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Ten Constituents of the Blood Stream of Well-Fed White Rats, Chickens, Swine, Sheep, and Horses in Guatemala

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COUNTRIES of the American tropics do not produce enough animal products for human consumption. Although the importation of purebred livestock from the United States and Canada is increasing, a large number of the imported animals die and those that survive do not produce as much milk, meat, and eggs as they should. Squibb *et al.*[12] point out that this situation applies particularly to dairy cattle.

Some of the reasons for the low production and high mortality among purebred animals in these areas have been described by Work.[15] It is generally agreed that malnutrition—the result of poor practices of animal management, shortage of feed during dry seasons, and lack of technical knowledge about the feeding of farm animals—is one of the most serious problems. A fundamental approach to the problem lies in a study of blood constituents of the animals. Becker and Smith,[1] Maynard,[8] and Rusoff and Piercy[10] have discussed the usefulness of blood data in evaluating the physiological status of farm animals. Squibb *et al.*[12] have found dairy cattle in three different areas of Guatemala to have extremely low levels of calcium and phosphorus in their blood.

Levels of essential blood constituents have not been established for most animals in tropical America. This report presents data for 24 white rats, 80 chickens, 60 pigs, 13 sheep, and 10 horses. Dietary histories of all were fairly well known; the chickens and livestock had been subjected to farm management of the kind that is practiced by better farmers in Guatemala.

PROCEDURE

Experimental Animals and Diets.—The white rats used were progeny of stock that had been obtained from the Animal Husbandry Division of the United States Department of Agriculture. Equal numbers of males and females 10 weeks old were studied. They were housed in individual wire cages and had been fed the following diet *ad libitum* over a 6-week period: casein, 20.0 per cent; sucrose, 63.7; minerals, including minor elements, 4.0; corn oil, 5.0; brewers' yeast, 7.0; and cod liver oil,* 0.3.

The chickens were New Hampshire Reds—40 hens and 40 baby chicks. The hens had been obtained from eggs imported from Texas and hatched at the Instituto Agropecuario Nacional. They were kept on a green pasture of Kikuyu grass *(Pennisetum clandestinum)* and had received the following ration over a six-month period: corn, 42.5 per cent; sesame oil meal, 34.4; rice bran, 10; wheat bran, 10; minerals, including trace elements, 3.2; and delsterol.** The chicks were the progeny of the hens. They were housed in all-metal-wire cages and were fed the following rations *ad libitum* over a six-week period: ground yellow corn, 31.2 per cent; sesame oil meal, 15; corozo oil meal, 30; cottonseed oil meal, 15; dried forage meals, 5; minerals, including the minor elements, 3; and vitarich, 0.8.†

The rats and chickens were housed in the animal nutrition laboratories of the Instituto's station at Guatemala City (elevation, 5,000 ft.; average annual rainfall, 40 in.).

The swine, Duroc-Jersey weanling pigs, were kept at the Instituto's substation in Chocolá (elevation, 2,500 ft.; average annual rainfall, 177 in.). At the time blood samples were collected, the pigs had been on green pasture approximately six weeks. The pasture had been supplemented with the following rations: corn, 50 per cent; sesame oil meal, 40; minerals, including trace elements, 3; and wheat bran, 7.

The sheep, which were native (or "criollo"), ewes approximately 18 months old, were part of the Instituto's flock located at the substation Labor Ovalle in Quezaltenango (elevation, 8,000 ft.; average annual rainfall, 65 in.). At the time of blood sampling, they had been on green pasture eight weeks; pasture had been supplemented with corn, 60 per cent; wheat bran, 30; cottonseed meal, 7; and minerals, including trace elements, 3.

The horses were criollo mares 3 to 8 years old with foals 3 to 4 months old. They were located at the United Fruit Co.'s farm at Tiquisate (ele-

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* The cod liver oil contained 1,700 I.U.'s of vitamin A and 400 I.U.'s of vitamin D per gram.

** Delsterol is a DuPont product. It was fed at the rate of 0.02 per cent of the ration.

† Vitarich is a product of the Thompson Hayward Co.

vation, 100 ft.; average annual rainfall, 110 in.). They had been on green pasture approximately eight weeks at the time the blood samples were collected.

Collection of Blood Samples.—Approximately 1 to 5 ml. of blood was obtained from the rats and chicks by heart puncture.

The hens were bled from the wing veins. Approximately 2 ml. of blood was collected and permitted to coagulate, and an additional 1 ml. was collected in tubes containing an anticoagulant composed of 6 per cent ammonium oxalate and 4 per cent potassium oxalate.

The swine were bled from the tails. Approximately 5 ml. of blood was collected and permitted to coagulate, and an additional 2 ml. was collected in tubes containing the same anticoagulant.

The horses and sheep were bled by jugular venipuncture. Approximately 6 ml. of blood was collected in tubes and permitted to coagulate.

