LXXVII. EXPERIMENTS ON NUTRITION.

X. COMPARATIVE VITAMIN B₁ VALUES OF FOODSTUFFS. CEREALS II.

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(Received March 23rd, 1931.)

IN our previous experiments [Plimmer, Rosedale, Raymond and Lowndes, 1927] on testing cereals for their vitamin B (B₁) value, rearing of young by pairs of adult pigeons was taken as the standard of comparison. Some data concerning the maintenance of adult birds were also then given. A greater amount of foodstuff containing vitamin B was needed for rearing than for maintenance. This fact has been again observed in subsequent experiments.

It was considered at that time that the standard of rearing was too high and not altogether satisfactory. Other factors might well be concerned in the hatching of eggs and rearing of young, such as the presence of fat-soluble vitamins which were not allowed for. The standard of maintenance for a period of at least 26 weeks was adopted in our trials with pulses and nuts [Plimmer *et al.*, 1929] with satisfactory results. In order to bring cereals into proper comparison it was necessary to test them again on this standard. The results of these experiments are herewith presented.

In addition we have made some experiments on the extraction of vitamin B from wheat germ and have again tested marmite for comparison with the cereals and for ascertaining if its value were the same after a period of 5 or 6 years.

The term vitamin B is now used to include several unknown factors. In these tests the symptoms of head retraction of pigeons have been taken as the sign of insufficient vitamin B, *i.e.* in the modern nomenclature vitamin B₁.

EXPERIMENTAL.

The experiments have been made with pairs of pigeons kept in cages on the roof of the building as in previous trials with pulses.

The food was made into pills of white flour and the test grain which was ground finely in a coffee mill. In the earlier experiments cod-liver oil was not included, but later 1 % was added so that the birds should not suffer from a shortage of fat-soluble vitamins. Fishmeal was included to supply protein and mineral salts.

The results are recorded in a series of tables in the same form as in our earlier experiments with pulses.

Wheat.

In our previous paper it was reported that a pair of adult pigeons had been maintained on a diet containing 50 % whole wheat flour for 45 weeks, and that another pair (Nos. 93 and 26/27) had been kept on 40 % whole wheat flour for 23 weeks. This pair has been continued on the same diet for 78 weeks. They lost a little weight in the first 20 weeks, but at 40 weeks were above their original weight. Then followed a small decline and after 78 weeks they were slightly below their original weight. The hen laid some eggs at the start, but not again till the 46th week. On reducing the quantity of whole wheat to 30 % both birds lost weight, became ill, showed polyneuritis and died. 40 % wheat was clearly the minimum for maintenance (Table I).

Table I. *Whole wheat.*

Date	Time in weeks	Diet			Weights, g.		Remarks
		Whole wheat	White flour	Fish- meal	Cock No. 93	Hen No. 26/27	
30. iii. 27					445	365	
to		40	55	5			
17. viii. 27	20				385	295	Six eggs. One squab hatched and reared, but poor growth. Other eggs deserted
to							
4. i. 28	40				530	430	
to							
23. v. 28	60				440	355	
to							
26. ix. 28	78				400	330	Twelve eggs; all deserted
to		30	65	5			
24. x. 28	4				335	305	Both showed retracted head positions and died

Bran.

Two pigeons had previously been maintained on 30 % bran for 32 weeks. The experiment has been repeated and young have been reared on this quantity. The same pigeons were then maintained on 20 % bran and a pair of young was reared. On reducing the quantity to 10 % both birds lost weight and showed polyneuritis. 10 % bran was insufficient as verified by testing with another pair of birds (Table II).

Middlings.

