TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 191 JUNE, 1916

DIVISION OF CHEMISTRY

The Composition of Rice and Its By-Products

POSTOFFICE:

COLLEGE STATION, BRAZOS COUNTY, TEXAS.

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BY

G. S. FRAPS, Ph. D.,
CHEMIST IN CHARGE; STATE CHEMIST

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*As of June 1, 1916.
**In cooperation with United States Department of Agriculture

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THE COMPOSITION OF RICE AND ITS BY-PRODUCTS.

BY G. S. FRAPS, PH. D., CHEMIST IN CHARGE; STATE CHEMIST.

This bulletin deals with the composition of rice, and particularly with rice by-products. It contains analyses of the various intermediate products secured in milling, together with a discussion of the composition, food, and feeding value of rice and rice by-products.

STATISTICS.

The rice industry in Texas in 1895 occupied about 2000 acres; in 1905 it had grown to about 125,000 acres. In 1915 the Texas industry occupied 260,000 acres. The acreage was 802,600 for the United States in 1915. Texas produced in 1915 over one-fourth of the rice grown in the United States. In 1913, 1914, and 1915, Texas produced over one-third of the United States' rice crop. Rice statistics are shown in Table 1, as given in the Monthly Crop Reporter of the

TABLE 1. RICE STATISTICS FROM MONTHLY CROP REPORTER, DECEMBER, 1915

	1915	1914	1913
Total acreage United States	802,600	693,530	827,100
Louisiana acreage	401,000	336,500	405,500
Texas acreage	260,000	239,700	303,000
Yield, bu. per acre, Louisiana	30.5	33.8	32.0
Yield, bu. per acre, Texas	34.2	32.1	29.0
Total production, bu., United States	28,947,000	23,649,000	25,774,000
Total production, bu., Texas	7,930,000	8,102,000	9,696,000
Total production, bu., Louisiana	13,714,000	10,802,000	11,760,000

United States Department of Agriculture for December, 1915. It is to be noted that, while the yield per acre in Texas has decreased, the yield in Louisiana has increased during these three years. The year 1914 was a bad rice year.

VARIETIES OF RICE.

The three principal varieties of rice grown in Texas are: Honduras, Japan, and Blue Rose. The Honduras variety of rice has a long slender grain and is more easily broken in milling than the other varieties. It also sells for a somewhat higher price, as its appearance is preferred. The yields are not as large as those of the Japan or the Blue Rose variety.

The Japan variety has a short rounded grain and does not break up so easily in milling as the Honduras variety. It also produces heavier yields per acre.

The Blue Rose variety is intermediate between the Honduras and

the Japan variety. It has a somewhat longer grain than the Japan, although not as long as the Honduras. It does not break up as easily in milling as the Honduras. The Blue Rose variety has only been grown extensively within the last few years, but in 1915 in some localities of Texas, it occupied 80 per cent. of the acreage. Some lots of the Blue Rose variety are much harder and more flinty than the Japan or Honduras variety. Red rice is a wild variety of rice. Its presence is not desired on account of the red color of the outside of the grain, which cannot be entirely removed in milling.

THE MILLING OF RICE.

Rice is covered with a hard, somewhat flinty husk. The grains inside of the husk are generally brown, and the rice with the husk removed is usually termed brown rice. Some grains have a greenish color; such grains are not fully ripe. A greater or less quantity of the greenish grains is present in nearly every lot. Red rice, when present, is shown by the red color of the grain. As the red bran is not entirely removed in milling, the presence of more than a few grains of red rice injures the color of the finished product and decreases its commercial value. The rough rice is also accompanied by trash, weed seed, and other impurities.

The object of rice milling is to remove the impurities, the husk, and also the colored outer epidermis of the rice grain, so as to give the rice the bright color and the more pleasing appearance demanded by the consumer. Milled rice has also better cooking qualities.

Rice is sold in bags which contain approximately 162 pounds of rough rice, and is generally stored in the bags until it is ready to be milled. Different lots are stored separately and milled separately. The following is an outline of rice milling. Practically every mill is different from every other in some respect.

Purifying Rice.—Rough rice, or paddy rice, as it is known, is purified by means of a series of flat vibrating screens, to which air suction is applied by fans. The rice goes through the coarse screens, and the coarser impurities tail over. The weed seed and finer impurities fall through the finer screens and the rough rice tails over. In passing through the air suction space, the light rice and chaff is lifted out of the rough rice and is dropped in a separate compartment. The air then goes through a dust collector, which removes the dust before the air is discharged.

Other machines are also used in cleaning the rough rice, such as a rotating hollow cylinder through which the rice is carried, and through which a blast of air is passed. This has the effect of drying the rice as well as removing the dust. Rice clippers are sometimes used for the purpose of cutting off short particles of straw adhering to the rough rice, so that the rice may be more easily purified on the screens. Rotating cylinders containing indentations or perforations of various sizes are sometimes used for the purpose of lifting impurities such as weed seed out of the rice, or for lifting the rice out of the impurities, as the case may be. These cylinders are similar to those used for the purification of wheat before it is manufactured into flour.

