THE INFLUENCE OF DIET ON IRON ABSORPTION

III. Comparative Studies with Rats, Mice, Guinea Pigs, and Chickens*

By D. MARK HEGSTED, Ph.D., CLEMENT A. FINCH, M.D., and THOMAS D. KINNEY, M.D.

(From the Department of Nutrition, Harvard School of Public Health, the Departments of Biological Chemistry and Pathology, Harvard Medical School; the Departments of Pathology and Medicine, Peter Bent Brigham Hospital, Boston; the Department of Medicine, the University of Washington Medical School, Seattle; the Departments of Pathology of Western Reserve University School of Medicine and Cleveland City Hospital, Cleveland; and the Department of Physics, Massachusetts Institute of Technology, Cambridge)

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Earlier work (1, 2) has shown that when rats are fed a diet composed chiefly of corn grits to which large amounts of iron have been added, excessive amounts of iron are absorbed and deposited in the liver. The addition of phosphate salts to the diet prevents the absorption of excessive iron. Furthermore, when enough iron is added to a normal diet, the same high levels of liver iron are obtained. The shape of the curve obtained by plotting liver iron content against the iron content of the diet showed that the amount of iron absorbed, as indicated by that in the liver, was only moderately increased by the first increments of dietary iron but increased rapidly as larger amounts of iron were added. This suggested that the barrier to iron absorption in the gut was only effective against relatively small amounts of ionizable iron, such as would be found in the presence of considerable amounts of phosphate but that after essentially all of the phosphate was bound by iron, the iron absorption was very rapid.

It has been shown that the findings in dogs are similar (3) although the quantitative aspects have not been investigated with this species. In view of the fact that species differences in the metabolism of iron have been reported (4), it appeared worth while to study the response of small animals of other sorts to diets high in iron. The data obtained with chicks, mice, and guinea

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pigs are reported in this paper and compared to those results obtained earlier with rats.

EXPERIMENTAL

The diets used in these studies were similar to those reported earlier (1). The corn grit diet contained 20 per cent lard and 80 per cent corn grits with supplements of thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and vitamins A and D. For guinea pigs the diet was modified to contain 2 per cent lard, 10 per cent cellulose, and 88 per cent corn grits. Guinea pigs were injected with ascorbic acid three times weekly. The Purina diet was ground Purina dog chow. When fed to guinea pigs, 10 per cent of cellulose was added. Ferric citrate powder, U.S.P. VIII, was used throughout as the iron supplement.

All the diets were fed *ad libitum*, and the animals were kept in groups in large cages. Guinea pigs, chicks, and mice responded so poorly to the corn grit diet that it was necessary to shift them to the Purina diet at intervals when their conditions appeared critical. When they improved somewhat, they were again given the experimental diet. The time the animals received the corn grit diet is indicated in the experimental results. Even with these changes the mortality was high with guinea pigs and the data obtained less satisfactory than with the other species.

At the end of the experimental period the animals were etherized. The chest cavity was opened before the heart stopped beating and the vena cava was cut. This allowed a considerable blood loss which was apparently fairly uniform and the livers were not perfused. After weighing the livers, sections were taken for histological examination and the remainder digested for iron analyses. All methods have been described (1).

RESULTS AND DISCUSSION

The summary of the results is presented in Table I and requires little comment. It can be seen that the findings in all species studied are similar in that they show considerably more liver iron when fed the corn grit diet rather than the Purina diet at comparable levels of dietary iron and that increases in dietary iron are associated with increases in iron stores. As indicated above, the data are not strictly comparable because of differences in the time of the experiments and the time the experimental diets were fed. However, it is doubtful whether a closer comparison is worth while because of the differences in the response to the diet, changes in weight, and food consumption, etc., in the various species.

The normal liver iron values obtained are in the same range with all species, varying from 10 to 30 mg. per 100 gm. in individuals. Rats generally seem to run somewhat higher than the other species but the data are not sufficient to decide whether this is characteristic of the species.

TABLE I

The Effect of Diet and Iron Supplementation on the Liver Iron Content of Various Species

Species	No. of animals	Supplement to diet	Time of experiment	Weight change	Liver iron		
					Per liver	Per 100 gm.	Histologic score
			days	*per cent*	*mg.*	*mg.*	
Rats	5	Purina + 2 per cent Fe citrate	52	+16	2.05	31.2	1
	5	" + 4 " " " "	"	+17	2.54	37.4	2
	5	" + 6 " " " "	"	+7	4.77	69.6	3–4
	5	" + 8 " " " "	"	+21	7.44	94.8	4–5
	5	" + 12 " " " "	"	+19	13.03	171.6	7
	4	Corn grit diet	40	−11	2.56	27.3	1
	4	" " + 0.25 per cent Fe citrate	"	−14	2.90	30.7	1–2
	4	" " + 0.75 " " " "	"	−17	2.01	24.5	1–2
	4	" " + 1.25 " " " "	"	−30	6.67	86.0	4
	3	" " + 2.00 " " " "	"	−38	10.97	148.3	6
Guinea pigs	4	Purina	81	+183	4.8	21.8	1–2
	5	" + 0.5 per cent Fe citrate	36/81*	+216	6.0	24.0	2
	5	" + 1.0 " " " "	"	+282	10.2	37.1	4
	5	" + 2.0 " " " "	"	+306	13.3	46.3	5
	1	Corn grit diet	"	+112	6.7	19.6	1–2
	3	" " + 0.5 per cent Fe citrate	"	+114	13.0	49.8	3–4
	3	" " + 1.0 " " " "	"	+85	12.4	50.7	4
	3	" " + 2.0 " " " "	"	+113	24.3	76.9	5
Chicks	6	Purina	27	+281	2.31	19.2	1
	6	" + 0.5 per cent Fe citrate	"	+275	2.03	19.6	1
	4	" + 1.0 " " " "	"	+296	2.78	21.1	1
	5	" + 2.0 " " " "	"	+319	3.91	32.0	2
	5	" + 5.0 " " " "	"	+230	5.91	59.6	3–4
	6	Corn grit diet	20/27‡	+38	0.77	22.4	1
	5	" " + 0.5 per cent Fe citrate	"	+45	2.52	58.1	3
	5	" " + 1.0 " " " "	"	+25	5.90	162.4	6
	5	" " + 2.0 " " " "	"	+22	9.22	217.4	7
Mice	6	Purina	41	+13	0.26	13.5	0–1
	5	" + 0.5 per cent Fe citrate	"	+10	0.33	20.9	1
	5	" + 1.0 " " " "	"	+11	1.18	64.4	2
	5	" + 2.0 " " " "	"	+9	2.11	117.3	4
	6	Corn grit diet	32/41‡	+4	0.25	21.8	5
	5	" " + 0.5 per cent Fe citrate	"	+1	0.89	78.3	4
	4	" " + 1.0 " " " "	"	0	1.62	547.5	6
	4	" " + 2.0 " " " "	"	+1	3.96	269.8	8

