Original Articles.

The Chemical Composition of Some Ceylon Paddies, Rices and Milling Products.

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RICE is the staple food of the greater part of the indigenous population of Ceylon, and as such, a study of the chemical composition of the local paddies, rices and milling products would not be without interest and value. It would also afford data for comparison with that of other paddy growing countries. A search of the literature revealed a surprising lack of definite data on the analyses of Ceylon paddies and rices, though undoubtedly several of these must have been made. To those who might question the utility of such analytical data it may be replied that, though admittedly, the nutritive value of a sample of rice does not depend solely on its chemical composition but on the digestive capacity of the individual consumer, yet previous workers have shown that, other things being equal, the value of a sample of rice is almost directly proportional to its phosphoric acid and albuminoid or protein contents. It is a well known fact that the deficiency disease 'beri-beri' is to a great extent brought about by the consumption of highly polished rice, which in the process of polishing, has been deprived of its useful vitamins and as analysis reveals, a great proportion of its phosphoric acid, protein and fat.

It was therefore thought desirable that a systematic chemical study of some of our widely-grown and more characteristic paddies and rices, and of the effects of parboiling, pounding,

husking and polishing on their composition, should be made. Both pure line and ordinary mixed varieties were analysed. The analytical work included determinations of both organic and mineral constituents of the paddies and milling products, because of the importance of minerals in the diet of human beings and animals, and was carried out by Mr. Kandiah. The investigation was planned in co-operation with the Economic Botanist who supplied the pure-line paddies and undertook the husking and polishing by the method carried out in Ceylon villages, of both raw and parboiled rices. He will be contributing a separate paper on the botanical characteristics and milling properties of these rices, and also details of the village pounding process. Samples were also obtained through the kindness of the Manager, Sravasti Estate Rice Mills, Anuradhapura, of paddy and rice products at different stages of milling.

Experimental.

In all no less than 35 samples of paddies, rices and milling products were analysed, as detailed below.

Paddies.—Pure line *a8* (*Podiwi*), from the Economic Botanist.

Pure line B 11 (*Mawi*), from the Economic Botanist.

Murungan, from Sravasti Estate, Anuradhapura.

Hill Paddy (*Elwi*), from Ratnapura. ... 4

Rices.—(a) Husked by hand. ... 4

(b) Raw pounded by the village method. *a8*, B11, *Murungan*, Hill Paddy. ... 4

(c) Parboiled and pounded by the village method. *a8*, B11, *Murungan*, Hill Paddy, H.K. 13 (*Hinati*) and village *Hatiel*. ... 6

(d) Machine milled and polished.

(i) Ceylon—*Murungan* before polishing, from Anuradhapura.

Ceylon—*Murungan* after polishing, from Anuradhapura. ... 2

(ii) Foreign—*Muttu Samba*

Milchard. ... 2

Bran.—From raw and parboiled paddy. *a8*, B11, *Murungan* and Hill Paddy ... 9

Husk.—From raw and parboiled paddy. *a8* and B11, ... 4

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From the detailed statement above it will be observed that the data obtained will afford some idea as to the differences in chemical composition (a) between pure-line paddies and paddy products and those of the ordinary cultivated varieties, (b) dry land and irrigated paddies and paddy products (c) as a result of husking, parboiling, and polishing paddies. Reference will be made whenever possible to the results of analyses of the rices, paddies, etc., of other rice-producing countries.

Analyses and Methods.—In each sample determinations were made of the moisture, nitrogen, protein or albuminoid, fat. fibre and ash contents by the ordinary analytical methods. The carbohydrates were obtained by difference. The ash was analysed for phosphoric acid and lime, these being regarded as the more important of the mineral constituents.

Results.—In all the tables, the figures in italics give the composition of the rices, etc., when calculated on dry matter at 100°C.

Table I.

Composition of Ceylon Paddies.

