of the s.a. system only.

Summary. 1. The hyperglycemic effect of lowered barometric pressure (anoxia) on normal rats of different age groups is less in animals subjected to a 4-hour fast than in those fasted for 22 hours. 2. Similar results are obtained for hypophysectomized rats fasted for 4 and 12 hours respectively. 3. In contradistinction to the findings reported in 1 and 2, different durations of fasting have no effect on the vago-insulin system as shown by observations on adreno-demedullated animals.

It is concluded that the reactivity of the sympathetico-adrenal system increases with rising blood sugar level.

[7] Gellhorn, E., and Feldman, J., *Endocrinology*, 1941, **29**, 467.

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Dietary Requirements for Fertility and Lactation. XXXII. Rice and its By-products as Sources of Pyridoxine and Pantothenic Acid for Reproduction and Lactation.*

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While considerable information is now available on the distribution of various components of the vitamin B complex in natural foods and on their influence on growth, very little is known concerning their biological value as sources of the B vitamins for reproduction and lactation.

In the milling of wheat there is 86% loss of thiamine[1] and 83% loss of nicotinic acid but the losses in pantothenic acid and pyridoxine are only about 50%.[2] In the milling of rice there is 80% loss of thiamine[3] and 66% loss of nicotinic acid[4] and only about 50% losses

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[1] Sherwood, R. C., Nordgreen, R., and Andrews, J. S., *Cereal Chemistry*, 1941, **18**, 811.

[2] Teply, L. J., Strong, F. M., and Elvehjem, C. A., *J. Nutr.*, 1942, **24**, 167.

[3] Kik, M. C., *Cereal Chemistry*, 1943, **20**, 103.

[4] Kik, M. C., and Van Landingham, F. B., *Cereal Chemistry*, 1944, **21**, 154.

TABLE I.
Rice and Its By-products as Sources of Pyridoxine for Reproduction and Lactation.*

Sources of pyridoxine	% of rice or its by-products in ration	Reproduction period (days)	No. of litters	Total young born	Young born dead	Young given to rear	Young reared	% young reared
Polished rice	15	56	4	25	2	21	0	0.0
Undermilled rice	15	57	3	22	0	17	0	0.0
Whole "	15	57	5	35	5	28	0	0.0
Polished "	30	100	8	68	3	47	14	29.8
Undermilled "	30	104	8	60	0	42	6	14.3
Whole "	30	96	5	42	4	29	6	20.7
Rice bran	5	128	11	90	0	66	18	27.3
" polishings	5	129	8	74	0	48	15	31.3
" bran	15	124	11	89	1	64	39	60.9
" polishings	15	134	10	103	0	60	41	68.3

* 5 females and 1 male in each experiment.

of pyridoxine and pantothenic acid.[5] The high content of the latter two vitamins in rice and its by-products stimulated an investigation on their biological value in this cereal and its by-products for reproduction and lactation.

The technic used for the lactation studies was essentially the same as that described in 1928.[6] The experiments were conducted in groups of 6 animals, consisting of 5 females and 1 male in each experimental set up. A total of 130 females and 26 males were used in this investigation. The animals were started on experiments when 24 to 31 days old and weighing from 40 to 55 g each. Each ration contained 22% purified casein (Smaco), 5% butter fat, 5% of Sure's salts No. 1,[7] and rice or its by-products at various planes of intake. The remainder of the ration consisted of cerelose (glucose). After the animals were 90 days of age and when the females weighed 155 to 160 g they were bred, at which time the ration was modified to contain 0.2% cystine which replaced an equivalent amount of cerelose, and the salt mixture was changed to Sure's salts No. 2, 5%.[8] The vitamin B complex supplements were given daily separately from the ration as follows: 20 μg thiamine, 20μg riboflavin, 20 μg pyridoxine, 6 mg choline chloride, and 200 μg calcium pantothenate. From the time of mating and through the periods of reproduction these were increased to 50 μg thiamine, 50 μg riboflavin, and 50 μg pyridoxine. During lactation they were further increased to 120 μg thiamine, 120 μg riboflavin, 120 μg pyridoxine, 9 mg choline chloride, and 600 μg calcium pantothenate. Those animals which received the rice or its by-products as a source of a specific B vitamin received no supplement of this particular vitamin. The results of previous work on quantitative requirements of the components of the vitamin B complex for lactation[9] served as a guide for dosage in this study. As a source of vitamins A and D, three drops of halibut liver oil were given once weekly to each animal, which was increased to 3 drops 3 times weekly per rat from the period of mating to the termination of the experiments. As a source of vitamin E, a concentrate was used, containing 34% tocopherols.† One drop of this concentrate, equivalent to about 8 mg of tocopherols, was administered once weekly to each animal. This was increased to 2 drops once weekly per animal from time of breeding and through the periods of reproduction and rearing of young.

