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By

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(Received July 30, 1953)

Introduction

Rice-refuse is one of the most popular and widely used concentrates in Japan. It is also known as an important source of vitamin B, and so in this field many works have been published. But we know of only a few works dealing with the subject from the viewpoint of the feeding. Katayama,[1)2)] Saito[3)4)] and other reported already about the chemical composition and the digestible nutrients, but no feeding trials were taken up by them.

Since rice-refuse is utilized as a material for making oil, the defatted rice-refuse left behind after the press or extraction process, has been used as a feed.

We attempted to clarify the differences in feeding values between the non-treated and defatted (pressed and extracted) rice-refuse.

Experimental

A quantity of rough rice produced in 1949 at Shichigo, a suburb of Sendai, was hulled and polished. The yield was 94 pounds of polished rice per hundred pounds of the rough rice. The rice-refuse consisting of rice-bran and crashed rice was divided into three lots. Two of them were separately treated : the one pressed (pressure 4500 lb) after heating and the other extracted by benzol after drying at 70°~80°C.

These experiments were performed from March to September in 1950.

I. Chemical Composition.

Each nutrient these feeds contain was analysed by the method of A. O. A. C.

Mineral matter in three feeds was determined by this usual method[5)] by 20 g. after burning on each sample.

The results of the analysis are shown in Tables 1 and 2.

Table 1. Chemical Composition (%).

Constituent / Feed	Moisture	Crude protein	Crude fat	N-free extract	Crude fiber	Crude ash
Rice-refuse	12.70	11.36	15.20	40.86	10.32	9.56
Pressed rice-refuse	9.56	17.38	10.56	38.11	13.39	11.00
Extracted rice-refuse	11.68	17.28	4.67	38.38	15.91	12.08

Table 2. Mineral matter contents (%).

Constituent / Feed	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5	Mn_3O_4	CaO	MgO	SO_3	K_2O	Na_2O
Rice-refuse	0.57	0.08	0.34	5.90	*	0.16	1.94	0.02	1.48	0.05
Pressed rice-refuse	0.79	0.20	0.39	5.18	*	0.14	1.69	0.01	1.22	0.08
Extracted rice-refuse	0.73	0.23	0.46	6.67	*	0.07	2.11	*	1.62	0.08

* We could not determine by the usual method.

II. Digestion Trial.

Two saanen bucks were confined to digestion crates and fed with rice-refuse and hay (its chemical composition and digestibility were determined. The results are shown in Table 3, 4). These animals were used repeatedly after a seven-day feed exchanging period. A seven-day preliminary feeding period was followed by a seven-day collection period. The feces collected were weighed and analysed. The digestibility of the rice-refuse were determined by difference.

Table 3. Chemical composition of the hay used.
(%)

Organic matter	Crude protein	Crude fat	N-free extract	Crude fiber
85.23	5.10	1.05	45.38	33.70

Table 4. Digestibility of the hay used.
(%)

Buck No.	Organic matter	Crude protein	Crude fat	N-free extract	Crude fiber
I	58.72	45.25	42.60	62.23	50.18
II	55.43	47.02	42.37	58.71	52.57

The amounts of the feed consumed and the feces excreted in the collecting period are given in Table 5.

Table 5. The amounts of the feed consumed and the feces excreted in the collecting period.
(g)

Feed and Fece / Feed	Buck No.	Rice-refuse	Hay	Fece (fresh)	Fece (dryed)
Non-treated rice-refuse	I	3204	1705	6181	2150
	II	3280	1718	6304	2183
Pressed rice-refuse	I	3225	1700	6127	2065
	II	3271	1693	6218	2114
Extracted rice-refuse	I	3480	1750	6410	2237
	II	3487	1736	6353	2162

The chemical composition of the feces are shown in Table 6.

Table 6. Chemical composition of the feces.
(%)

Constituent / Feed	Buck No.	Moisture	Crude protein	Crude fat	N-free extract	Crude fiber	Crude ash
Non-treated rice-refuse	I	12.60	9.03	5.31	36.49	20.63	15.94
	II	10.87	8.60	5.25	39.65	21.05	14.58
Pressed rice-refuse	I	10.30	11.51	4.12	31.69	23.54	18.84
	II	9.14	11.23	3.98	32.51	25.11	18.03
Extracted rice-refuse	I	11.52	10.58	2.01	33.90	24.30	17.69
	II	10.26	9.53	2.19	35.80	22.79	19.43

The digestibility of the rice-refuse calculated from the data is given in Table 7.

