ON JAPANESE FOODS*

Report 1

RYOZO HIROHATA

From Laboratory of Protein Chemistry, Yamaguchi Medical School, Ube, Japan.

(Received for publication on Nov. 10. 1961)

Generally speaking, the ordinary Japanese diet is unique in that the requisite ingredient are derived far more from vegetable than from animal sources. Though improved in many respects with the recent advances among the people in the knowledge about nutrition, it leaves much room for further investigation from the dietetic point of view. It is as important as ever in Japan that the main foodstuffs be one all examined thoroughly and be improved if possible, with a view to elevating the physical level and working efficiency of the nation. The notably improved physique with which the American-born Japanese and the younger generation of postwar Japan are blessed may largely be ascribed to the ample and nourishing food with which they have been fed.

I. ON RICE

Rice is still the staple, not merely a supplementary, food with the Japanese and is taken as a source of heat energy and also of protein. The annual output of rice in Japan was estimated roughly as follows:

1957	11464000 t
1958	11993000 t
1959	12501000 t
1960	12858000 t
1961	12572000 t

The amount of rice consumed per person per day averaged, according to one reliable source[1], was as follows:

1957	351.2 g
1958	354.7 g
1959	394.4 g

Another statistical survey[2] gives these figure:

445–640 g in 1924–1928 for each farm-worker and a member of his family.

The figures, obtained by our own investigation[3,4] made in Fukuoka-ken are:

---

* More than 40 reports in Japanese have been made from our laboratory on this and related subjects. These will be reviewed, with the data summarized later on.

406.7 g for the average resident,
473 g for a farm-worker or a member of his family, and
373.6 g for a non-farm-worker or a member of his family,

in 1954–1956, the amount of rice consumed including that from the black market.

1. EFFECT OF POLISHING ON THE CHEMICAL CONSTITUENTS AND THE ABSORPTION RATE OF RICE[5,6]

White rice or some 8% polished rice, taken preferablly for its exquisite flavor, is less nutritive but better digestible and absorbable, than unpolished rice, as has been pointed out fragmentarily by several workers from other laboratories.

MATERIAL AND METHODS

The materials used in the present series of experiments were those kinds of rice known as Taichu No. 65 and No. 150 and Kanan No. 2, each a variety of Horaimai-rice from Taiwan (Formosa). The polishing was effected in a small scale mill (a horizontal type, Satake) capable of receiving about 1.5 kg of rice and furnished with a balance available for weighing precisely the amount of removed bran to check the degree to which the rice is polished.

The polished rice and bran obtained were chemically analyzed by routine methods and their vitamin B_1 content determined by converting it to thiochrome.

The absorption rate of rice polished in several degrees and whole (brown) rice with some other foodstuffs was examined 3 times on human subjects as in the program shown in **Table 1.**

Tab. 1. The program of absorption experiments on humans

Series of experiments	Number of subjects used (age)	Duration of each exp. in days	Food stuffs examined
I	male, 6 (16–50)	3	Rice, a small amount of kidney-bean, cucumber, pork, green vegetables, and "miso"
II	male, 14 (17–50)	3	Rice, a small amount of pork, "miso" and pickled radish.
III	male, 3 (23–27)	1	Rice, table salt

RESULTS

a. Chemical constituents of polished rice

The average proportions in which the different ingredients of rice, polished or

otherwise, were found present in 11 specimens of 3 varieties of "Horaimai" are tabulated below, with their respective calorific value indicated in the last column.

Table 2. Composition of rice

Rice	On moisture free basis (%)						Calorific value calculated from the yield of polished rice
	Crude fat	Crude protein	Crude carbohydrate	Crude fiber	Ash	Vitamin B_1 γ	
Whole rice	2.62	8.07	85.98	1.67	1.66	546.2	300.5 Cal
2% Polishing	2.21	7.77	87.18	1.23	1.43	424.2	296.2
4% Polishing	1.76	7.50	88.63	1.05	1.06	330.2	289.3
6% Polishing	1.41	7.30	89.06	0.85	0.84	252.3	284.1
8% Polishing (White rice)	0.94	6.88	90.97	0.62	0.64	171.6	279.0

The content of crude fat, protein, fiber and B_1 decreases gradually by polishing, while that of carbohydrate increases relatively.