Stones.—The purified paddy rice goes next to the stones. These consist of a pair of grooved stones, somewhat like mill stones, the lower one fixed and the upper one revolving. The motion of the stones whirls the rice on the end and the rotation of the stones grinds off the tips, thereby allowing the rice to escape from the hulls or chaff. In order to avoid breaking the grain, the rice must be touched by the stones as lightly as possible, and the stone must be adjusted for the different kinds of rice. The use of a rice grader to separate rice of different sizes aids in milling without breaking. The first stones only remove the husk of a portion of the rice. The remainder of the paddy rice is separated and removed by another set of stones. The great problem of the rice miller is to remove the husk and the bran without breaking the grain.

Stone Bran Reel.—The mixture of brown rice, paddy rice, and rice hulls from the stones, goes to the stone bran reel, which is a hollow rotating cylinder covered with screen wire, usually 13x13 wire, .028 gauge at the head of the reel; while behind this is a section of chit wire screen, usually 8x8, No. 17 wire. The finer wire takes out finely broken rice, rice germs, and finely broken hulls. This is termed *stone bran.* The material which goes through the chit wire is termed "chits," and consists of a mixture of broken rice and rice hulls. The quantity of rice hulls present depends upon the length of the rotating surface and the speed with which the mixture passes through the reel. The material towards the head of the chit wire may be almost entirely broken rice and towards the end it may be entirely hulls or chaff.

A double screw conveyor with wooden valves at the base of the stone bran reel permits the products which go through the reel to be conveyed as desired. The stone bran is mixed with huller bran; the chits rich in rice go to the huller, while the hulls or by-products rich in hulls go to the hull house. Sometimes the hulls are removed by a subsequent air current.

The object of the stone bran reel is to remove the broken rice and the fine material of feeding value before the mixture goes to the fans. The fans would lift out this light material if it were not previously removed, and it would then pass in with the less valuable hulls or chaff. All rice mills do not use reels for separating the stone bran; some use air currents.

From the stone bran reel, the product goes to the fans. The chaff or hulls go to the conveyor leading to the hull house. In some cases, the hulls go direct to the furnace room.

Paddy Machine.—The mixture of brown rice and paddy rice goes to the paddy machines. These separate the brown rice from the rough or paddy rice. The brown rice goes to the hullers. The rough rice from the paddy machine goes to a separate pair of stones. These can be set somewhat closer than the first pair of stones without danger of breaking so much rice. The product from this pair of stones goes into the stone bran reel with the products from the other stones. The rough rice continues to be separated in the paddy machine until it is finally all milled free of husk.

Hulling.—This term is a misnomer, as it is the *bran* that is removed in this process, not the hulls. The hullers consist of tapering,

grooved cylinders revolving within an iron case, which rub the grains of rice against one another and against the walls of the outer case. The adjustment may be varied, according to the size of the rice. The action of the rice huller is to remove some of the outer coating of the rice or bran, and the germ. Too vigorous action will result in considerable breakage of the rice. The huller blades must be set to suit the variety of rice scoured. The products of the scouring, together with some broken rice, fall through slits $\frac{3}{4}$ inch wide by $\frac{1}{2}$ inch long or 4/64 inch wide by $\frac{1}{2}$ inch long, in iron plate in the bottom of the huller.

The mixture of broken rice and huller bran is conveyed to a reel, having meshes 14x14, .028 wire. The huller bran is mixed with the stone bran and the product is known as rice bran. The broken rice from the huller bran reel goes to the second huller, or to the cone, if such is used. A small amount of rice bran adheres to the rice coming from the hullers and this may be removed in another reel.

The rice then goes either to the second hullers, or to the pearling cones. In some mills three hullers are used and no cones. In other mills two hullers and no cones are used.

The mixture of broken rice and hulls separated from the other material in the stone bran reel also goes to the hullers for milling. In some mills it is distributed into all the first hullers, or half of the first hullers, and in other cases it is milled in a separate huller. The latter practice is probably the best milling method, as the separate huller can be adjusted more closely to suit the broken rice being milled.

Pearling Cones.—The pearling cones consist of the frustum of a cone covered with a composition stone. This is surrounded by a wire screen, 12x14 or 14x14 mesh. The rice is rubbed between the stone and the wire screen and some of the finely divided product passed through the screen. The thorough rubbing removes a considerable portion of the outer covering of the rice and gives it a better appearance. The cone meal, which is the name given to the by-product of this machine, is sometimes sold separately, and sometimes it is mixed with the polish or sold separately as rice polish. The cone, however, takes the place of the second break huller, and cone meal is properly a portion of the rice bran. It is not rice polish.

Brushes.—The brush is the last scouring machine. It consists of an upright cylindrical frame work covered with hide or skin, and revolving rapidly inside of a covering consisting of a close mesh wire screen, 12x14 mesh of .035 and .041 wire. The rice is rubbed up against the outer screen by means of the rapidly revolving cylindrical frame work, and the thin outer covering of the rice is rubbed off. This is forced through the surrounding screen and is known as rice polish.

Grading.—After passing through these brushes, the rice goes to a reel which removes the brewer's rice. The wire used is usually for one-third of the reel 10 by 10 mesh, the second third 9 by 9 mesh, and the last third 8 by 8 mesh, all of .032 wire. If the rice is not to be coated, it is then passed into the grading machine, which divides it into the several grades of rice, consisting of the entire grain, the second head, and the screenings. The grader usually consists of a number of vibrating screens carrying perforated metal with holes vary-

ing from 11/64 to 11/128 of an inch in diameter. The grades are made according to the kind of rice. The fancy head and second head are usually combined in case of Japan or Blue Rose rice.