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*)	...	12·16	6·43	1·94	9·35	64·43	5·69	1·03	·600	·086
			7·32	*2·21*	*10·64*	*73·35*	*6·48*	*1·17*	*·680*	*·098*
B11 (*Mawi*)	...	12·27	6·60	1·89	11·52	61·78	5·94	1·06	·629	·087
			7·52	*2·15*	*13·13*	*70·43*	*6·77*	*1·20*	*·716*	*·099*
Murungan	...	11·95	6·31	1·84	10·65	63·35	5·90	1·01	·591	·073
			7·17	*2·09*	*12·11*	*71·93*	*6·70*	*1·15*	*·671*	*·083*
Hill Paddy (*Elwi*)	...	11·67	7·00	1·98	10·02	65·80	3·53	1·07	·353	·066
			7·59	*2·24*	*11·34*	*74·85*	*3·98*	*1·21*	*·406*	*·074*
Average	...	12·01	6·69	1·91	10·40	63·84	5·26	1·04	·544	·078
			7·40	*2·17*	*11·80*	*72·64*	*5·98*	*1·18*	*·618*	*·089*
Indian varieties (1)	...	12·67	6·11	2·09	8·29	64·82	6·02	—	—	—
			6·99	*2·39*	*9·51*	*74·22*	*6·89*	—	—	—
König (2)	...	9·6	5·9	1·8	5·8	72·7	4·2	—	—	—
			6·25	*1·99*	*6·42*	*80·42*	*4·65*	—	—	—
Burmese (4)	...	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	*·92*	*·54*	*·030*

It would be observed, although it is obviously impossible to generalize from a single analysis, that the sample of hill paddy is richer on the whole in organic constituents but poorer in minerals chiefly phosphoric acid than the irrigated paddies. This is what had previously been observed by other workers, e.g., Kellner in Japan and referred to by Cochran (2). A further observation is that the samples of pure-line paddies appear to be richer in proteins, fats and minerals than the ordinary cultivated paddy varieties, e.g., *Murungan*. The average chemical composition of the Ceylon paddies is similar to that of the Indian paddies (1) and those analysed by König (2). They appear however to be richer in proteins and minerals than the other paddies.

Table II.

Composition of Ceylon Rices.

(Husked by Hand.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	11·51	9·33	2·77	·61	74·05	1·73	1·49	·85	·085
		10:54	**3:13**	**·69**	**83·66**	**1:98**	**1:69**	**:96**	**:096**
B11 (*Mawi*) ...	11·77	9·44	2·06	·69	74·33	1·71	1·51	·94	·062
		10·70	**2·34**	**·78**	**84·24**	**1·94**	**1:71**	**1:06**	**·070**
Murungan ...	12·05	8·38	2·37	·83	75·09	1·28	1·34	·67	·055
		9:53	**2:70**	**:94**	**85·37**	**1:46**	**1·52**	**·76**	**·063**
Hill Paddy (*Elwi*) ...	11·21	9·26	2·47	·47	75·69	·90	1·48	·39	·052
		10:43	**2:78**	**:53**	**85·25**	**1·01**	**1:67**	**·44**	**·058**
Average ...	11·64	9·10	2·42	·65	74·79	1·41	1:46	·71	·064
		10·30	**2:74**	**·73**	**84·63**	**1·59**	**1·65**	**:81**	**·071**

The samples were obtained by husking each grain of paddy separately by hand. An examination of the figures of Table II. would show that next to carbohydrate, the rices are richest in proteins or flesh formers. Here again it will be observed that while the sample of hill paddy is just as rich in protein and fat as the irrigated paddies, it is poorer in minerals, chiefly phosphoric acid. The pure-line paddies a8 and B11 are also seen to be richer in protein and minerals than the ordinary cultivated paddy-*Murungan*, possibly because a8 and B11 are long-aged paddies and *Murungan* a short-aged paddy. With regard to the ash composition it will be noted that phosphoric acid is the chief constituent, amounting to about half the ash. Lime amounts only to about one-twentieth of the ash.

In Table III. is shown the average composition of the "husked" rices of other rice-growing countries. By "husked" is here meant as stated by Sen (3), rice "in the bran."

Table III.

Composition of Husked Rices.