The bran taken off by polishing had the following composition on the average of 11 specimens, each having 4 polishing degrees and the whole bran: (**Table 3**).

The amount in percentage of crude fat, protein and fiber and of vitamin B_1 diminishes by degrees, and that of carbohydrate relatively increases, in course of the polishing. Several ingredients of the bran left separated after the polishing of 11 specimens of the said 3 varieties of rice were detected each in its average quantity shown in **Table 3.**

Tab. 3. Composition of bran

Bran separated at different stages of polishing	On moisture free basis (%)					
	Crude fat	Crude protein	Crude carbohydrate	Crude fiber	Crude ash	Vitamin B_1 γ
0–2%	23.83	16.68	32.92	13.93	12.25	1179.9
2–4%	25.79	17.62	34.81	10.88	11.20	1499.2
4–6%	26.07	18.00	36.44	9.08	10.03	1667.7
6–8%	24.67	17.16	39.88	8.12	10.01	1210.5
Whole	24.93	17.29	36.15	10.87	10.87	1400.3

Whole rice seems rich in crude fibers and ash in its outermost layer and in crude fat, protein and carbohydrate in its internal layer. The perispermatic and embryonic portion of a rice grain will of course be lost in part to be concentrated in the bran in course of the polishing.

Three fractions of protein in the rice polished at different stage (%) and in the bran separated by polishing at different degree (%) were determined, and the results obtained are averaged and shown in **Table 4.**

The vitamin B_1 content will be summarized in **Table 5.**

Tab. 4. Protein in rice and bran (%)

Protein	Whole rice	Rice polished at (%)				Bran separated by polishing at (%)				
		2	4	6	8	0–2	2–4	4–6	6–8	Whole
Albumin	1.29	1.14	1.06	0.92	0.83	3.45	3.41	3.40	3.20	3.34
Globulin	1.02	0.96	0.91	0.85	0.79	2.55	2.57	2.59	2.64	2.62
Oryzenin	3.34	3.08	2.99	2.85	2.54	5.91	6.22	6.38	6.25	6.19

Tab. 5. Content of Vitamin B_1 (γ%)

Variety	District cultivated in	Whole rice (not polished)	White rice (polished)	Bran
Taichu No. 65 (7 specimens)	Taihoku, Taichu, Tainan etc.	553	200	332
Kanan No. 2 (5 specimens)	Tainan, Taihoku etc.	600	170	1543
Taichu No. 150 (5 specimens)	Taichu, Taihoku etc.	464	49	2320
Takao No. 10 (2 specimens)	Takao, Taihoku	725	145	2185
Shinchiku No. 4	Taihoku	450	180	2900
Kagi Okute No. 2	Taihoku	450	100	2600
Taino No. 28	Taihoku	650	210	3050
〃 No. 40	Taihoku	450	150	2500
〃 No. 42	Taihoku	540	140	2200
〃 No. 45	Taihoku	550	190	2220
Binto	Taihoku	480	120	1600

It is noteworthy that, as **Tab. 5** shows, Taichu No. 65, contrary to the case of Taichu No. 150, retains vitamin B_1 in a relatively large quantity in its polished state and in a rather small quantity in its bran. Those 2 varieties of rice examined for their vitamin B_1 content were those grown in several different districts and on one and the same farm but the result reached was quite or nearly the same.

The bran oil obtained by extraction from 60 specimens respectively was examined and found not significantly different in properties, although the samples of rice used for the purpose were of different varieties, polished in different degrees, and reserved in their hulled state for different periods—some for 3 months. The following were the properties of the bran oil, the figure showing the mean values:

$d\frac{25^\circ}{4^\circ} = 0.9241$; $n_D^{30} = 1.4701$; acid value = 18.91; saponification value = 148.42; Reichert-Meissl value = 3.09; iodine value = 100.60

For comparison rice from South-East Asia was also analysed with the result shown

Table 6. Rice from South-East Asia (%)[11]