If the rice is to be coated, it is passed through a revolving cylinder, into which a small amount of glucose and talc is fed. The cylinder may be heated by steam in cold weather. The object of this coating is to give the rice a high polish. The average quantity of coating material used consists of .20 per cent. glucose and .07 per cent. talc, according to Bulletin No. 330 of the United States Department of Agriculture. The fact that such coating is used must be printed on the label attached to the sack or package when it enters into interstate commerce.

TABLE 2. PRODUCTS FROM RICE MILLING, REPORTED BY VARIOUS MILLS

	Hulls.	Bran.	Polish.	Fancy rice.	Second rice.	Screenings, rice.	Brewers' rice.	Loss and dirt.
Mill 1, 1914	36	12	5	52	27	16	10	4
Mill 2, 1914	28	19	5	.....	.....	.....	.....	4
Mill 3, 1914	31	15	5	.....	.....	.....	.....	9
Mill 4, 1914	34	16	6	55	20	15	10	3
Average	32	16	5	53	24	16	10	5
Japan, 1914	32	12	3	93	.....	12	5	5
Japan, 1914	27	19	6	100	.....	7	5	.....
Japan, 1914	30	14	4	90	.....	15	4	5
Japan, 1915	.....	11	4	98	0	5	6	.....
Japan, 1915	28	12	3	96	.....	12	6	5
Japan, 1915	.....	15	5	98	0	6	5	.....
Japan, 1915	.....	14	4	96	.....	10	4	3
Japan, 1915	28	14	5	80	5	5	4	.....
Japan, 1915	.....	14	5	98	.....	.....	4	.....
Japan, 1915	.....	13	6	98	.....	6	4	.....
Average	29	14	5	95	5	9	5	5
Honduras, 1914	40	15	4	54	22	15	7	5
Honduras, 1914	27	19	6	60	10	26	6	.....
Honduras, 1915	35	15	5	56	18	20	8	5
Honduras, 1915	.....	15	5	64	13	16	8	.....
Honduras, 1915	.....	12	4	65	23	10	8	.....
Honduras, 1915	30	16	6	65	28	20	7	3
Honduras, 1915	.....	15	5	60	.....	.....	7	.....
Honduras, 1915	36	14	3	60	9	30	5	5
Honduras, 1915	.....	16	5	60	25	15	4	.....
Honduras, 1915	.....	14	6	60	20	12	10	.....
Average	34	15	5	60	19	18	7	5
Blue Rose, 1915	.....	15	5	88	.....	12	5	.....
Blue Rose, 1915	28	14	5	95	6	4	3	.....
Blue Rose, 1915	.....	12	5	93	0	4	4	.....
Blue Rose, 1915	30	13	3	95	4	8	4	5
Blue Rose, 1915	.....	15	4	97	0	10	3	.....
Blue Rose, 1915	.....	10	4	94	0	8	5	.....
Blue Rose, 1915	.....	11	4	86	0	17	.7	.....
Average	29	13	4	93	5	9	4	5
Honduras. Bul. 330, U. S. D. A	33	22	6	59	19	15	8	.....
Japan, Bul. 330, U. S. D. A	30	20	6	96	.....	5	5	.....
(Honduras) Texas Bul. 72	32	20	6	62	23	10	5	3.4
	32	21	6	72	21	10	6	3.4

QUANTITY OF OUTPUT.

The quantity of output depends upon the method of milling and also upon the quality of rice. Some lots of rice break up to a much greater extent than others. The quantity of the different grades of cleaned rice is therefore very variable. Table No. 2 shows the average quan-

tity of the different by-products as reported to the writer by a number of rice millers during the years given. The table also gives the yield as given in Bulletin No. 330 of the United States Department of Agriculture. It is noted that there is considerable difference in the quantity of rice bran reported.

THE COMPOSITION OF RICE AT THE DIFFERENT STAGES OF MILLING.

The samples analyzed were collected from a number of Texas mills at various times. Table No. 3 shows the average composition of rice

TABLE 3. AVERAGE COMPOSITION OF RICE AT DIFFERENT STAGES OF MILLING.