(As Recorded by Previous Workers.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Phosphoric Acid.	Lime.	Authority.
Indian (Bihar) ...	(11·95)	**8·50**	**2·68**	**·86**	**86·14**	**1:82**	**·80**	—	Sen (3)
Burma Red Ngasein ...	(13·97)	**8·07**	**2·57**	**·84**	**86·89**	**1·63**	**·76**	**·028**	Warth and Darabsett (4)
Burma Byat ...	(12·31)	**7·85**	**2·78**	**·31**	**86:89**	**2·17**	**·78**	**·024**	ditto
Japan Mino Superior ...	(13·42)	**9:40**	**3·14**	**1·39**	**84·55**	**1·52**	—	—	Kellner (3)
Japan Echiu Medium ...	(13·65)	**7:98**	**2·43**	**1·83**	**86·72**	**1·04**	—	—	ditto
Hawii ...	(13·79)	**8·28**	**2:47**	**3·18**	**84·53**	**1:54**	—	—	Krauss (3)
* Ceylon (Hand-husked) ...	(11·64)	**10:30**	**2:74**	**:73**	**84:63**	**1:59**	**·81**	**·071**	

* Included for comparison.

It is obvious that these figures would only be strictly comparable if the method of "husking" adopted has been the same in all countries, but this is hardly possible. The Ceylon samples were hand-husked, the Indian varieties husked by gently rubbing them against two smooth planks of wood. The figures for Burmese husked rices are those of "loonzein" or skinned rice. No details are available regarding the method of husking of the Japanese or Hawiaan rices. It is therefore clear that as the husking processes are different, the analytical composition of the rices even of identical samples are bound to vary, being dependent on the amount of "skin" left on the grain after the husking.

A glance at Table III. would show that Ceylon rices compare favourably in chemical composition with those of other countries. The figures for protein are higher, but this is probably due to the fact that no loss of the "skin" took place in the husking of these paddies by hand. Ceylon rices approximate nearest to the Indian rices in composition. In fats and minerals they are about the average, but Ceylon rices seem to be somewhat richer in lime than the Burmese rices.

Changes in Chemical Composition due to Pounding, Husking and Polishing Rices by the Ceylon Village Method.—Samples of the paddies already referred to were subjected to husking and polishing by the Ceylon village method, viz: pounding, and the samples of raw rices obtained thereby, analysed.

A description of the method will be given by the Economic Botanist.

Table IV.

Composition of Ceylon Raw Rices.

(Pounded and Polished by the Village Method.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	12.27	5.89	1·18	·26	79·08	1·32	·94	·55	·059
		6·72	**1·34**	**·30**	**90·12**	**1·52**	**1·07**	**·63**	**·067**
B11 (*Mawi*) ...	12·08	8·64	·97	·22	77·46	·85	1·38	·46	·026
		9·82	**1·11**	**·25**	**87·85**	**·97**	**1·57**	**·52**	**·030**
Murungan ...	12·52	7·63	·80	·47	77 48	1·10	1·22	·45	·048
		8·72	**·92**	**·54**	**88·57**	**1·25**	**1·39**	**·51**	**·055**
Hill Paddy (*Elwi*) ...	11·95	8·39	1 04	·38	77·53	·71	1·34	·27	·041
		9·53	**1·18**	**·43**	**88·05**	**·81**	**1·52**	**·30**	**·047**
Average ...	12·21	7·64	1·00	·33	77·90	1·00	1·22	·43	·043
		8·70	**1 14**	**·38**	**88·65**	**1·14**	**1·39**	**·50**	**·050**

A comparison of these figures with those of Table II. would show that husking and polishing of rices by the village method has resulted in a decrease in all their chemical constituents except carbohydrate, the decrease in fat, woody fibre, and phosphoric acid being to the extent of about half the original content. This is due to the "skin" and outer layer of the rice grain, the so-called

"aleurone" layer, which contains the more valuable nutritive constituents of the paddy grain, having been removed to a great extent in the husking process. The greatest loss of portein is observed in the case of a8, and is due probably to the ease with which its "skin" is removed while husking. These results bear out the previous work of Sen (3). The Indian polished rices were husked in an "okhri" the indigenous wooden mortar and pestle, the operation being continued till much of the coloured "skin" was removed. Compared with these, Ceylon rices are much the same in composition but appear to be somewhat higher in protein and minerals. The figures for the fat and protein contents of the samples of local raw rices polished by the village method are higher than those of the Burmese and Hawiaan rices but lower than those of the Japanese superior rices. The Burmese rices were however mill-polished and the reason for the significant differences in analytical composition between these and the Ceylon varieties, in favour of the latter, is therefore apparent. On referring to Table VII. it will be noted that mill-polished Ceylon *Murungan* rice has about the same chemical composition as the Burmese polished rices.