Previously, a pair of pigeons had been maintained on a diet containing 30 % of middlings mixed with white rice for 16 weeks. In these experiments some of the middlings on account of the small particles could not be picked up so that white flour pills were substituted; a longer time for maintenance was also essential. The trial was started with a pair of birds on 30 % middlings which was reduced to 20 % after a short period on whole wheat. Cod-liver oil (1 %) was now mixed with the food to ensure the presence of fat-soluble vitamins. They were maintained on this diet for 27 weeks and again after an interval on whole wheat the amount of middlings was reduced

Table II. *Bran.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Bran	White flour	Fish- meal	Cod- liver oil	Cock No. 75	Hen No. 76	
8. v. 29 to 13. xi. 29	27	30	65	5	0	510	360	Eight eggs laid, four hatched and young reared. Four hatched and young died
11. xii. 29 to	4	20	74	5	1	585	450	
18. vi. 30 to 2. vii. 30	27	10	84	5	1	595	410	Ten eggs laid; first two hatched and young reared, Nos. 4 and 6 below. Eight deserted
23. vii. 30	5					535	405	
						455	355	Cock showed head retraction and died
						—	305	Hen showed head retraction and died
29. i. 30 to 6. viii. 30	28	20	74	5	1	No. 4 95	No. 6 105	Squabs reared on 20 % bran
						460	425	
28. v. 30 to 9. vii. 30	6	10	84	5	1	No. 9 425	No. 29 430	
23. vii. 30	8					245	310	Cock showed paralysis and died
						—	245	Hen showed head retraction and died

to 10 %. They were quite well on this quantity, but on reducing the amount to 5 % they lost weight and showed the symptoms of polyneuritis.

The experiment was confirmed with another pair of pigeons, starting at 10 % middlings. The insufficiency of 5 % middlings was verified with a third pair of pigeons. The details are shown in Table III. The sample of middlings would thus appear to contain a considerable proportion of wheat germ, the value of which we had found to be 6 % for maintenance. Other samples of middlings may not have such a high vitamin B value. We have not tested any other samples.

Wheat germ.

For comparison with whole wheat, middlings and bran some further trials have been made with wheat germ. No difference was previously noticed between fresh and heated wheat germ. In these experiments "bemax" was used as source of wheat germ. Maintenance was secured on 6 %, but on prolonging the test both birds died without showing the typical signs of polyneuritis. Two pairs of birds were maintained on 7 % for 26 weeks and one pair was kept for 53 weeks. The details are shown in Table IV. The material had thus the same value as the wheat germ of the previous trial.

Extraction of wheat germ with solvents. With a view of extracting and concentrating vitamin B₁ some experiments were first made to ascertain the completeness of the extraction with solvents. Fat solvents, such as ether, chloroform, light petroleum do not extract vitamin B₁. The residue after

Table III. *Middlings.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Midd- lings	White flour	Fish- meal	Cod- liver oil	Cock No. 15 370	Hen No. 44 375	
8. v. 29 to		30	65	5	0			Seven eggs. First two hatched and young reared; one died later
13. xi. 29 to	27		On whole wheat			455	445	Other eggs deserted
11. xii. 29 to	4	20	75	5	0	410	435	No eggs
12. iii. 30 to	13	20	74	5	1	415	450	No eggs
18. vi. 30 to	14	10	84	5	1	430	425	Nine eggs. One hatched, squab died. Others deserted
17. xii. 30 to	26	5	89	5	1	455	420	Six eggs at beginning, none later
14. i. 31	4					335	335	Hen showed head retraction and was cured. Cock had paralysis and died
28. v. 30 to						No. 85 460	No. 86 420	
31. xii. 30 to	31	10	84	5	1	550	435	Six eggs; all deserted
28. i. 31	4	5	89	5	1	390	320	Cock showed head retraction and was cured. Hen had head retraction and died
5. xi. 30 to						No. 100 420	No. 1557 375	
10. xii. 30	5	5	89	5	1	300	315	Both showed head retraction and were cured

Table IV. *Wheat germ.*

Date	Time in weeks	Diet			Weights, g.		Remarks
		"Bemax"	White flour	Fish- meal	Cock No. 329	Hen No. 327	
28. ix. 27 to		6	89	5	330	330	Six eggs; deserted
18. iv. 28 to	29				355	340	Cock died
27. vi. 28	39						Hen died. Both birds at p.m. examination had very wet tissues and very large hearts
1. viii. 28 to					No. 88 380	No. 80 410	
20. ii. 29	29	7	88	5	465	495	No eggs during winter months
26. ix. 28 to					No. 89 390	No. 49 345	
20. iii. 29 to	25				450	385	Four eggs; deserted
16. x. 29	30				410	365	

extraction, as shown in Table IV *a*, fed to pigeons in an amount of 6 % gave maintenance for 26 weeks. Extraction with absolute alcohol subsequent to

Table IV *a*.