	Number Averaged.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Pentosans.
Rough rice (Paddy)	9	8.09	1.80	8.89	64.52	11.68	5.02	.....
Brown rice (from stones)	16	9.13	2.00	1.08	74.53	12.16	1.10	2.12
Rice from huller	11	8.75	.93	.56	76.41	12.66	.69	1.91
Rice from second break huller	3	9.10	.77	.52	76.80	12.23	.09	1.65
Rice from pearling cone	7	8.86	.58	.47	76.78	12.81	.50	1.78
Rice from brushes	5	8.98	.46	.35	76.98	.37	.10	1.76
Head rice	8	9.01	.50	.40	77.02	12.57	.50	1.75
Second head rice	9	8.71	.43	.43	77.37	12.41	.65	1.86
Screenings rice	8	8.35	.54	.41	78.68	11.39	.63	1.75
Brewers' rice	9	8.88	.95	.56	77.14	11.78	.79	1.71
Honduras rough rice (U. S. D. A.)	4	7.48	1.58	8.67	.....	11.27	5.40	6.90
Japan rough rice (U. S. D. A.)	3	6.50	1.74	7.93	.....	11.05	5.14	5.48
Honduras brown rice (U. S. D. A.)	4	8.57	1.79	.99	.....	12.32	1.18	2.42
Japan brown rice (U. S. D. A.)	3	7.24	1.52	.85	.....	12.38	1.13	2.28
Honduras rice from huller (U. S. D. A.)	4	7.79	.40	.39	.....	12.56	.53	1.90
Japan rice from huller (U. S. D. A.)	3	6.82	.66	.42	.....	13.70	.70	1.76
Honduras rice from cones (U. S. D. A.)	4	7.88	.28	.30	.....	12.50	.47	1.53
Japan rice from cones (U. S. D. A.)	3	6.59	.31	.29	.....	13.38	.40	1.60
Honduras rice from brushes (U. S. D. A.)	4	8.06	.25	.30	.....	11.89	.36	1.80
Japan rice from brushes (U. S. D. A.)	3	6.61	.22	.29	.....	12.82	.32	1.68
Honduras rice from trumbles (U. S. D. A.)	4	7.75	.21	.26	.....	12.02	.40	1.66
Japan rice from trumbles (U. S. D. A.)	3	6.47	.19	.29	.....	12.50	.34	1.68
Rough rice (Louisiana)	.....	7.44	2.58	9.28	.....	10.95	5.45	.....
From hulling stones	.....	8.09	2.10	3.03	.....	12.12	2.55	.....
Pounded	.....	8.14	2.50	2.55	.....	12.42	2.38	.....
From cooling floor	.....	7.74	1.05	.72	.....	12.75	.82	.....
Clean	.....	7.52	.38	.47	.....	12.85	.73	.....

at different stages of milling as averaged from Table No. 4, which contains the individual analyses of the different series. Table No. 3 also contains the average of three series of Japan rice and four series of Honduras rice given in Bulletin No. 330 of the United States Department of Agriculture; it also contains, as published in Bulletin 24, 1889, of the Louisiana Experiment Station, the average of one series of Louisiana rice, Honduras type, milled in the old-fashioned mortar and pestle mill. The by-products of the mortar and pestle mill would contain considerable rice hulls, since they are not completely removed by the stones.

The hulls are rich in crude fiber and ash. The effect of the removal of the hulls from the rough rice is to decrease the ash and crude fiber of the rice markedly and to increase the percentages of the other constituents. A large portion of the ether extract and of the crude fiber is removed from the brown rice, as it is called, by the huller. The quantities removed by the other machinery is much smaller. The process of milling thus involves a decrease of ether extract, fiber, and ash. The removal of the ether extract undoubtedly increases the keeping qualities of the rice, rendering it less liable to become rancid. This is perhaps more clearly shown by comparing the composition of the rice bran and rice polish with that of the clean rice.

TABLE 4. ROUGH RICE OR PADDY RICE.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9587	Honduras	7.39	1.81	8.69	64.45	12.62	5.04	.....
9600	Honduras	8.35	1.40	10.10	60.95	13.59	5.61	4.24
9821	Honduras	8.79	2.07	8.24	65.80	10.71	4.39	.....
9843	Honduras	8.69	1.39	9.52	63.86	11.18	5.36	.....
9900	Honduras	8.95	1.64	9.51	62.90	12.18	4.82	.....
9620	Blue Rose	8.11	1.96	8.31	66.04	11.28	4.30	.....
9853	Blue Rose	7.23	1.99	9.14	65.53	11.25	4.86	.....
9882	Japan	7.44	2.05	6.99	66.41	12.71	4.40	.....
9645	Red, largely	7.85	1.89	9.48	64.72	9.64	6.42	.....
	Average	8.09	1.80	8.89	64.52	11.68	5 02	.....

TABLE 4. (Continued.) BROWN RICE (FROM STONES).

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9591	Honduras	8.38	2.20	1.04	73.78	13.52	1.08	.15
9604	Honduras	9.69	1.85	1.14	71.64	14.14	1.54	.....
9478	Honduras	10.43	1.69	1.05	71.39	14.41	1.03	.12
9487	Honduras	9.15	1.88	.96	75.67	11.39	.95	.05
9926	Honduras	9.21	1.84	.99	74.52	12.26	1.18	.....
9817	Honduras	9.55	1.41	1.07	75.30	11.70	.97	.....
9832	Honduras	9.38	2.30	1.11	74.35	11.88	.98	.15
9898	Honduras	10.65	2.04	1.20	73.13	11.85	1.13	.20
11206	Honduras	8.56	1.88	0.97	76.74	10.87	0.98	0.13
9621	Blue Rose	9.61	2.01	1.05	74.28	12.08	.97	.....
9854	Blue Rose	7.90	2.19	.97	75.90	12.04	1.00	.....
11198	Blue Rose	8.56	2.33	1.51	75.89	10.55	1.16	0.28
9890	Japan	7.96	1.73	.78	75.72	12.78	1.03	0.18
9918	Japan	8.22	1.91	.95	75.72	12.11	1.09	.16
9638	Red, largely	9.43	2.56	1.43	74.39	10.79	1.40	.24
9917	Red, largely	9.32	2.14	1.06	74.21	12.14	1.13	.15
	Average	9.13	2.00	1.08	74.53	12.16	1.10	.1