The results of this investigation are summarized in Tables I, II, and III. From Table I it is apparent that, while polished rice, undermilled rice, and whole rice fed at a 15% plane of intake, as sources of pyridoxine, allowed reproduction to take place, lactation

[5] Williams, V. R., Knox, Wm. C., and Fieger, E. A., *Cereal Chemistry*, 1943, **20**, 560.

[6] Sure, B., *J. Biol. Chem.*, 1928, **76**, 673.

[7] Sure, B., *J. Nutr.*, 1941, **22**, 499.

[8] Sure, B., *J. Nutr.*, 1943, **26**, 275.

[9] Sure, B., *J. Nutr.*, 1940, **19**, 57.

† Kindly furnished by Dr. P. L. Harris of the Distillation Products, Inc., Rochester, N.Y.

TABLE II.
Rice and Its By-products as Sources of Pantothenic Acid for Reproduction and Lactation.*

Sources of pantothenic acid	% of rice or its by-products in ration	Reproduction period (days)	No. of litters	Total young born	Young born dead	Young given to rear	Young reared	% young reared
Polished rice	15	41	2	15	0	12	0	0
Undermilled rice	15	40	3	29	2	18	0	0
Whole "	15	41	2	18	0	12	0	0
Polished "	30	83	8	67	4	45	0	0
Undermilled "	30	84	5	23	0	17	0	0
Whole "	30	83	5	41	1	29	0	0
Rice bran	5	66	5	38	0	29	0	0
" polishings	5	80	5	47	0	36	0	0
" bran	15	77	5	50	0	30	3	10
" polishings	15	70	5	46	0	30	0	0

* 5 females and 1 male in each experiment.

was an absolute failure. Increasing the rice to 30% in the ration permitted 14 to 30% success in rearing of young. As little, however, as 5% of rice bran or rice polishings in the ration resulted in about 30% success in lactation. Increasing these rice by-products to 15% in the ration resulted in marked improvement in rearing of young, *i.e.*, a lactation efficiency of 61 to 68%.

According to Williams, Knox, and Fieger[5] rice polishings contain 30.8 μg/g pyridoxine and 92.5 μg/g pantothenic acid and rice bran contains 32.1 μg/g pyridoxine and 71.3 μg/g pantothenic acid. Calculating on the basis of an average 20 g food intake during lactation, the ration containing 15% rice polishings furnished daily 277.5 μg pantothenic acid and only 92.4 μg pyridoxine. The 15% rice bran ration provided a daily intake of 213.9 μg pantothenic acid and 96.3 μg pyridoxine. Yet, such rations when fed as sources of pyridoxine allowed over 60% success in lactation, and when fed as sources of pantothenic acid produced 90 to 100% failure in rearing of young. The question arose: Is pantothenic acid unavailable in rice polishings and rice bran or are the pantothenic acid requirements for lactation greater than those of pyridoxine? That the latter was probably the case was suggested from the findings of Unna and associates[10] and from the report of Henderson[11] and coworkers that a daily dose of 80 to 100 μg calcium pantothenate is required for the optimum growth of the rat. That there is a relatively greater requirement of pantothenic acid than of pyridoxine for optimum growth of the albino rat is evident from the experiences of Unna and associates[10] who used 40 μg pyridoxine and 80 to 100 μg calcium pantothenate, and from the work of Pilgrim and Elvehjem[12] who used 20 μg pyridoxine and 200 μg calcium pantothenate. We used the latter two doses of these vitamins for growth. We used the 200 μg daily dose of calcium pantothenate, so that this same dose would insure a sufficiency for reproduction as well as for growth.