Date	Time in weeks	Diet			Weights, g.		Remarks
		Ether- extracted "bemax"	White flour	Fish- meal	Cock No. 54	Hen No. 75	
28. ix. 27 to		6	89	5	385	400	
24. iv. 28 to	30				365	350	
26. ix. 28	52				350	320	Two eggs in 43rd week; deserted
		Ether + abs. alc.- extracted "bemax"			No. 64	No. 520	
8. ii. 28 to		10	85	5	465	495	
8. viii. 28 to	26		On wheat		440	470	Eighteen eggs; deserted
29. viii. 28 to	3	6	89	5	420	455	Two eggs; deserted
17. x. 28 to	7				350	390	Two eggs; deserted. Cock had head retraction. Cured
31. x. 28	9				—	305	Hen died. Had large heart
		Light petroleum + abs. alc.- extracted "bemax"			No. 88	No. 80	
20. ii. 29 to		7	88	5	465	495	
21. viii. 29	26				435	455	Twelve eggs; deserted
		Abs. alc.- extracted "bemax"			No. 26/28	No. 58	
13. ii. 29 to		50	47.5	2.5	445	360	
7. viii. 29	25				395	330	No eggs
		Petroleum + 50 % alc.- extracted "bemax"			No. 93	No. 50	
20. iii. 29 to		7	88	5	420	470	
24. iv. 29	5				275	305	Both had head retraction
					No. 26/28	No. 58	
4. ix. 29 to		21	74	5	430	335	
9. x. 29	5				315	275	Both had head retraction
					No. 89	No. 49	
20. xi. 29 to		42	53	5	450	385	
11. xii. 29	3				350	300	Both had head retraction

these solvents removed only a small quantity of vitamin B₁. Pigeons were maintained with 10 % of the residue in the diet, but failed on 6 %. Complete extraction was effected with 50 % alcohol. The residue was tested in amounts of 7, 21 and 42 % of the diet. The birds showed symptoms of polyneuritis at each level in 3 to 5 weeks. The vitamin was present in the 50 % alcoholic

extract. It is thus not necessary to use acid alcohol for the extraction. Further experiments with the alcoholic extract have been discontinued as similar work is being carried out by Guha and Drummond [1929].

Barley.

55 % of whole barley in the diet with white rice was the smallest amount used previously and the pigeons were maintained for 42 weeks. Two pigeons were started on 40 % barley with white flour to compare with wheat. After 7 weeks they were found to be two cocks and a hen was substituted for one of them. They were maintained for 35 and 27 weeks respectively. After an interval on whole wheat, the barley was reduced to 30 %. Both suffered from polyneuritis. The vitamin B₁ value of barley was thus the same as that of wheat.

Table V. *Barley.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Barley	White flour	Fish- meal	Cod- liver oil	Cock No. 333	Hen No. 54	
5. ix. 28						405	—	
to 7. xi. 28	11	40	55	5	0	420	345	
to 15. v. 29	29					415	355	Four eggs; one hatched, squab died
to 3. vii. 29	7	On whole wheat						Two eggs; one hatched and reared
to 14. viii. 29	6	30	65	5	0	320	325	Four eggs; deserted Cock had head retraction and died
to 11. ix. 29	10					—	210	Hen had head retraction and died

Malt extract.

Cooper [1914] examined several malt extracts for vitamin B by the curative method and found that two samples had curative action. Stammers [1924] and Southgate [1924] have also found vitamin B in malt. Randoin and Lecoq [1927] on substituting malt extract for dextrin to the extent of 66 % of the diet obtained cure and prevention of polyneuritis. Bacharach and Allchorne [1928] considered malt extract a rich source of vitamin B and of almost equal value to the cereal from which it was made.