TABLE 4. (Continued.) RICE FROM HULLER.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9597	Honduras	7.55	.78	.63	78.60	11.85	.59	.03
9609	Honduras	9.19	.34	.46	74.86	14.51	.64	.....
9480	Honduras	9.70	.61	.47	74.12	14.63	.47	.10
9829	Honduras	9.44	.94	.62	75.17	13.22	.61	.....
9847	Honduras	10.44	.85	.62	74.98	12.59	.52	.....
9901	Honduras	10.19	1.10	.53	73.81	13.18	1.19	.....
9616	Blue Rose	8.45	1.36	.71	77.09	11.58	.80	.....
9855	Blue Rose	7.60	1.58	.65	77.28	12.12	.77	.10
9919	Blue Rose	6.80	.75	.28	79.62	11.99	.56	.08
9885	Japan	7.75	.88	.58	77.26	12.81	.72	.15
9639	Red	9.09	1.09	.58	77.79	10.73	.72	.....
	Average	8.75	.93	.56	76.41	12.66	.69	.09

TABLE 4. (Continued.) RICE FROM SECOND BREAK HULLER.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9589	Honduras	7.81	.66	.44	77.51	13.07	.51	.01
9895	Honduras	10.23	.82	.62	75.32	12.41	.60	.....
9619	Blue Rose	9.25	.83	.51	77.58	11.20	.63	.16
	Average	9.10	.77	.52	76.80	12.23	.58	.09
	Rice From Pearling Cone. Variety.							
9588	Honduras	7.69	.65	.40	78.02	12.74	.50	.04
9485	Honduras	10.00	.40	.39	75.19	13.68	.34	.....
9825	Honduras	9.49	.69	.42	76.14	12.71	.55	.16
9840	Honduras	9.66	.53	.37	76.96	12.13	.35	.....
9905	Honduras	10.24	.47	.49	75.86	12.39	.55	.....
9856	Blue Rose	7.00	.70	.58	78.27	12.89	.60	.14
9875	Japan	7.93	.61	.41	77.29	13.13	.63	.16
	Average	8.86	.58	.47	76.78	12.81	.50	.13
	Rice From Brushes. Variety.							
9482	Honduras	9.69	.16	.52	75.23	14.12	.28	.06
9838	Honduras	10.25	.78	.29	76.19	12.05	.44	.....
9897	Honduras	9.95	.51	.27	75.97	12.96	.34	.....
9863	Blue Rose	7.26	.40	.36	79.16	12.50	.32	.06
9881	Japan	7.75	.45	.32	77.72	13.28	.48	.18
	Average	8.98	.46	.35	76.86	12.98	.37	.10

TABLE 4. (Continued.) HEAD RICE OR FANCY RICE.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9598	Honduras	9.44	.78	.40	76.07	12.37	.94	.....
9486	Honduras	9.97	.25	.39	75.11	13.84	.44	.13
9824	Honduras	8.94	.27	.35	77.00	13.14	.30	.....
9833	Honduras	10.04	.98	.35	76.26	12.00	.37	.....
9892	Honduras	9.92	.33	.38	76.59	12.00	.78	.....
9622	Blue Rose	8.68	.48	.44	78.12	11.91	.36	.....
9864	Blue Rose	6.60	.39	.43	79.85	12.28	.45	.08
9879	Japan	8.50	.50	.48	77.18	12.98	.36	.06
	Average	9.01	.50	.40	77.02	12.57	.50	.09
	Second Head Rice. Variety.							
9596	Honduras	8.40	.30	.45	77.48	13.08	.29	.04
9607	Honduras	9.20	.39	.37	75.95	12.69	1.40	.....
9481	Honduras	9.25	.44	.43	75.22	14.14	.52	.16
9830	Honduras	9.00	.56	.37	76.56	12.91	.60	.....
9848	Honduras	9.64	.43	.60	76.65	12.24	.44	.....
9894	Honduras	9.69	.19	.53	76.65	11.87	1.07	.....
9624	Blue Rose	8.51	.41	.39	78.74	11.54	.41	.....
9862	Blue Rose	6.56	.58	.39	80.09	12.07	.31	.05
9647	Red	8.14	.58	.37	78.92	11.15	.84	.....
	Average	8.71	.43	.43	77.37	12.41	.65	.08