Place of Production	Variety	Moisture	Crude protein	Crude carbohydrate	Crude fat	Crude ash	Crude fiber	Vitamin B_1 γ %	
								white rice	whole rice
Vietnam	Saigon rice 1. Cl. (white)	14. 20	7. 89	76. 61	0. 23	0. 56	0. 4	86	
〃	〃 (1/3 of complete polishing*)	15. 08	8. 78	77. 05	0. 87	1. 46	0. 79		350
〃	〃 (whole)	13. 87	9. 78	73. 09	1. 15	0. 84	1. 27		
〃	〃 (white)	14. 44	8. 66	75. 37	0. 74	0. 47	0. 32	75	
〃	〃 (〃)	14. 62	7. 03	76. 84	0. 68	0. 52	0. 31	86	
Thailand	Bangkok rice (white)	14. 86	7. 09	76. 00	0. 89	1. 12	0. 58	130	
Burma	Rangoon rice (white)	13. 42	7. 51	77. 43	0. 71	0. 58	0. 35	72	
Hainan	Haikow, Okayama taihaku (white)	13. 18	7. 19	73. 46	0. 74	1. 56	0. 44	117	
〃	〃 Binto (whole)	15. 03	6. 48	77. 15	0. 59	1. 72	0. 37	50	300
〃	Renswei Taihoku No. 7 (whole)	13. 18	6. 58	78. 68	0. 72	1. 26	0. 95	52	460
〃	〃 Taihoku No. 182 (〃)	13. 18	7. 48	68. 12	0. 88	1. 73	1. 64	100	450
〃	〃 Taichu No. 153 (〃)	14. 92	7. 49	73. 70	2. 01	1. 53	0. 55	60	500
〃	〃 Ordinary (white)	12. 35	8. 01	79. 95	0. 96	0. 71	0. 51	80	
〃	〃 Kanan No. 2 (〃)	14. 65	7. 53	71. 12	0. 84	1. 59	0. 82	70	
〃	Haikow ordinary "Daisen" (whole)	14. 46	7. 40	75. 03	1. 89	1. 78	0. 80	63	250
〃	〃 〃 "Shosen" (whole)	14. 89	7. 53	76. 22	1. 84	1. 42	0. 60	50	225
Philippine	Manila 1. Cl. (white)	13. 85	6. 83	80. 78	0. 83	0. 85	1. 25	112	
〃	〃 2. Cl. (whole)	13. 40	6. 89	80. 41	1. 40	1. 31	0. 77	80	225
Celebes	"Mandy" var. 1. Cl. (white) A	13. 57	6. 27	84. 66	0. 30	0. 37	0. 37	80	
〃	〃 〃 (whole) B	12. 44	8. 23	74. 52	2. 31	1. 44	1. 38		225
〃	"Laba" var. 2. Cl. (whole) AA	12. 99	7. 79	74. 22	0. 85	0. 87	1. 19		200
〃	〃 〃 (white) A	13. 22	7. 07	79. 76	0. 41	0. 54	0. 70	100	
〃	〃 〃 (white) B	13. 12	6. 29	82. 24	1. 99	0. 57	0. 85	100	
〃	〃 〃 (whole) C	14. 70	8. 64	73. 65	2. 30	1. 17	0. 14		110
〃	〃 〃 (white) D	13. 12	6. 56	83. 63	1. 50	0. 53	0. 54	90	
〃	"Banda" var. 3. Cl. (white) A	14. 32	6. 55	82. 76	0. 48	0. 71	0. 39	137	
〃	〃 〃 (white) B	14. 22	6. 50	70. 86	0. 36	0. 73	1. 06	185	
〃	〃 〃 (whole) C	13. 67	7. 51	70. 71	0. 56	0. 45	0. 31		225
Java	Djakarta "round" (white)	15. 08	5. 76	80. 10	0. 55	0. 74	0. 32	200	
〃	〃 〃 (half polish.)	14. 88	6. 53	73. 62	0. 58	1. 51	0. 24	230	
〃	Surabaja Mas (whole)	13. 45	8. 53	72. 95	1. 24	1. 25	0. 42		350
〃	〃 S. K. K. A (〃)	13. 27	8. 02	74. 68	2. 73	1. 44	0. 70	125	450
〃	〃 S. K. K. B (white)	13. 77	7. 68	74. 38	0. 43	1. 26	0. 42	125	
〃	〃 Hooing, A (whole)	14. 28	7. 57	72. 34	2. 53	1. 54	0. 72	100	550
〃	〃 〃 B (white)	14. 29	7. 47	75. 90	1. 46	1. 24	0. 46	100	
〃	〃 Mas, B (white)	13. 31	7. 52	77. 59	0. 81	1. 21	0. 83	130	
〃	〃 K. S. A. (whole)	13. 08	8. 02	75. 67	2. 19	1. 71	0. 88		
〃	〃 K. S. B. (〃)	13. 39	8. 00	75. 66	2. 29	1. 08	0. 55		