Malt extract had not been previously tested by us. With the pill method of feeding pigeons it was easy to incorporate the sticky material with white flour and try its value in comparison with cereals. The extract tested was the same as is used for patients in St Thomas's Hospital. Two trials were made with 40 % malt in the diet, three with 30 % and one with 20 %. The birds suffered from polyneuritis on 20 %, but were maintained on 30 % and 40 % for 23 and 27 weeks. The value of the malt extract was thus slightly greater than that of barley. The data are given in Table VI.

Table VI. *Malt extract.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Malt extract	White flour	Fish- meal	Cod- liver oil	Cock No. 24	Hen No. 70	
29. v. 29 to 11. ix. 29 to	15	40	55	5	0	375 260	375 295	Birds ate very little and lost weight. Both not well. Cock had head retraction and was cured. Both got better. No eggs
19. ii. 30 to 13. viii. 30 to	23 25	30	65	5	0	415 345	410 305	Hen paralysed and died
27. viii. 30	27					310	—	Cock had head retraction and died
23. x. 29 to 19. iii. 30 to		40	55	5	0	No. 343 465	No. 60 410	Ten eggs; all deserted
7. v. 30 to 23. vii. 30 to	7 11	40 30	54 64	5 5	1 1	440 425 410	375 365 320	Four eggs; deserted
17. ix. 30	19					390	305	Cock had head retraction and died. Hen was paralysed and died
6. xi. 29 to 8. i. 30 to		30	64	5	1	No. 98 490	No. 62 405	
26. iii. 30	20					415 —	375 330	Cock had head retraction and died Hen had head retraction and died
19. iii. 30 to 21. v. 30		20	74	5	1	No. 42 455 340	No. 38 300 245	Both showed head retraction and were cured

Oatmeal and oats.

Previous work led to the conclusion that rearing was not possible on oatmeal without an addition of marmite, though adult pigeons could be maintained for 40 and 52 weeks on 95 % oatmeal. Maintenance experiments with oatmeal were therefore essential for proper comparison with other cereals. Maintenance was found on a diet containing 50 % oatmeal for 31 weeks, and also with 40 % oatmeal. This result was confirmed with a second pair of birds. On reducing the amount of oatmeal to 30 %, the cock bird showed polyneuritis in 28 weeks. 30 % oatmeal was tested again with another pair of pigeons. In this case the hen showed polyneuritis, but not the cock. There was failure on 20 % oatmeal. Maintenance was thus possible on 30 % oatmeal as the minimum quantity, but it is not certain and we ought to take 35 % as the proper minimum quantity. Oats had the same value as oatmeal. The data are given in Table VII.

Table VII. *Oatmeal.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Oat- meal	White flour	Fish- meal	Cod- liver oil	Cock No. 56	Hen No. 14	
29. ii. 28 to		50	45	5	0	415	375	Twelve eggs. Ten deserted. Hatches from last two, but squabs died
3. x. 28	31					400	390	
1. viii. 28 to		40	55	5	0	No. 57 465	No. 6 385	Two eggs at beginning, hatched but squabs died No more eggs
27. ii. 29	29					540	515	
1. v. 29 to		40	55	5	0	No. 236 475	No. 99 390	Ten eggs. Four hatched and reared with poor growth and weak. Two hatched and died. Four deserted
13. ii. 29 to	28					525	445	
8. i. 30 to		30	On whole wheat			555	405	Ten eggs. Two hatched; squabs died. Others de- serted
			64	5	1			
23. vii. 30 to	28					425	445	Cock showed head retrac- tion and was cured
6. viii. 30 to	30	(Oats) 30	64	5	1	475	415	
1. x. 30 to	8					380	400	Four eggs; deserted. Cock showed head retrac- tion and was cured. Hen kept on diet
11. ii. 31	27					—	410	
16. vii. 30 to						No. 1156 410	No. 35 400	Two eggs; deserted Hen paralysed and died. Cock continued on diet
29. x. 30 to	15	30	64	5	1	410	330	
11. ii. 31	15					420	—	
30. vii. 30 to						No. 56 395	No. 38 305	Both showed head retrac- tion. Hen died; cock cured
17. ix. 30	7	20	74	5	1	285	215	

Buckwheat.