III. Feeding Trial

1) Rat.

Rats weighing 67 to 141 g. were employed to test the feeding effects of these feeds and divided into three groups, each group consisting of two females and two males. The room, in which the rats were fed, was so devised to maintain the temperature at 15° to 25°C. An individual circular cage was provided for each animal. The food cup and water bottle were attached to the opposite side of the cage and were so made that there was very little spilling of food or

Table 7a. The amounts of nutrients ingested, excreted and digested.

1) Non-treated Rice-refuse

	Buck I				Buck II			
	Crude protein	Crude fat	N-free extract	Crude Fiber	Crude protein	Crude fat	N-free extract	Crude fiber
Rice-refuse consumed	363.97	487.00	1309.15	330.65	372.61	498.56	1340.21	338.50
Hay consumed	86.96	17.90	773.73	574.59	87.62	18.04	779.63	578.97
Total consmed	450.93	504.90	2082.88	905.24	460.23	516.60	2119.84	917.47
Feces excreted	194.15	114.17	784.54	443.55	187.74	146.08	865.56	459.52
Digested (total)	256.78	390.73	1298.34	461.69	272.49	370.52	1254.28	457.95
Digested (hay)	39.35	7.63	481.49	288.33	41.20	7.64	458.72	304.36
Rice-refuse digested	217.43	383.10	816.85	173.36	231.29	362.88	796.56	153.59
Digestibility (%)	59.74	78.67	62.40	52.43	62.07	72.79	59.44	45.37

2) Pressed Rice-refuse

	Buck I				Buck II			
	Crude protein	Crude fat	N-free extract	Crude fiber	Crude protein	Crude fat	N-free extract	Crude fiber
Rice-refuse consumed	560.50	340.56	1229.05	431.83	568.50	345.42	1246.58	437.99
Hay consumed	86.70	17.85	771.46	572.90	86.34	17.78	768.28	570.54
Total consumed	647.20	358.41	2000.51	1004.73	654.84	363.20	2014.86	1008.53
Feces excreted	237.68	85.08	654.40	486.10	237.40	84.14	687.26	530.83
Digested (total)	409.52	273.33	1346.11	518.63	417.44	279.06	1327.60	477.70
Digested (hay)	39.23	7.60	480.08	287.48	40.60	7.53	451.06	299.93
Rice-refuse digested	370.29	265.73	866.03	231.15	376.84	271.53	876.54	177.77
Digestibility (%)	66.06	78.03	70.46	53.53	66.29	78.61	70.32	40.59

water and practically no contamination by the urine and feces.

Three parts of calcium carbonate were respectively added to 100 parts of these feed so as the phosphorus to calcium ratio close to 2. The rats were respectively fed 15 to 17 g. of the supplemented diets per head daily for a period of three weeks and the water was supplied for drinking. The body weight

3) Extracted Rice-refuse

	Buck I				Buck II			
	Crude protein	Crude fat	N-free extract	Crude fiber	Crude protein	Crude fat	N-free extract	Crude fiber
Rice-refuse consumed	601.34	162.52	1335.62	553.67	602.55	162.84	1338.31	554.78
Hay consumed	89.25	18.38	794.15	589.75	88.54	18.23	787.80	585.03
Total consumed	690.59	180.90	2129.77	1143.42	691.09	181.07	2126.11	1139.81
Feces excreted	236.67	44.96	758.34	543.59	206.04	47.35	774.00	492.72
Digested (total)	453.92	135.94	1371.43	599.83	485.05	133.72	1352.11	647.09
Digested (hay)	40.39	7.83	494.20	295.94	41.63	7.72	462.52	307.55
Rice-refuse digested	413.53	128.11	877.23	303.89	443.42	126.00	889.59	339.54
Digtesibility (%)	68.77	78.83	65.68	54.89	73.59	77.38	66.47	61.20

Table 7b. Digestibility and digestible nutrients.