TABLE 4. (Continued.) CLEANED RICE SCREENINGS.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9594	Honduras	8.56	.40	.42	77.51	12.78	.33	.02
9603	Honduras	8.69	.81	.48	76.75	12.08	1.19	.....
9822	Honduras	9.00	.44	.53	82.46	7.05	.52	.06
9891	Honduras	8.73	.55	.29	77.99	11.73	.71	.....
9623	Blue Rose	8.81	.49	.36	78.14	11.78	.42	.....
9861	Blue Rose	6.77	.58	.65	79.43	12.12	.40	.05
9877	Japan	7.75	.48	.28	78.68	12.37	.44	.03
9643	Red	8.45	.59	.30	78.45	11.21	1.00	.....
	Average	8.35	.54	.41	78.68	11.39	.63	.04
	Brewers' Rice. Variety.							
9592	Honduras	8.51	.31	.59	77.36	12.85	.38	.11
9599	Honduras	8.87	.92	.47	76.29	12.88	.57	.....
9475	Honduras	9.43	.66	.57	74.84	14.05	.45	.....
9816	Honduras	9.85	.82	.68	76.15	11.73	.77	.....
9842	Honduras	9.79	.63	.42	81.61	6.85	.70	.....
9893	Honduras	8.75	.43	.55	77.84	11.76	.67	.18
9612	HondurasBlue Rose	8.48	.87	.50	77.24	12.02	.89	.....
9849	Blue Rose	7.59	1.79	.73	77.23	11.95	.71	.10
9876	Japan	8.62	2.08	.57	75.73	11.89	1.11	.....
	Average	8.88	.95	.56	77.14	11.78	.69	.13

Table No. 5 shows the average phosphoric acid and potash content, and other constituents of the rice as it occurs from various stages of the milling process. The number averaged is variable, and may be

TABLE 5. AVERAGE COMPOSITION OF RICE AT DIFFERENT STAGES OF MILLING.

	Phosphoric acid.	Polish.	Insoluble ash.	Lime.	Magnesium.	Reducing sugar.	Di. Sugars.	Pentosans.
Rough rice (Paddy)	.54	.25	.....	.....	.....	.....	.....	.....
Bran rice (from stones)	.63	.25	.16	.09	.14	.12	.79	2.12
Rice from huller	.40	.13	.09	.04	.07	.11	.48	1.91
Rice from second break huller	.36	.05	.09	.04	.09	.03	.14	1.65
Rice from pearling cone	.29	.14	.13	.05	.05	.11	.16	1.78
Rice from brushes	.25	.13	.10	.02	.06	.09	.24	1.76
Head rice	.23	.07	.09	.04	.06	.14	.17	1.75
Second head rice	.27	.09	.08	.05	.08	.10	.23	1.86
Screenings rice	.26	.05	.04	.04	.05	.05	.30	1.75
Brewers' rice	.32	.16	.13	.04	.09	.17	.24	1.71

found by referring to the detailed Table No. 6. Decided changes in some of these constituents are also noticed, especially in the phosphoric acid content of the brown rice and the clean rice. There is twice as much phosphoric acid in the brown rice as there is in the clean rice. The other mineral constituents, the pentosans, and the sugars, also decrease. Rice contains only small quantities of sugars. This is also reflected in the composition of the by-products as given on another page of this bulletin.

TABLE 6. ROUGH RICE.

Lab. No.		Silica.	Lime.	Magnesia.	Potash.	Phosphoric acid.
9587		.....	.....	.....	.26	.59
9620		.....	.....	.....	.25	.52
9600		4.24	.08	.21	.24	.54
9645		.....	.....	.....	.25	.69
9821		.....	.....	.....	.....	.47
9853		.....	.....	.....	.15	.53
9843		.....	.....	.....	.21	.45
9900		.....	.....	.....	.27	.59
9882		.....	.....	.....	.37	.52
	Average	4.24	.08	.21	.25	.54

TABLE 6—Continued.

Laboratory No.		Lime.	Magnesium.	Potash.	Phosphoric acid.	Pentosans.	R. Sugar.	Di. Sugar.
	Rice From Stones.							
9591		.09	.20	.24	.64	2.46	.05	.85
9621		.....	.....	.24	.....	1.95	.....	.....
9604		.....	.....	.21	.76	2.26	.....	.....
9638		.12	.04	.26	.81	2.23	.....	.....
9478		.05	.11	.20	.67	2.31	.33	.51
9487		.....	.....	.26	.75	1.58	.14	.....
9926		.....	.....	.38	.80	2.15	.....	.....
9817		.....	.....	.....	.48	2.23	.....	.....
9854		.....	.....	.....	.56	2.03	.....	.....
9832		.08	.16	.23	.49	2.22	.....	.....
9898		.....	.....	.....	.56	.....	.....	.....
9890		.10	.20	.....	.55	.....	.06	.89
9917		.....	.....	.....	.55	1.93	.03	.74
9918		.....	.....	.....	.57	2.14	.12	.96
	Average	.09	.14	.25	.63	2.12	.12	.79
	Rice From First Huller.							
9597		.09	.12	.19	.44	1.62	.05	.46
9616		.....	.....	.....	.43	2.23	.....	.....
9609		.....	.....	.08	.36	1.73	.....	.....
9639		.....	.....	.....	.50	2.20	.....	.....
9480		.05	.13	.15	.50	1.67	.24	.37
9829		.....	.....	.....	.31	.....	.....	.....
9855		.01	.01	.05	.41	2.11	.....	.....
9847		.....	.....	.18	.28	.....	.....	.....
9901		.....	.....	.....	.41	.....	.....	.....
9885		.06	.04	.....	.41	2.06	.11	.....
9919		0	.03	.....	.35	1.64	.03	.62
	Average	.04	.07	.13	.40	1.91	.11	.48
	Rice From Second Huller.							
9589		.06	.11	.11	.36	1.61	.03	.14
9619		.02	.07	.....	.....	1.68	.....	.....
	Average	.04	.09	.11	.36	1.65	.03	.14
	Rice From Cones.							
9588		.05	.05	.13	.28	1.79	.03	.01
9485		.....	.....	.24	.32	1.87	.18	.30
9825		.08	.03	.12	.27	1.85	.....	.....
9856		.01	.05	.....	.28	1.85	.....	.....
9840		.....	.....	.08	.23	.....	.....	.....
9905		.....	.....	.13	.33	.....	.....	.....
9875		.01	.05	.....	.30	1.73	.....	.....
	Average	.04	.05	.14	.29	1.82	.11	.16
	Rice From Brushes.							
9482		.04	.08	.20	.29	1.74	.14	.27
9640		.....	.....	.....	.33	1.73	.....	.....
9838		.....	.....	.06	.20	.....	.....	.....
9897		.....	.....	.....	.24	.....	.....	.....
9863		.01	.03	.....	.21	1.67	.....	.....
9881		.01	.06	.....	.22	1.91	.03	.21
	Average	.02	.06	.13	.25	1.76	.09	.24
	Fancy Head Rice.							
9595		.08	.04	.06	.25	1.61	.04	.05
9622		.....	.....	.23	1.62	.....	.....	.....
9598		.....	.....	.08	.26	1.91	.....	.....
9486		.07	.10	.08	.27	1.61	.24	.29
9824		.....	.....	.....	.20	2.00	.....	.....
9864		.01	.07	.....	.19	1.82	.....	.....
9833		.....	.....	.07	.19	.....	.....	.....
9879		.01	.02	.....	.....	1.70	.....	.....
	Average	.04	.06	.07	.23	1.75	.14	.17