Buckwheat had not been found a satisfactory grain for rearing, but a pair of pigeons had been maintained on 70 % buckwheat in the diet for 31 weeks. Proper comparison with other cereals was needed. A pair of pigeons was kept for 29 weeks first on 40 %, then on 30 % and later on 20 %. On reducing the amount of buckwheat to 10 %, both birds showed polyneuritis and died. The data are in Table VIII. Buckwheat is thus slightly richer in vitamin B than the other grains.

Table VIII. *Buckwheat.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Buck- wheat	White flour	Fish- meal	Cod- liver oil	Cock No. 334	Hen No. 335	
10. x. 28						375	345	
to 1. v. 29	29	40	55	5	—	360	340	Five eggs; deserted
to 29. v. 29	4	On whole wheat				350	335	Two eggs; deserted
to 18. xii. 29	29	30	65	5	—	410	400	Seven eggs; deserted
to 6. viii. 30	29	20	74	5	1	365	340	Eight eggs; deserted
to 17. ix. 30	6	On whole wheat				345	320	One egg; deserted
to 12. xi. 30	8	10	84	5	1	255	280	Two eggs; deserted Cock had head retraction and died
to 26. xi. 30	10					—	255	Hen showed paralysis and died

Maize.

The experiment with maize carried out previously was maintenance on 60 % maize with 35 % white flour for 18 weeks. The same pair of pigeons after an interval on whole wheat was tested with 40 % maize. As seen from Table IX they showed polyneuritis in about 20 weeks. This amount was thus insufficient. No further experiment was made, as previously a pair had been maintained on 50 % maize for 23 weeks.

Table IX. *Maize.*

Date	Time in weeks	Diet			Weights, g.		Remarks
		Maize	White flour	Fish- meal	Cock No. 26/4	Hen No. 26/5	
5. x. 27					445	395	
to 15. ii. 28	19	40	55	5	380	290	Ten eggs; deserted Hen had head retraction and died
to 22. ii. 28	20				360	—	Cock had head retraction and died

Rye.

With rye it had been observed that a pair of birds could be maintained for 31 weeks on a diet containing 45 %. The next trial was to use 40 %. The first cock bird was not satisfactory, but a second was kept on this amount for 26 weeks and the hen for a total of 47 weeks. On reducing the amount of rye to 30 %, both birds showed polyneuritis. This was confirmed with another pair and another hen put in with the cock after the first hen had died. The cock bird seemed rather resistant to shortage of vitamin B and only showed symptoms after 39 weeks. During the last period of 6 weeks his food consumption was measured and was from 10 to 13 g. daily as compared with a normal consumption by healthy birds of 30 to 40 g. daily. On a small consumption of food it has often been noticed that pigeons will live for long

periods before they show head retraction, or die showing only symptoms of paralysis. The data are in Table X.

Table X. *Rye*.

Date	Time in weeks	Diet			Weights, g.		Remarks
		Rye	White flour	Fish- meal	Cock No. 77	Hen No. 25/27	
27. vi. 28					405	360	
to		40	55	5			
12. ix. 28	11				330	365	Cock changed
					No. 87		
					395	—	
to					475	385	Four eggs; deserted
14. xi. 28	10						Cock escaped
					No. 64		
					420	—	
to							Fourteen eggs; deserted
22. v. 29	26 (47)				425	345	
to		On whole wheat					
19. vi. 29					420	380	
to		30	65	5			
14. viii. 29	8				340	275	Two eggs; deserted
to							Cock had head retraction
28. viii. 29	10				—	255	and died
							Hen had head retraction
							and died
					No. 167	No. 82	
5. ix. 28					415	320	
to		30	65	5			
28. xi. 28	12				340	250	Hen had head retraction
							and died
						No. 94	
9. i. 29	18				440	385	
to							
1. v. 29	13				320	285	Hen had head retraction
to							and was cured
5. vi. 29	39				285	—	Cock had head retraction
							and was cured

Dari and millet.

Rearing experiments only were made previously with these grains. The smallest amounts with white rice were 55 %. Tests have now been made using white flour pills with 40 % of the grains. On this amount the pigeons

Table XI. *Dari*.