* 36 out of 81 days the animals received the experimental diet. The remainder of the time they were fed Purina chow.

‡ Number of days out of the total that the animals received the experimental diet. The remainder of the time they received the Purina diet containing the same amount of iron as the experimental diet.

Even with the differences in experimental conditions, some quantitative comparisons appear possible. Chicks and mice which received the diet for relatively short periods had liver iron concentrations much higher than were found with rats which received the diets for a long time. These differences can best

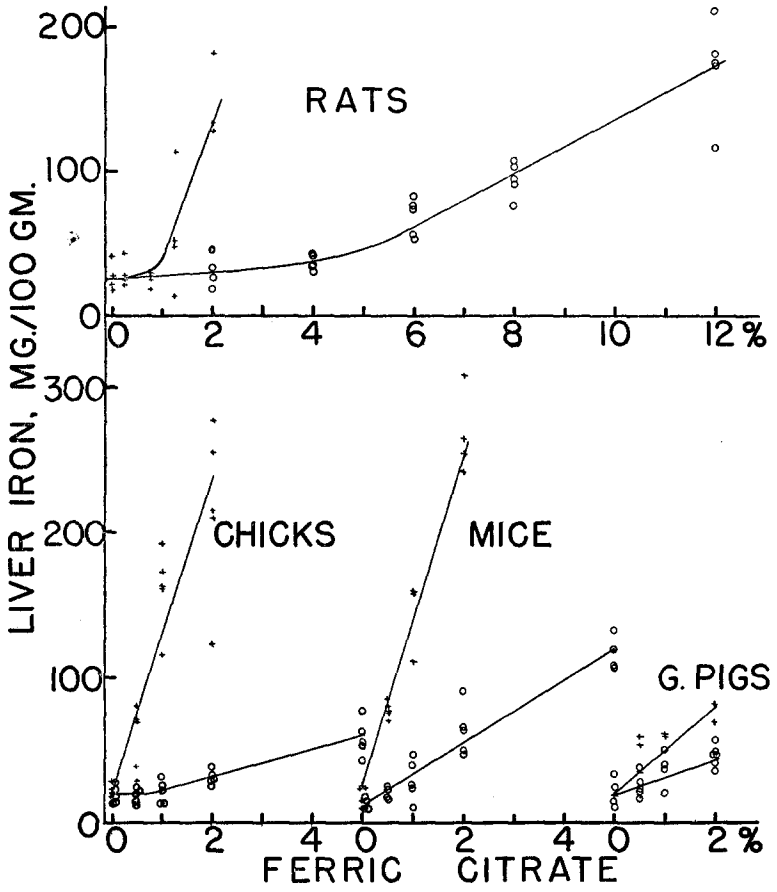

FIG. 1. Liver iron compared to the per cent of ferric citrate powder in the diet. Crosses indicate animals fed the corn grit diet. Open circles indicate animals fed Purina dog chow.

be seen from the plot of the data in Fig. 1 and are especially noteworthy in the case of mice. These and chickens apparently also absorb iron from the Purina diet much more easily than do rats. It will also be noted, especially with the mice, that on either diet the iron content of the liver is nearly a straight line function of dietary iron content. This type of curve is less easily explained than that obtained with rats receiving the Purina diet. Since the low phos-

phorus corn grit diet does allow much greater quantities of iron to be absorbed, one would expect the low levels of iron to be ineffective relatively on the Purina diet.

These studies serve to emphasize the importance of luminal factors in iron absorption. There is also good evidence that the mucosa can regulate iron absorption to some degree, particularly in the iron-deficient animal as compared to the normal animal (5) and when the iron content of the diet is low. Undoubtedly both mechanisms are involved. The appreciable differences in the ability of individual animals to control iron absorption in these studies may well represent quantitative differences in mucosal function although differences in iron intake as well as other luminal factors may be important.

SUMMARY

The response of rats, chicks, mice, and guinea pigs to two diets containing various amounts of iron has been compared. With diets composed chiefly of corn grits animals of all these species absorb and store considerably more iron than those with normal diets of the same iron content. If sufficient iron is added to a normal diet, all species will absorb large amounts of iron. However, there appear to be great species differences in the level of iron which must be fed to cause the increase in absorption. Chicks and mice appear to have less effective control over iron absorption on high iron diets. Attention is called to large individual differences in ability to control iron absorption under the conditions of these experiments.

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