All blood samples were refrigerated immediately after being taken and were delivered to the laboratory for analysis within six hours. The blood serum of these samples was analyzed for total proteins,[6] riboflavin,[4] vitamin A and carotenoids,[3] total tocopherols,[9] alkaline phosphatese,[2] and ascorbic acid.[5,7] The methods for ascorbic acid were modified by using a solution of copper sulfate and thiourea instead of norite as a reducing agent. The analyses of the red components of the blood were made by standard methods.[15]

RESULTS AND DISCUSSION

Data were obtained on the levels of ten blood constituents (table 1). The animals studied were healthy, well fed, and well managed. Although some knowledge of the dietary histories was available, the data are as yet too limited to permit the correlation of the observed blood values with data on production or environment.

It is apparent that variability of levels of certain nutrients in the blood will need to be considered when critical nutrition experiments are undertaken. The New Hampshire hens showed extremely variable levels of riboflavin, carotenoids, vitamin A, and total tocopherols. Such variations are not peculiar to this area: Scrimshaw *et al.*[11] have found similar variations in serum riboflavin, carotenoids, and ascorbic acid in hens in New York. The rats, baby chicks, sheep, and horses had fairly uniform values for all the blood constituents studied except vitamin A. The Duroc-Jersey pigs had comparatively uniform values for all the constituents.

It has been pointed out that malnutrition is one of the most pressing problems in tropical America. Although the increased use of blood data could do much to define the responsible deficiencies, there are as yet too few data to tell what may be considered normal levels for the several constituents reported here. It is hoped that

TABLE 1—Several Blood Constituents of White Rats, New Hampshire Red Chicks and Hens, Duroc-Jersey Swine, and Native Sheep and Horses*

Constituent	Rats (24)	Chicks (40)	Hens (40)	Pigs (60)	Sheep (13)	Horses (10)
Serum						
Total proteins (Gm./100 cc.)	6.26 ± .06	3.86 ± .04	4.98 ± .07	6.81 ± .05	7.16 ± .11	6.94 ± .16
Riboflavin (μg./100 cc.)	2.44 ± .09	.85 ± .05	69.0 ± 6.0	2.99 ± .07	.82 ± .11	1.16 ± .10
Ascorbic acid (mg./100 cc.)	1.05 ± .08	2.23 ± .07	2.45 ± .05	2.04 ± .05	1.30 ± .07	1.30 ± .13
Carotenoids (μg./100 cc.)	2.0 ± .1	867.0 ±50.0	142.0 ±16.0	7.5 ± .43	9.5 ± .7	9.7 ± 1.2
Tocopherols (mg./100 cc.)	0.01 to 0.70	0.04 to 1.91	**	.14 ± .01	.17 ± .01	.30 ± .04
Alkaline phosphatase (millimoles/liter/hour)	11.05 ± .70	.....	17.40 ± .92	2.05 ± .06	1.97 ± .11	9.10 ± .67
Vitamin A (μg./100 cc.)	24.4 ± 1.4	53.4 ± 2.2	32.0 ± 3.3	25.2 ± .64	33.8 ± 2.0	12.1 ± 1.23
Whole Blood						
Hemoglobin (Gm./100 cc.)	13.8 ± .2	5.6 ± .1	6.7(20) ± .15	11.2(30) ± .12	†	†
Hematocrit (%)	44.0(3)	29.0 ± .3	31.0(20) ± .5	37.6(30) ± .38	†	†
Red cell count (thousands per cu. cm.)	6,780.0 ±100.0	2,280.0 ±50.0	2,445.0(20) ±74.0	6,545.0(30) ±107.0	†	†

* Figures in parentheses refer to the number of animals sampled; figures after the ± signs are standard errors of the mean.

** 20 hens had 0.00 mg. total tocopherols per 100 cc. of serum; the rest ranged from 0.01 to 0.35 mg./100 cc. Standard error for 22 hens was 0.10 ± 0.02 mg./100 cc.

† These values were not determined. Becker and Smith[1] give the following report for sheep: hemoglobin, Gm. 70, 12.4 Gm./100 cc.; hematocrit, 37.9/100 cc.; and red cell count, 11.9 ± 1.2 million per cubic centimeter.

the figures in the table may serve as reference or base line data upon which to compare animals fed similar or diffierent diets, and that they may serve as a basis for controlled feeding experiments in the future.

SUMMARY

Means with standard errors are given for the following constituents in the blood stream of rats, hens, and baby chicks, pigs, sheep, and horses: total proteins, riboflavin, ascorbic acid, carotenoids, tocopherols, alkaline phosphatase, vitamin A, hemoglobin, hematocrit, and red cell count.

These data may serve to compare with data for other animals fed similar or different diets. The potential value of blood data as an aid in evaluating the physiological status of farm animals in the American tropics is stressed.

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