Feed	Digestibility				Digestible nutrients				TDN
	Crude protein (%)	Crude fat (%)	N-free extract (%)	Crude fiber (%)	Crude protein (%)	Crude fat (%)	N-free extract (%)	Crude fiber (%)	(%)
Non-treated rice-refuse	60.91	75.73	60.92	48.90	6.92	11.51	24.89	52.05	62.76
Pressed rice-refuse	66.18	71.44	70.39	46.56	11.50	7.54	26.83	6.23	61.53
Extracted rice-refuse	71.18	78.11	66.08	58.05	12.30	3.65	25.36	9.24	55.11

was measured before feeding in the evening every other day. The results of feeding trial are shown in Table 8. The weights of the animals in every group showed a decrease, particularly in III group. The body weight of rat 2 in I group increased temporarily. Rat 1 in I group and rat 5, 6 in II group died respectively in 15, 20, 13 days. In III group, all rats died in a short time.

The rats in III group had a good appetite at first, but soon showed a rapid loss of appetite, fall of body temperature and decrease of body weight. The conjunctiva and the mucous membranes of nose and mouth became pale, slight diarrhoea was ensured. They died just like falling asleep without showing any sign of agony or disturbance (Fig. 1). The stomach and duodenum were filled with the dark brown liquor, but almost no trace of diet was recognized in many cases. The jejunum and ileum were slack and filled with black liquid materials

Table 8. Feeding effects on rat.

Group	Diet	No	Sex \ Day	Body weight (g) 1	3	5	7	9	11	13	15	17	19	21	Age at death days
I	Rice-refuse	1	♀	69	67	63	67	64	59	55	–	–	–	–	15
		2	♀	90	98	105	102	100	101	100	99	95	99	90	–
		3	♂	135	132	130	132	132	130	125	120	120	119	110	–
		4	♂	139	133	135	135	135	135	130	130	130	125	120	–
II	Pressed rice-refuse	5	♀	67	67	65	64	60	60	60	58	54	54	–	20
		6	♀	141	136	140	136	134	135	135	132	122	121	115	–
		7	♂	78	76	73	66	66	58	–	–	–	–	–	13
		8	♂	137	135	135	135	133	135	135	130	125	118	105	–
III	Extracted rice-refuse	9	♀	72	63	56	–	–	–	–	–	–	–	–	7
		10	♀	98	86	69	–	–	–	–	–	–	–	–	7
		11	♂	78	–	–	–	–	–	–	–	–	–	–	3
		12	♂	135	127	117	102	–	–	–	–	–	–	–	8

(Fig. 2). The mucous membranes of caecum and colon, the liver and kidney presented stagnation. The spleen was slightly swelled, and the lung presented a fresh rose color. In I, II group, the above symptoms and lesion of digestive organ were not recognized.

These facts were further confirmed in the histological preparations. The stomach, intestines, liver, kidneys, lungs, heart and brain of the rats in III group were fixed in 10 percent formalin solution immediately after dying. The samples were treated with "Paraffin method", stained with Hematoxylin-Eosin for observation. The results obtained were as follows : necrosis was found in every part of the epithelium of the stomach and intestines and stagnation were found in the tunica propia mucosa of these organs (Fig. 3, 4). In the liver, stagnation in the sinusoid between liver cell cords and mild fatty degeneration of the liver cells were found (Fig. 5). In the kidney, stagnation of the capillary and swelling of the epithelium of proximal convolution and collecting tubules are found (Fig. 6). Mild catarrh was shown in the bronch of the lungs (Fig. 7). Stagnation of the capillary was also recognized in the lungs, heart and brain.

2) Chick

Method : Three lots of male chicks (White-Leghorn) hatched at Iwaya Poultryfarm in Sendai were employed. Each lot consisted of 35 chicks. Each lot was separately housed an electrically heated brooder, which was maintained at temparature of 90° to 100° F for the first week and at a little lower temparature afterwards. The same feeds as were given to rats were respectively fed *ad libitum* 24 hours after hatching and water was provided for drinking.

Result : The results of feeding trial are shown in Fig. 8. All chicks in the extracted rice-refuse lot died within 15 days. Whereas, only three chicks died in the rice-refuse lot, ten chicks in the pressed rice-refuse lot. In the

Fig. 1. Photograph of rat 9 immediately before dying.