Date	Time in weeks	Diet				Weights, g.		Remarks
		Dari	White flour	Fish- meal	Cod- liver oil	Cock No. 84	Hen No. 73	
7. xi. 28						535	355	
to		40	55	5	0			
15. v. 29	27					515	385	Four eggs; one hatched, squab died
to		On whole wheat						
19. vi. 29	5					560	370	
to		30	65	5	0			
20. xi. 29	22					435	320	Both birds had head retrac- tion and were cured

were maintained with both grains. They failed on 30 % dari, and on 20 % millet. The data are in Tables XI and XII.

Table XII. *Millet.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Millet	White flour	Fish- meal	Cod- liver oil	Cock No. 100	Hen No. 1557	
6. iii. 29 to 9. x. 29	31	40	55	5	0	395	360	Twelve eggs; three hatched, one squab reared, two died
6. xi. 29 to 4. vi. 30	4	On whole wheat				445	380	Two eggs; deserted
23. vii. 30 to 3. ix. 30	30	30	64	5	1	415	375	Eight eggs; one hatched, squab died, others deserted
10. ix. 30	7	20	74	5	1	410	350	Two eggs; hatched and squabs reared
	6					270	305	Cock had head retraction and was cured
	7					280	270	Hen had head retraction and was cured

Rice.

It was of interest and importance to compare the value of brown rice, *i.e.* rice with its pericarp, with that of other cereals. Tests were started with 40 % rice. On this amount the pigeons were maintained, but they suffered from polyneuritis on 30 %. Such rice has thus the same value in vitamin B as wheat and other cereals. The results are in Table XIII.

Table XIII. *Rice.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Brown rice	White flour	Fish- meal	Cod- liver oil	Cock No. 88	Hen No. 80	
25. ix. 29 to 16. iv. 30	29	40	55	5	0	445	455	Six eggs; deserted
28. v. 30 to 4 vi. 30	6	30	64	5	1	370	420	Hen died, new hen used
25. vi. 30 to 3. ix. 30	10					395	No. 95 365	
	13					275	350	Cock had head retraction and died
						—	285	Hen had head retraction and died

Marmite.

Partly from our experiments and partly from experiments of other workers the belief has arisen that marmite has not such a high content of vitamin B as it had 8 or 9 years ago. Our first trials [Plimmer, Rosedale, and Raymond, 1923] indicated that 3 % marmite was sufficient to keep a pair of pigeons in health. These trials were of short duration, from 5 to 6 weeks, and are not strictly comparable with those of our present standard of maintenance for at

least 26 weeks. Also, white rice was used instead of white flour, which allowed the birds to reject any grains not properly coated with marmite. It is therefore possible that this amount would not have sufficed in a long trial. Later [Plimmer, Rosedale and Raymond, 1927, pp. 929-931] it was found that amounts varying from 4 to 8 % of different yeast extracts, again tested for short periods, sufficed. The first trial with marmite with long maintenance as the standard indicated that 8 % was the minimum amount.

Since marmite is so often used as the source of vitamin B in experimental diets, it was considered of distinct importance to make tests with marmite of recent manufacture. It was not possible to test marmite manufactured 10 years ago so as to obtain an exact comparison. Two samples have been kindly supplied by the makers, prepared from the same yeast. The first