* Polished at 1/3 degree of white rice　　** Polished at a half degree of white rice

in **Table 6**[11]. The chemical constituents of rice are not likely to vary with the particular variety the rice may belong to, with an exception of vitamin B_1.

b. The absorption rate of rice

The absorption rate of each component of rice polished at 5 stages was studied thrice over. The results on the average are shown in **Table 7, 8** and **9.** The more the rice was polished the better absorbed were crude protein, fat and carbohydrate, but the total calorie absorbed was smaller when the quantity of rice was calculated on

Tab. 7. Absorption rate of the calorific contents of rice (Experiment 1)

Rice examined	Absorbed calorific contents of 100 g of rice (Cal)				Cal. absorbed from rice obtained by polishing from 1 kg whole rice (Cal)
	Protein	Fat	Carbohydrate	Total	
White rice (9% polished)	22.4	7.3	313.5	343.2	3123
6% polished	22.6	11.5	310.3	344.4	3237
4% //	22.9	15.7	304.5	343.1	3294
2% //	24.2	18.9	294.7	337.1	3310
1% //	22.8	20.1	290.2	333.2	3299
Whole rice	23.1	20.1	285.8	329.0	3290

Tab. 8. Absorption rate of the calorific contents of rice (Experiment 2)

Rice examined	Absorbed calorific contents of 1 kg of rice (Cal)				Cal. absorbed from rice obtained by polishing from 1 kg whole rice (Cal)
	Protein	Fat	Carbohydrate	Total	
White rice (8% polished)	179.4	64.3	3259.5	3503.2	3177.4
4% polished	191.8	88.1	3214.0	3493.9	3354.2
3% //	193.1	130.0	3134.1	3457.2	3353.4
2% //	199.4	151.0	3105.0	3455.4	3386.3
1% //	206.3	170.3	3067.4	3444.0	3409.6
Whole rice	201.8	161.1	3036.9	3399.7	3399.7

Tab. 9. Absorption rate of the calorific contents of rice (Experiment 3)

Rice examined	Absorbed calorific contents of 1 kg of rice (Cal)				Cal. absorbed from rice obtained by polishing from 1 kg whole rice (Cal)
	Protein	Fat	Carbohydrate	Total	
White rice (8% polished)	203.7	43.4	3255.2	3502.4	3047.1
4% polished	220.0	59.4	3175.2	3454.7	3316.5
3% //	225.6	80.7	3136.1	3442.4	3339.1
2% //	235.6	86.2	3102.6	3424.5	3356.0
1% //	241.0	66.7	3069.9	3377.7	3343.9
Whole rice	244.6	55.8	3044.0	3344.5	3344.5

the basis of the same amount of whole rice, since the yield of rice will be reduced according to the polishing degree. The results indicate that the calorific components of rice are best available when the rice is 1–2% polished: viz. 1–2% means biologically the most efficient polishing.

In the 2nd experiment, the differences of the absorbed calorie among the rice polished at several stages are statistically significant, except between 3% and 4% polished specimens of rice[7]. Experiment 3 showed that a small amount of vegetables, pork and "miso" (bean paste) taken with rice has little or no effect on the absorption rate of rice components.