Table V.

Composition of Polished Rices.

(As Recorded by Previous Workers.)

Percentages.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Authority.
Indian (Bihar)	...		8·14	1·09	·22	89·66	·89	Sen
Indian varieties	...	(12·8)	8·38	·69	·46	89·78	·69	Church
Burma white Ngasein	...	(11·48)	7·84	·61	·18	90·82	·55	Warth and Darabsett
Burma Byat	...	(12·5)	7·13	·56	·17	91·61	·53	ditto
Japan Superior	...	(15·21)	8·25	1·16	·56	89·02	·71	Kellner
Japan Medium	...	(15·27)	6·69	0·95	·46	91·35	·65	ditto
Hawii	...	(14·10)	7·89	·54	1·54	89·47	·56	Krauss
* Ceylon (Hand-polished)	...	(12·21)	8·70	1·14	·28	88·65	1·14	

*Included for comparison.

The Effect of Parboiling on the Chemical Composition of Rices.—In Table VI. below is given the analytical figures of Ceylon pure-line rices a8, B11 and *Hinati*, hill paddy, and ordinary cultivated *Murungan* and village *Hatiel*, parboiled and pounded by the village method. It will be noted that except in the fat content which falls somewhat, there is on the whole no appreciable change in chemical composition as a result of parboiling rices. But as the Economic Botanist will show, and as is commonly known (7) parboiling results in a higher percentage of whole rice being obtained, i.e., milling losses are greatly reduced. As regards individual analyses, it will be noted that the protein content of H.K. 13 (*Hinati*) is the highest and of a8 *Podiwi*, lowest of all the varieties analysed.

Table VI.

Composition of Ceylon Parboiled Rices.

(Pounded and Polished by the Village Method.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8 (*Podiwi*) ...	12·72	5·81	·85	·26	81·22	1·29	0·93	·55	·046
		6·66	**·97**	**·30**	**90·60**	**1·47**	**1·06**	**·63**	**·053**
B11 (*Mawi*) ...	12·62	8·57	·76	·23	76·90	·92	1·37	·42	·030
		9·81	**·87**	**·26**	**88·01**	**1·05**	**1·58**	**·48**	**·034**
Murungan ...	14·74	6·88	·47	·39	76·33	1·19	1·10	·37	·041
		8·07	**·55**	**·46**	**89·53**	**1·39**	**1·29**	**·43**	**·046**
Hill Paddy (*Elwi*) ...	14·82	7·68	·84	·38	75·58	·70	1·23	·27	·042
		9·02	**·99**	**·45**	**88·72**	**·82**	**1·44**	**·32**	**·054**
Hatiel ...	12·89	6·68	·72	·36	78·49	·86	1·07	·36	·033
		7·67	**·83**	**·42**	**90·09**	**·99**	**1·23**	**·42**	**·038**
H. K. 13 (*Hinati*) ...	11·86	9·00	·75	·36	77·31	·90	1·44	·43	·041
		10·19	**·85**	**·41**	**87·53**	**1·02**	**1·63**	**·49**	**·046**
Average ...	13·24	7·44	·73	·33	77·64	·98	1·19	·40	·039
		8·57	**·84**	**·38**	**89·08**	**1·12**	**1·37**	**·46**	**·045**

The Effect of Machine-Milling and Polishing on the Chemical Composition of Rices.—In Table VII. below is shown the composition of Ceylon and foreign machine-polished parboiled rices.

Table VII.

Composition of Ceylon Parboiled Rices.

(Pounded and Polished by Machine.)