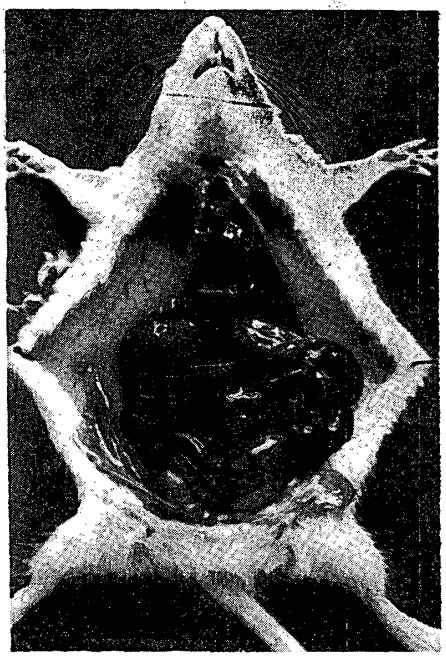

Fig. 2. Dissection of abdomen and thorax of rat 9. The intestines show a black color resulting from hemorrhage.

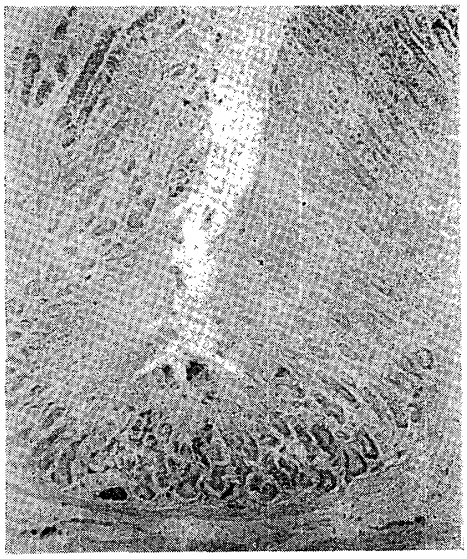

Fig. 3. Section of mucous membrane of stomach. Necrosis and hemorrhage are seen in the central portion. Hematoxylin and eosin. ×100.

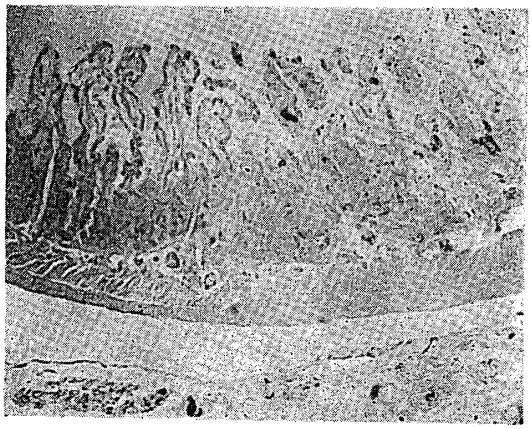

Fig. 4. Section of mucous membrane of jejunum. Surface of the mucosa is almost broken down by necrosis. Hematoxylin and eosin. ×100.

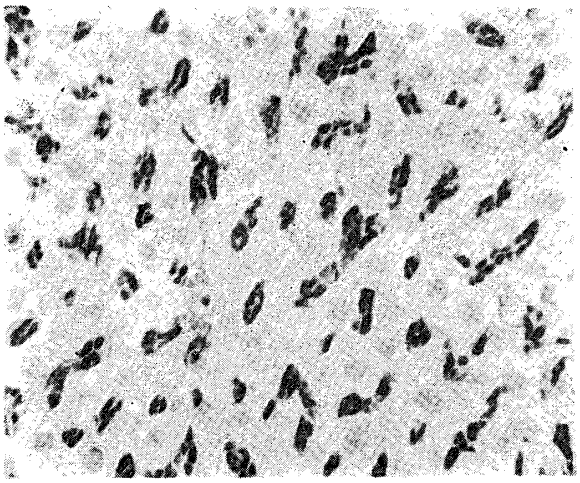

Fig. 5. High power view of a portion of hepatic lobule from liver. Darkly stained parts are erythrocytes in the hepatic sinusoid. Some of the nuclei show picnotic degeneration, and cytoplasm is seen as a light vacuole for the fatty degeneration. Hematoxylin and eosin. ×500.

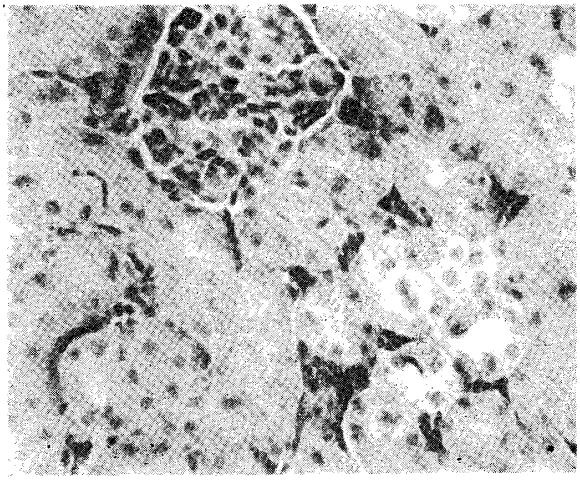

Fig. 6. Section of kidney, showing renal corpuscle in the upper center. Epithelium of the tubule shows swelling and sinusoid is filled with erythrocytes. Hematoxylin and eosin. ×500.