Since complete success in lactation in the rat has not yet been achieved with synthetic components of the vitamin B complex on purified diets fortified with optimum amounts of pure pantothenic acid, it is impossible at this time to compare the relative efficiency of this vitamin as provided by the rice polishings and rice bran rations with equivalent amounts of this pure vitamin. Accordingly, another series of experiments were conducted to throw further light on the problem. The results of these experiments are given in Table III. The supplementation of the 15% rice polishings ration with 300 μg calcium pantothenate daily furnished an additional amount of 253 μg of this vitamin, or a total of 277.5 + 253, or 530.5 μg. In other

[10] Unna, K., *J. Nutr.*, 1940, **20**, 565; Unna, K., Richards, G. V., and Sampson, W. L., *J. Nutr.*, 1941. **22**, 553; Unna, K., and Richards, G. V., *J. Nutr.*, 1942, **23**, 545.

[11] Henderson, L. M., McIntire, J. M., Waisman, H. A., and Elvehjem, C. A., *J. Nutr.*, 1942, **23**, 47.

[12] Pilgrim, F. J., and Elvehjem, C. A., *Arch. Biochem.*, 1945, **6**, 121.

TABLE III.
Influence of Supplementing Rice Polishings and Rice Bran with Calcium Pantothenate on Reproduction and Lactation.*

Sources of pantothenic acid	% in ration	Reproduction period (days)	No. of litters	Total young born	Young given to rear	Young reared	% young reared
Rice polishings	15	75 to 90	5	48	36	0	0.0
Rice polishings + 300 μg calcium pantothenate daily	"	80	7	67	42	21	50.0
Rice polishings + 600 μg calcium pantothenate daily	"	80	7	67	42	22	52.4
Rice bran	15	74 to 84	6	61	36	0	0.0
Rice bran + 300 μg calcium pantothenate daily	"	90	6	61	36	17	47.2
Rice bran + 600 μg calcium pantothenate daily	"	90	7	76	42	27	64.3

* 5 females and 1 male in each experiment.

words, it required about 7 times as much pantothenic acid to secure 50% success in lactation as for optimum growth and about 6 times as much pantothenic acid as pyridoxine (92.4 μg pyridoxine and 530.5 μg pantothenic acid) to secure relatively the same degree of success in lactation. Similar results were obtained with the 15% rice brand ration, but 300 μg additional calcium pantothenate did result in 17% increased success in rearing of young. The definite physiological requirements of the animal organism for pantothenic acid become more accentuated during lactation than during growth. Unna, Richards, and Sampson[10] found that the reduction to half the optimum dose of pantothenic acid during growth results only in less gain in body weight. These investigators found it necessary to reduce the daily dose of calcium pantothenate below 25 μg, in order to produce achromotrichia, and adrenal necrosis was produced in only 50% of the animals on a diet entirely deficient in pantothenic acid. However, even three to four times the dose of this vitamin required for optimum growth still results in 90 to 100% failure in lactation.

We know of no specific work dealing with relative quantitative requirements of pantothenic acid versus pyridoxine for optimum growth of the albino rat. Since, however, we have found in this laboratory 20 μg pyridoxine adequate for optimum growth and other workers[10,11] have reported 80 to 100 μg calcium pantothenate, equivalent to an average of about 75 μg pantothenic acid, it would appear that the optimum growth requirements of pantothenic acid are over three times those of pyridoxine. Our work then indicates that this ratio is much wider in lactation, *i.e.*, at least six times as much pantothenic acid as pyridoxine. This ratio cannot be considered as the final expression, since the optimum success in lactation we secured in this study was only 68%. The 32% infant mortality still to be accounted for may be due to some missing dietary factors or to imbalances of some essential constituents in the rations we employed. This work, however, establishes a greater requirement of pantothenic acid than of pyridoxine for the albino rat, which becomes more accentuated during the period of lactation.

Summary. Results are given on rice and its by-products as sources of pyridoxine and pantothenic acid for reproduction and lactation. The data in this study show that the requirements of pantothenic acid are much greater than those of pyridoxine for the albino rat, which become more accentuated during the period of lactation.