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
CEYLON:									
Murungan rice before polishing ...	12·89	7·38	·78	·54	76·70	1·71	1·18	·48	·047
		8·48	**·90**	**·63**	**88·03**	**1·96**	**1·36**	**·55**	**·054**
Murungan rice after polishing ...	13·24	6·31	·38	·33	78·14	1·60	1·01	·37	·041
		7·27	**·44**	**·38**	**90·07**	**1·84**	**1·16**	**·43**	**·047**
FOREIGN:									
Muttu Samba ...	11·48	6·28	·42	·23	80·85	·74	1·00	·33	·026
		7·10	**·48**	**·27**	**91·32**	**·83**	**1·13**	**·37**	**·029**
Milchard ...	11·56	5·97	·80	·25	80·75	·66	·96	·32	·024
		6·75	**·90**	**·29**	**91·30**	**76**	**1·08**	**·36**	**·027**

The samples of Ceylon machine-polished rice were prepared from *Murungan* paddy from Sravasti Estate, Anuradhapura. Analyses were made of the rice before polishing and after polishing. It will be observed that the composition of the *Murungan* rice before polishing is not very different to that of the *Murungan* raw rice pounded by the village method. But on polishing, the rice loses the greater part of its fat, this being reduced to less than half its previous value. Its protein, ash and phosphoric acid contents also decrease. Compared with the hand-husked *Murungan* rice, the phosphoric acid content of the machine

sample is only about half. Machine-polishing of Ceylon rices brings its composition more or less into line with those of the Indian and Burmese polished rices largely imported into Ceylon, e.g., *Muttusamba* and *Milchard*. The Ceylon polished *Murungan* is however slightly higher in protein, phosphoric acid and lime but lower in fat than these latter. In this connection it has to be pointed out that the sample of *Milchard*, a lower grade and cheaper rice than *Muttusamba*, has nearly twice the amount of fat. This is probably a single instance of what has been demonstrated by some workers in Japan, e.g., Sawamura (3) " that inferior rice is likely to be rich in fatty matters and ash." The result of polishing is to reduce the fat, protein, phosphoric acid and lime contents of a sample of rice considerably, and especially the fat and phosphoric acid. By the village method of preparation of rice it would appear that less fat and phosphoric acid would be lost to the grain than by machine-polishing. The more perfect the polish, the less fat and phosphoric acid the rice contains, but the higher its market price. This is an observation made by several previous workers, viz: Hooper (6) and Kellner and Nagakoa (3). As a lack of phosphoric acid has been found to be a pre-disposing cause of beri-beri, it is surprising why polished rices are in greater demand and fetch higher prices than the less polished rices. It is probably because polished rice cooks better besides being cleaner and better looking.

It would be interesting at this stage to compare the chemical composition of rice with that of the more important grains, pulses and legumes commonly used as food. In Table VIII. are shown the compositions of these foodstuffs as quoted chiefly by Wood (5).

Table VIII.

Composition of Foodstuffs.

Percentages.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.
Wheat (5) ...	13·4	12·1	1·9	1·9	69·0	1·7
Wheat flour ...	13·3	10·2	·9	0·3	74·8	0·5
Oats ...	13·3	10·3	4·8	10·3	58·2	3·1
Maize ...	13·0	9·9	4·4	2·2	69·2	1·3
Millet ...	12·5	10·6	3·9	8·1	61·1	3·8
Gram ...	11·0	23·4	1·1	5·1	54·3	5·1
Dhal (1) ...	10·9	16·6	1·0	4·8	62·9	3·7
Rice husked ...	11·64	9·10	2·4	·65	74·9	1·4
Rice hand-polished ...	12·2	7·64	1·0	·33	78·0	1·2
Rice Machine-polished ...	13·24	6·3	·38	·33	78·2	1·6

Compared with other foodstuffs it will be noted that polished rice has very much less protein and fat, but considerably more carbohydrate, and that it is nearest to wheat flour in composition. It has therefore a wide nutritive ratio. Unpolished rice however

approaches fairly closely wheat in chemical composition, though it is richer in carbohydrate content. Rice pounded by the village method much more nearly approximates the other grains in composition than polished rice. It will also be noted that legumes like dhal, gram, etc., are much richer in protein than cereals and have consequently a narrow nutritive ratio. A diet comprised of polished rice and legume or other albuminoid substances will therefore form a much more balanced ration than rice alone.

Brans.

Table IX.

Composition of Brans.

Percentages.