Table XIV. *Marmite.*

Date	Time in weeks	Diet				Weights, g.		Remarks
		Marmite. Ct. marmite	White flour	Fish- meal	Cod- liver oil	Cock No. 89	Hen No. 49	
15. i. 30 to 26. iii. 30	10	8	87	5	0	455	380	
						455	305	Hen died from burst egg in oviduct
2. iv. 30 to 16. vii. 30	11 26, 15	8	86	5	1	460 435	No. 43 445 460	Eight eggs; one hatched, squab died. Others deserted
11. ii. 31 to 25. ii. 31	30 2	6 4	88 90	5 5	1 1	430 305	445 375	Two eggs, one hatched, squab died Both birds had head retraction. Cock cured, hen died
1. x. 30 to 19. xi. 30 to 28. i. 31	8 17	4	90	5	1	No. 96 370 340 —	No. 2 295 315 —	Cock had head retraction and died Hen paralysed and died
15. i. 30 to 26. iii. 30	10	K. marmite				No. 18 530	No. 39 505	
26. iii. 30 to 16. vii. 30	16	8	87	5	0	515	510	Four eggs; deserted
16. vii. 30 to 11. ii. 31	30	8	86	5	1	475	455	Eight eggs; deserted
11. ii. 31 to 4. iii. 31	3	6	88	5	1	520	500	Six eggs; deserted
4. iii. 31 to 18. iii. 31	5	4	90	5	1	470	400	Hen had head retraction and cured
						350	—	Cock had head retraction and cured
1. x. 30 to 19. xi. 30 to 28. i. 31	8 17	4	90	5	1	No. 23 355 285 —	No. 3 325 275 235	Cock had head retraction and cured Hen paralysed and died

(Ct. marmite) was similar to the material of the last few years, the second (K. marmite) was material made from a clarified extract. This is the present method of manufacture. As may be seen from Table XIV both the samples had the same value. 6 % in the diet was the minimum for maintenance. This compares with 8 % found in 1925. There is thus no essential change in the vitamin B value of marmite in a period of 6 years. It may be noted that marmite if kept for such long periods may lose value, as we observed in 1923. Freshly manufactured marmite seems of approximately the same value from year to year.

Baker's yeast.

The amount of baker's yeast required to supply vitamin B was found previously to be above 10 % of the diet. An experiment with 12 % in the diet sufficed for maintenance of two pigeons for 31 weeks. This value corresponds with its moisture content and reckoned on dry weight its value is the same as that of dried brewer's yeast, 4 % of the diet.

DISCUSSION.

These experiments do not differentiate between the several factors of the vitamin B complex. They give essentially the vitamin B₁ or antineuritic value. The vitamin B₂ value of cereals has been examined by Aykroyd and Roscoe [1929] and has been found to be very small. It was presumably supplied in the fishmeal of our diets and is probably not needed by pigeons according to the work of Carter, Kinnersley and Peters [1930]. If vitamin B₃ is to be regarded as necessary for the maintenance of weight, its amount in cereals and pulses must be in close correspondence with the amount of vitamin B₁. Reference to the weights of the pigeons in our tables shows that weight is maintained over the long periods of 26 or more weeks and loss of weight occurs as soon as the amount of cereal is reduced below the maintenance quantity, followed in a few weeks by the symptoms of head retraction in most cases and paralysis in the others. There was also invariably a fall in food consumption which really accounts for the loss in weight. Occasionally a bird has lived for many weeks at a much lower weight level and with a very small food consumption. The general metabolism of these birds is less and a smaller amount of vitamin B₁ or B₃ or both is then required. The vitamin B complex is wanted for the health of the bird to replenish the store in every cell of the body. At the low weight level the bird eventually dies unless cured, but, if cured, there is a large food consumption and gain in weight. *Post mortem* examination of our dead birds has almost invariably shown that the hearts are very large and flabby, and frequently the tissues of the birds are wet. Maintenance of weight may be due to such a wet condition of the tissues, and should be distinguished from increase of tissue substance.

SUMMARY.

Adopting the same standard of comparison as in our work on pulses and nuts, the comparative vitamin B values of cereals are as follows:

	Percentage amount in diet for maintenance	Comparative vitamin B value
Dried yeast	4	100
Marmite	6	67
Wheat germ ("bemax")	6-7	62
Middlings	10	40
Baker's yeast	12	33
Bran	20	20
Buckwheat	20	20
Millet	30	13
Oatmeal	35	11
Wheat	40	10
Barley	40	10
Malt	40	10
Rye	40	10
Dari	40	10
Brown rice	40	10

Cereals are thus not quite so rich in vitamin B as pulses, which had a comparative figure of 13.

We desire to express our thanks for grants from the Government Grant Committee of the Royal Society and from The Imperial Chemical Industries, Limited, which have defrayed the costs of the foods and birds used in these experiments.

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