TABLE NO. 6—Continued.

Laboratory No.		Lime.	Magnesium.	Potash.	Phosphoric acid.	Pentosans.	R. Sugar.	Di. Sugar.
	Head Rice.							
9596		.08	.08	.14	.31	1.74	.01	.18
9624		.....	.....	.....	.25	1.94	.....	.....
9647		.04	0	.....	.34	1.79	.....	.....
9607		.....	.....	.08	.35	1.82	.....	.....
9481		.04	.08	.05	.29	1.89	.18	.27
9830		.....	.....	.....	.22	1.97	.....	.....
9848		.....	.....	.10	.20	.....	.....	.....
9894		.....	.....	.....	.31	.....	.....	.....
9862		.03	0	.....	.20	.....	.....	.....
	Average	.05	.08	.09	.27	1.86	.10	.23
	Screenings Rice.							
9594		.06	.06	.02	.28	1.58	.05	.30
9623		.....	.....	.....	.25	1.76	.....	.....
9603		.....	.....	.07	.37	1.85	.....	.....
9643		.....	.....	.....	.33	1.91	.....	.....
9822		0	.02	.....	.20	1.64	.....	.....
9891		.02	.09	.....	.19	.....	.....	.....
9861		.04	.03	.....	.20	.....	.....	.....
9877		.03	.....	.....	.24	.....	.....	.....
	Average	.04	.05	.05	.26	1.75	.05	.30
	Brewers' Rice.							
9592		.07	.07	.12	.30	1.70	.04	.24
9612		.....	.....	.....	.32	1.79	.....	.....
9599		.....	.....	.12	.31	1.73	.....	.....
9475		.....	.....	.14	.34	1.62	.30	.23
9816		.....	.....	.....	.32	.....	.....	.....
9849		.02	.11	.19	.37	.....	.....	.....
9842		.....	.....	.24	.26	.....	.....	.....
9893		.03	.08	.....	.37	.....	.....	.....
	Average	.04	.09	.16	.32	1.71	.17	.24

FOOD VALUE OF RICE.

A food furnishes an animal with *protein,* which is used for the building of flesh or muscle, or similar tissue, or for repairs to such tisue as is worn out by the life activities of the animal; and *energy* which is used for the purpose of furnishing heat, of furnishing energy to do work, to carry on the activities of the body, such as the beating of the heart, and movement of the lungs, or which is stored up as fat or used in the manufacture of meat, milk, or other products. Food is used by men for similar purposes.

In addition to the food value, so far as it fulfills the above uses, we have to consider with man the palatability of the food and its appeal to the senses or to the appetite. There are in addition substances in food which have effects quite out of proportion to their feeding value, and these must also be taken into consideration when one is choosing a food.

The value of a food for the repair or production of tissue may be expressed in its content of digestible protein. Its value for the pro-

duction of heat, fat, or energy, may be expressed in terms of energy as calories.

Table No. 7 contains a comparison of the protein and energy values of rice and some other foods. The results are expressed in terms of the weight as purchased. In the preparation of food for human con-

TABLE 7. COMPARATIVE COMPOSITION OF RICE AND OTHER FOODS.

	Protein Per cent.	Calories Per pound.
Rice	8.0	1630
Oat meal	16.1	1860
Wheat flour	13.1	1665
Corn meal	9.2	1655
Cheese, American	28.8	2055
Potatoes, Irish (as purchased)	1.8	310
Potatoes, sweet (as purchased)	1.4	460
Peanuts, edible part	25.8	2560
Cabbage, as purchased	1.4	125

sumption, a certain loss is unavoidable, due to unedible parts. This portion is practically nothing in the case of rice, but in the case of some other foods, it is a high proportion of the weight of the food. The table contains the total content of protein and of energy furnished by the different foods. The digestible part should be considered as well as the total, but there is comparatively little difference in the digestibility of rice and the foods mentioned.