From Raw Rice.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8	...	11·22	9·93	10·85	13·98	40·42	13·6	1·59	2·97	·235
			11·17	**12·23**	**15·75**	**45·53**	**15·32**	**1·80**	**3·34**	**·265**
B11	...	11·79	11·31	9·32	14·32	43·09	10·17	1 81	2·97	·162
			12·82	**10·58**	**16·24**	**48·83**	**11·53**	**2·07**	**3·36**	**·184**
Murungan	...	16·38	10·44	7·48	14·43	38·06	13·21	1·67	3·70	·426
			12·47	**8·93**	**17·26**	**45·55**	**15·79**	**2·00**	**4·43**	**·510**
Hill Paddy	...	10·64	11·01	12·81	13·46	43·32	8 76	1·76	1·99	·296
			12·31	**14·34**	**15·06**	**48·49**	**9·80**	**1·98**	**2·23**	**·331**
Average	...	12·51	13·17	10·12	14·05	38·72	11·44	1·71	2·93	·280
			12·19	**11·52**	**16·07**	**47·10**	**13·11**	**1·95**	**3·34**	**·323**
Burmese Meal (4)	...	8·21	5·72	8·31	25·18	34·25	18·34	—	—	—
			6·23	**9·04**	**27·44**	**37·31**	**19·98**	—	—	—

From Parboiled Rice.

a8	...	11·13	9·29	12·17	13·90	34·63	18·90	1·49	3·42	·440
			10·46	**13·68**	**15·65**	**38·98**	**21·23**	**1·68**	**3·85**	**·493**
B11	...	11·70	10·81	14·30	14·78	34·11	14·30	1·74	4·08	·220
			12·25	**16·18**	**16·75**	**38·75**	**16·07**	**1·97**	**4·61**	**·249**
Murungan	...	13·22	8·44	7·66	15·32	38·46	16·90	1·35	4·62	·418
			9·73	**8·83**	**17·62**	**44·67**	**19·15**	**1·55**	**5·33**	**·481**
Hill Paddy	...	10·19	11·49	12·97	14·01	41·42	9·92	1·84	2·03	·380
			12·79	**14·44**	**15·60**	**46·13**	**11·04**	**2·08**	**2·26**	**·422**
Average	...	11·56	10·01	11·78	14·50	37·15	15·00	1·60	3·58	·362
			11·31	**13·28**	**16·40**	**42·13**	**16·87**	**1·81**	**4·01**	**·411**
Murungan (Machine made)	...	8·64	11·81	7·36	16·82	19·94	35·43	1·89	1·31	·441
			12·93	**8·06**	**18·41**	**21·87**	**38·73**	**2·06**	**1·45**	**·481**

A glance at Table IX would show that the brans or the residues obtained after the second pounding by the village method, are much richer in fat, phosphoric acid and lime, and to a lesser extent in proteins than the corresponding rices. This is due as already pointed out to the concentration of the fats, minerals and to a lesser extent proteins in the "skin" and "aleurone" layer of the rice grain. The fibre and ash contents of the brans are much higher but the carbohydrate contents much lower than that of the corresponding rices. The amounts of bran obtained are however small and it may be thought that the actual amounts of nutritive constituents removed by husking would not be very great. This is not so, as the following Table in the case of *Murungan* paddy, would show.

Table X.

		Protein. lb.	Phosphoric Acid. lb.	Fat. lb.
100 lb. *Murungan* paddy containing	...	6·31	·59	1·84
Gave 73 lb. Parboiled rice containing (see Table VI.)	...	5·02	·27	·34
68·4 lb. Raw rice containing (see Table II.)	...	5·21	·29	·53
Therefore bran and husk from Parboiled rice contained	...	1·29	·32	1·50
Therefore bran and husk from Raw rice contained.	...	1·10	·30	1·29
Mean	...	1·2	31	1·4
Percentages of nutritive constituents in bran and husk on those in paddy	...	19·0	52·5	76·0

It would thus appear that over three-fourths of the fat, half the phosphoric acid and one-fifth of the protein content of the paddy is lost in the bran and husk. The greater part of this is found in the bran. This bears out what has been found by Warth and Darabsett (4).

To turn again to Table IX, it would be seen that the effect of parboiling rices is to increase the fat content of the bran as it decreases that of the rice. The mineral content is also increased. The sample of bran obtained from the machine polishing of *Murungan* paddy is characterized by its very high ash content due probably to contamination with sand. The samples of bran from Ceylon paddies compare very favourably with those of Burma (4).