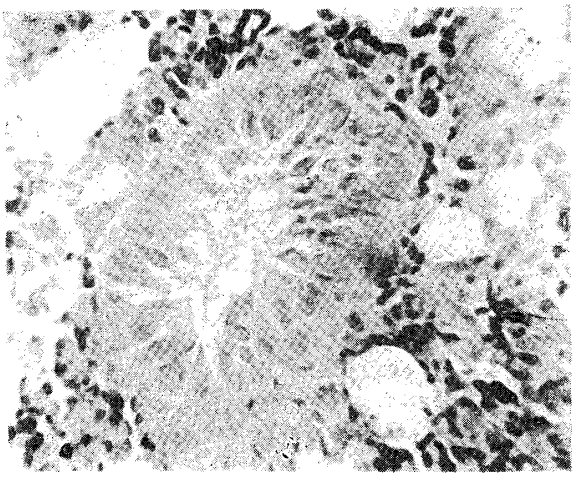

Fig. 7. Section of lung, showing catarrh of bronchi in the center. Epithelium of the bronchi is falling off and degenerated. Hematoxylin and eosin. ×500.

extracted ric-refuse lot, the color of their wings turned dull, diarrhoea appeared. They died crouching. The hemorrhage of digestive organ was not evident as in the case of rats. The gall bladder was filled with the dark green bile, which exuded in some cases into the duodenum, pylorus of stomach and liver. In the other lots such symptom was not observed.

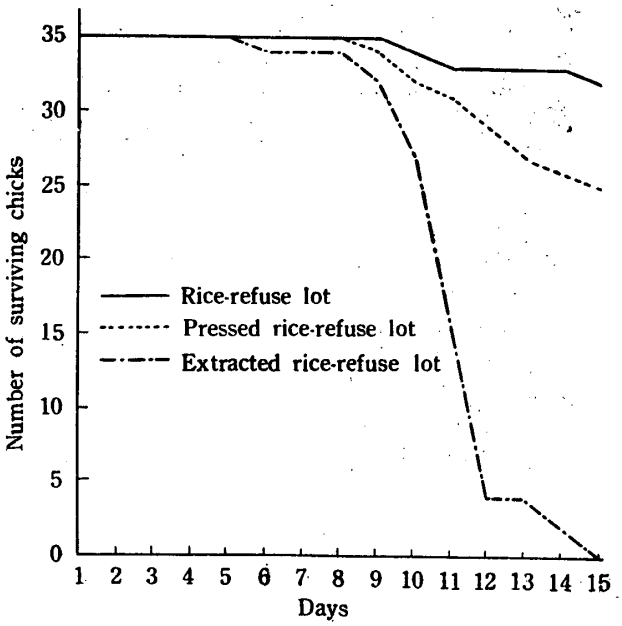

Fig. 8 Feeding effects on chick.

Discussion and Conclusion

In respect of feeding value for rats and chicks, untreated rice-refuse seemed to be superior to pressed rice-refuse, but no remarkable difference was recognized between the two feeds. However, as all rats and chicks fed the extracted ricerefuse died in a short time, its feeding value seemed to be far inferior to other feeds. From the hemorrhage of digestive organs, stagnation of internal organ and mild fatty degeneration of liver cells, etc. in rat, it may be assumed that the abnormal symptom developed is due to be the impediments derived from the extracted rice-refuse.

Summary

The feeding value of extracted rice-refuse was found remarkably inferior compared with those of rice-refuse and pressed rice-refuse. All rats and chicks fed the extracted rice-refuse died in a short time developing characteristic symptoms and lesion. In the case of rats, the hemorrhage of digestive organs was remarkable, besides the stagnation of internal organs and mild fatty degeneration of liver. In the case of chicks, the hemorrhage of digestive organs was not evident. The gall bladder was filled with dark green bile and in some cases it exuded into the duodenum, pylorus of stomach and liver.

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