THE PHOSPHORIC OXIDE CONTENT OF MAIZE FLOUR.

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In 1909, in a paper published from the Federated Malay States Institute for Medical Research, Fraser and Stanton in discussing the etiology of beri-beri found that polyneuritis could be produced in fowls by a diet of polished white rice and that the fowls remained healthy if, in addition to the polished rice, they received a sufficient quantity of rice polishings or a quantity of an alcoholic extract (evaporated at a temperature of 52° C.) of whole rice. They established the fact that the essential cause of beri-beri was to be sought for in a nutritive defect, and they endeavoured to determine by chemical methods precise differences between rices capable of causing polyneuritis in fowls and rices which did not cause the disease. Their experiments had shown conclusively that highly polished rice gave rise to the disease but whole rice did not and that the disease could be cured by adding rice polishings to the diet. The chemical examination showed that, whereas whole rice contains about 0·469 per cent. of phosphoric oxide, polished white rice contains only about 0·277 per cent. and the polishings contain about 4·2 per cent.

At that time Fraser and Stanton did not claim that the disease was due to a deficit of phosphoric oxide in the diet, but they claimed that the amount of phosphoric oxide in a rice could be used as an indicator of the disease-producing power of the rice: the lower the amount of phosphoric oxide in a polished rice the more likely is it to cause polyneuritis in fowls or beri-beri in man.

Later work by Fraser and Stanton showed that phosphoric oxide or phosphorus compound is not the substance in whole rice or rice

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polishings which prevents the disease, and researches by other workers have amply confirmed this.

Several investigators (Fraser and Stanton, Funk, Schaumann, Eadie and Simpson, etc.) have contributed towards the solution of the problem as to the nature of what may be termed the preventive substance occurring in grain. The subject has been completely reviewed by Casimir Funk in his book on *Die Vitamine* (Wiesbaden, 1914). It has now been proved that vitamine is the preventive substance and that it occurs in greatest abundance in the germinal portion and in the outer layers of the pericarp of the grain. The constitution of vitamine has not yet been established, but it is certain that vitamines from different grains and other natural products (yeast, meat, milk, etc.) are not identical.

The isolation of vitamine from a foodstuff is a tedious process and is not available as an analytic method. Fraser and Stanton have suggested that the amount of phosphoric oxide in rice may be used as an indicator: although vitamine contains no phosphorus, yet since the portion of the grain in which the vitamine is concentrated is also the portion richest in phosphorus, Fraser and Stanton's suggestion is probably well founded when applied to grain or grain-products which have been subjected only to mechanical processes and not to extraction processes and which have not been heated to too high a temperature (which is detrimental to vitamine). For, if that portion of the grain rich in vitamine is lost in the milling process then the waste must also be richer in phosphorus and the milled flour must be correspondingly poorer in phosphorus. Much experimentation has established that this is the case with rice, and in the Philippines "a rice containing less than 0·4 per cent. of phosphoric oxide is regarded as polished and that which contains a greater percentage of phosphoric oxide as unpolished rice" (Victor G. Heiser, *Philippine Journ. Sci.*, B. Med. Sci., 1911, VI. 229).

If this holds for rice it seems highly probable that it applies to other grains also. If in the grinding of a grain the flour produced is poorer in phosphorus than the original grain, then it is almost certain that some of the vitamine present in the grain has been lost in the milling. Since vitamine occurs in small proportion in foodstuffs, it is advisable to avoid the loss of any of it if possible.

In order to ascertain if the loss of vitamine (as measured by the loss of phosphoric oxide) in the usual production of maize meal or flour is serious a number of samples of maize and of the flours and

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wastes therefrom were obtained from mills on the Witwatersrand, Transvaal.

The milling practice varies considerably, and in most cases a fine white flour of good appearance is produced: this flour represents, as a rule, from 84 to 89 per cent. of the original maize. From 6 to 9 per cent. of bran is produced and about 3 to 5 per cent. of seconds: 1 to 3 per cent. of waste (including dirt, stones, wire, nails, string, etc.) is removed at the mill.

In the samples examined the water and ash were determined as well as the phosphoric oxide. In estimating the phosphoric oxide the precautions advocated by Leavitt and LeClerc (*Journ. Amer. Chem. Soc.*, 1908, xxx. 391, 617) were observed.

It is needless to record here all the results obtained: the following three examples are typical, and in *every* case it was found that the fine meal (flour) contained not more than four-fifths of the phosphoric oxide present in the original grain.

		% Water	% Ash	% Phosphoric oxide
A.	Whole maize	11·5	1·11	0·55
	Fine meal	10·9	0·94	0·44
	Seconds	10·8	3·64	0·78
	Bran	10·2	2·10	0·70
	Waste	10·9	4·20	0·70
B.	Whole maize	12·1	1·01	0·45
	Fine meal	10·7	0·72	0·32
	Bran	10·3	2·21	1·08
	Waste	9·7	2·19	0·81
C.	Whole maize	11·5	1·18	0·53
	Fine meal	11·6	0·86	0·40
	Waste No. 1	9·7	13·03	0·62
	Waste No. 2	10·3	8·73	1·05
	Waste No. 3	10·5	16·05	0·54
	Bran	10·2	3·38	1·23

Incidentally it may be mentioned that samples of "samp" (consisting only of maize endosperm) contained only from 0·16 to 0·20 per cent. of phosphoric oxide.

Many analyses proved that in the conversion of the grain into flour a loss of phosphoric oxide always took place and it is presumed that concomitantly there was a loss of vitamine. The loss is not so considerable as takes place in the polishing of rice, and it is probable therefore that a diet of this maize meal does not induce such serious effects as a diet of polished rice does, but as maize meal is a staple

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article in the diet of the native labourers at the Witwatersrand gold mines it seemed desirable to ascertain if, by milling the grain in such a way as to minimise the loss of phosphoric oxide (and vitamine), the flour would be improved. For experimental purposes the milling practice at a mill was altered in such a way that 96 per cent. of the original grain was converted into fine meal passing a 30-mesh sieve. Many analyses of the product have been made, and it has been proved that the fine meal contains nearly as much phosphoric oxide as the original grain. The following analyses are typical:

	% Phosphoric oxide				
	A	B	C	D	E
Whole maize	0·53	0·49	0·48	0·57	0·45
Fine meal	0·51	0·46	0·46	0·53	0·45

The loss of phosphoric oxide (and with it the loss of vitamine) has been reduced to a minimum and dietary experiments have proved that very considerable advantage has thereby been achieved.

Experiments on a large scale with about 6000 native labourers are being conducted by Dr D. Macaulay with the old type of meal and with the new. Half of the labourers receive in their rations the old type and the others receive the new. Dr Macaulay will report later on his experiments, but I have his permission to state that the incidence of disease amongst those using the new type of meal is much lower than that amongst those using the old type. Further, no intestinal disturbances due to the use of the new type of meal have been observed. The conclusion appears to be justified that fine white meal, produced after removal of the husk and a considerable proportion of the germinal portion of maize, is a defective foodstuff which may give rise to some form of deficiency disease: by grinding the maize in such a way that practically the whole of the grain is converted into fine meal this defect is remedied.

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