Husk.

The husk is the residue obtained from the first pounding of the paddies by the Ceylon village method.

In Table XI below is shown the composition of husks obtained from raw and parboiled paddies. The samples obtained contained varying proportions of bran and broken rice grains and hence are not typical. High results are obtained for proteins and minerals as compared with the figures of Warth in Burma, (4) but they are similar to those of Wolff as quoted by Cochran (2). Parboiling appears to increase the fat and phosphoric content of the husk, but otherwise there is little effect on its chemical composition.

Table XI.

Composition of Husk.

Percentages.

From Raw Rice.

Variety.		Moisture.	Protein.	Fat.	Woody Fibre.	Carbo-hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8	...	11·03	3·37	1·28	39·01	25·56	19·75	54	495	·267
			3·78	**1·44**	**43·80**	**28·78**	**22·20**	**·61**	**·556**	**·307**
B11	...	11·67	4·43	1·24	41·44	26·11	15·11	·71	·51	—
			5·01	**1·41**	**46·89**	**29·58**	**17·11**	**·80**	**·578**	—
Average	....	11·35	3·90	1·26	40·22	25·83	17·43	·62	·502	—
			4·39	**1·42**	**45·34**	**29·18**	**19·65**	**·70**	**·567**	—
Wolff (2)	...	9·7	3·4	1·4	42·8	27·0	15·7	—	—	—
			3·72	**1·53**	**46·87**	**29·51**	**17·20**	—	—	—
Burmese (4)	...		—	—	—	—	—	·03	·041	—

From Parboiled Rice.

Variety.	Moisture.	Protein.	Fat.	Woody Fibre.	Carbo hydrate.	Ash.	Nitrogen.	Phosphoric Acid.	Lime.
a8	10·97	3·63	1·39	39·42	24·27	20·32	·58	·584	·234
		4·07	1·56	44·26	27·29	22·82	·65	·654	·267
B11	11·34	4·28	2·08	39·67	25·13	17·50	·69	·780	—
		4·82	2·34	44·72	28·39	19·73	·78	·883	—
Average	11·15	3·95	1·73	39·54	24·70	18·91	·63	·682	—
		4·44	1·95	44·49	27·84	21·27	·71	·768	—

Conclusions.

Chemical analyses were made of samples of typical Ceylon paddies, rices and milling products, and the changes in chemical composition of the grain as a result of parboiling, pounding and polishing by the Ceylon village method, and machine-milling and polishing, studied.

The following conclusions have been drawn:—

(1) Ceylon paddies are on the whole similar in composition to the paddies of India and other paddy growing countries. They appear however to be richer in proteins and minerals than the latter. Dry land or Hill paddy as reported by previous workers, is found to be richer in organic constituents but poorer in minerals than irrigated paddies. The pure-line paddies analysed were richer in nutritive constituents than the mixed varieties.

(2) The same remarks as above apply to the hand-husked rices. The high protein content of Ceylon hand-husked rices as compared with those of other countries is very probably due to the method of husking. Phosphoric acid is the chief inorganic constituent of the samples analysed and amounts to just over half the ash content.

(3) The pounding and polishing of rices result in a marked decrease in their fat, phosphoric acid, fibre and to a smaller extent protein contents. It would therefore appear that the "skin" and surface or "aleurone" layer of the rice grain contain the more valuable nutritive constituents of the grain. Machine polishing of rices results in greater losses of fat and phosphoric acid than by the village method of pounding.

(4) Parboiling affects inappreciably the chemical composition of rices except for the fat content which falls slightly.

(5) Bran or the residue after the second pounding of paddies contains large proportions of the fat, protein and phosphoric acid of the latter. More than half the phosphoric acid, three-fourths the fat and one-fifth the protein of *Murungan* paddy were found in the bran. Higher percentages of fat and ash are found in the bran of parboiled than of raw rices.

(6) The chemical composition of polished rice is nearest to that of wheat flour. Rice has much less protein and fat and considerably more carbohydrate than other foodstuffs. A diet of rice and legumes is a well-balanced one.

(7) The samples of husk analysed were not typical, but the analytical data are similar to those obtained by Wolff (2). The ash content is very high.

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