2. ADAPTATION TO WHOLE (BROWN) RICE DIET[8]

The adaptability of the Japanese to a whole-rice diet is denied by some authors. We came across 3 Japanese–H. aged 15, S. 16 and Y. 38, who had been in the habit of taking whole rice for 9–14 months. We examined the absorption rate of the whole rice in these persons and the results reached was compared with those obtained in our previous experiments (**Tabs. 7, 8, 9**). The points of difference will be seen in **Tab. 10.**

Tab. 10 Absorption rate of whole rice

	Number of subjects (or name)	Age (averaged)	Mastication time in minutes	Protein %	Fat %	Carbohydrate %	Absorpt. rate of calorie %
Not accustomed to eating whole rice	6	30. 1	—	71. 37	78. 05	96. 85	93. 1
	14	23. 4	18′	72. 01	60. 51	97. 55	92. 9
	3	27. 2	15′	87. 30	20. 98	97. 78	92. 4
	Mean	25. 6	—	73. 87	59. 93	97. 40	92. 9
Accustomed whole rice	Y.	38	15′	78. 66	70. 94	97. 89	94. 46
	H.	15	〃	77. 18	69. 30	98. 10	94. 41
	S.	16	〃	76. 23	67. 81	98. 18	94. 30
	Y.	38	70′	78. 75	74. 79	98. 53	95. 34
	H.	15	35′	79. 21	70. 28	98. 72	95. 16
	S.	16	〃	79. 35	70. 40	98. 63	95. 09

All available evidence goes to show clearly that we Japanese can adapt ourselves to taking rice unpolished and that the additional time required for its mastication enhances the digestion and absorption of the whole rice taken.

3. THE REAL ABSORPTION RATE OF WHITE RICE[9]

The absorption rate of rice hitherto dealt with is what it apparently and not actually is and the more important actual rate of absorption can be ascertained by taking into account the fecal N and fat of the Japanese.

Experiments on 5 individuals, ranging in age from 15 to 28, and fed on a protein- and fat-free diet, led Y. Okuda[10] to this results ($M \pm \delta$):

Fecal N averaged 0.76 ± 0.22 g/day
Fecal fat averaged 0.79 ± 0.14 g/day

The real absorption rate (RAR) of protein and of fat was each determined from the following formula:

$$RAR = \frac{N(\text{or fat}) \text{ consumed-}[N(\text{or fat}) \text{ in feces- fecal } N(\text{or fat})]}{N(\text{or fat}) \text{ consumed}}$$

Another experiment made by Ichiki et al.[9] on two successive days in 5 humans, males aged 25–30 and fed with white rice and a small quantity of "miso" and "fu", a kind of cracknel made from gluten, showed the apparent and the real absorption rate averaged as presented in **Tab. 11.**

Tab. 11. The real absorption rate of white rice ($M \pm \delta$)

	Protein	Fat	Carbohydrate	Fiber	Ash
Apparent abs. rate	78.57 ± 2.09	78.63 ± 1.97	99.59 ± 0.24	23.49 ± 1.66	81.23 ± 1.56
Real abs. rate	84.18 ± 1.88	83.31 ± 1.00			

The above result may profitably be referred to in determining by experiments the absorption rate of any Japanese food taken together with rice.

(to be continued)

REFERENCES 1.

1. Ministry of Public Welfare (Japan), *The Present Status of Nutrition of the Nation*, 1960, p. 147.
2. *Union of Cooperative Association of Food Industry (Japan)* Series No. 15, 1955, p. 88.
3. Ogata, H. and Kimura, Y., *Food and Nutrition (Japan)*, **10**: 120, 1957.
4. Watanabe, K., Tsutsumi, I., Hatae, H., Fujino, Y., Fukumoto, F. and Mizobe, K. *Food and Nutrition (Japan)*, **10**: 123, 1957.
5. Hirohata, R., To, T. and Rin, E., *Food and Nutrition* (Japan), **1**: 93, 1948.
6. Hirohata, R., To, T., Kyo, S. and Rin, E., *Food and Nutrition (Japan)*, **1**: 153, 1948.
7. Hirohata, R. and Fukuyama, K., *Food and Nutrition (Japan)*, **3**: 111, 1950.
8. To, T., *Food and Nutrition (Japan)*, **2**: 112, 1949.
9. Ichiki, K., Nakamura, M., Kimura, N., Yuya, S., Tanaka, T., Sakata, H., Nakajima, T. and Onishi, I., *Food and Nutrition (Japan,)* **5**: 88, 1952.
10. Okuda, Y. read before *the 14. Annual Meeting of Japanese Society of Food and Nutrition, Osaka*, 1960, and to be published elsewhere.
11. Hirohata, R. and Chen C. C., *Food and Nutrition (Japan)*, **12**, 196, 1959.