The table shows that rice has a high food value. Fancy head rice, though selling for a higher price, has no greater food value than the second grade rice. Rice screenings have a high food value, practically the same as head rice, and thus are a much cheaper human food. Brewer's rice also has a high food value and could likewise be used as a human food. Table No. 8 shows the quantity of calories or of pro-

TABLE 8. COMPARATIVE VALUES OF RICE AND OTHER FOODS.

	Price, cents per pound.	Quantity for ten cents.	
		Calories.	Protein, ounces.
Oat flakes	10	1850	2.67
Corn meal	7	3972	3.52
Wheat flour	5	3300	3.64
Potatoes, Irish, $1.00 a bushel	.....	1890	1.74
Rice, cheaper grades	5	3250	2.56
Rice, fancy head	8	2025	1.60
Macaroni	10	1665	2.14

tein that may be purchased in rice and other foods, at the prices given. Rice compares very favorably in food value with these other foods at the prices given. There is no reason why the lower grades of rice should not be used for human food in this country, as they are used elsewhere.

According to D. D. Van Slyke (*Journal of Biological Chemistry*, 22, 259), the protein or flesh-forming constituent of rice, in its general make up, more nearly resembles the proteins of the animal body, than do the proteins of corn or wheat. This, he says, may explain the

extensive use of rice as an almost exclusive diet, in spite of its low protein content. In other words, the protein of rice may be better suited to the building or repair of tissue in the human body, than is the protein of corn or wheat.

Vitamines.

When polished rice forms a large proportion of the diet, or almost all of it, as is sometimes the case in China or Japan, a disease occurs which can usually be cured by substituting unpolished rice for the polished rice and may be entirely avoided by using the unpolished rice. This disease may also be cured by means of an extract of rice bran or rice polish. The disease is evidently due to the absence of some constituent of the rice removed during the process of polishing. There are other diseases which occur under similar conditions, and which may be prevented or rectified by proper changes in diet. It has been claimed that the trouble experienced in using polished rice referred to above is due to the removal of phosphoric acid during the process of polishing, but the addition of inorganic phosphates to the diet did not effect a cure (Chamberlain, *Philippine Journal of Science,* 1911, page 177). It is certain that considerable quantities of phosphoric acid are removed during the process of polishing rice.

The later theories ascribe the disease to the removal of substances termed *vitamines* from the rice (Frank, *Journal of Physiology,* 46, 172, 1913). According to this theory, some plants or foods contain substances which, in small amounts, are essential to the proper performance of the functions of the body, and when these substances are not eaten in sufficient quantity, disturbances of health follow. The vitamines are organic compounds somewhat unstable in character, and there are several different groups, the absence of which give rise to different symptoms. Three diseases that have been ascribed to the absence of the corresponding vitamines are beri-beri, scurvy, and pellagra. Beri-beri occurs among races consuming polished rice as a large proportion of their diet, and may be prevented or usually cured by the substitution of unpollshed rice for the polished rice. The vitamines corresponding are supposed to be present not only in unpolished rice, but also in yeast (which is very rich in vitamines), milk, egg yolk, fresh meat, fish, beans, peas, oats, barley, wheat, and corn. These foods are named in order, beginning with those richest in vitamines. Highly milled cereals, starch, pork, sterilized milk or meat, cabbage, and turnips are all poor in vitamines. (See Voegtlin, *Scientific Monthly,* 2, page 289.)

Pellagra is a disease which has been ascribed to a number of sources, including mouldy corn meal and the buffalo gnat. The latest theory ascribes it to deficient nutrition and probably to the absence of proper vitamines. Possibly where corn meal has been used as a food it has been so highly milled as to remove the vitamines, or cooked with soda, which destroys the vitamines. Although a person living on a varied diet is likely to secure a sufficient quantity of the proper vitamines, at least to maintain fairly good health, yet it is possible that minor disturbances of health or failure to reach the maximum of good health may

be due to the absence of the proper vitamines in sufficient amount. Further, an improper diet will furnish insufficient vitamines and cause disturbances of health.

POLISHED RICE VERSUS BROWN RICE.

Brown rice is the rice as it comes from the stones, before the bran has been removed. It is usually brown in color, with some grains of a greenish tinge, which are rice grains not completely ripe. When brown rice is sold as such, the lot is carefully selected so that it will not contain any greenish grains. These grains are not objectionable except that the color does not appeal to the eye. Brown rice is more easily attacked by the weevil than polished rice, and must, therefore, be stored more carefully. It takes longer to cook, and has a different taste from that of polished rice.

Brown rice contains the vitamines necessary for the animal body, which are removed in the preparation of polished rice. When the diet contains sufficient milk, meat, and fresh vegetables to supply the deficiency, no trouble is experienced, but where the diet consists largely of rice, brown rice is preferable. According to Worth and Darabsett (*Experiment Station Record,* 31, 163), from the Burmese native standpoint, "the more perfect the polish, the better does the rice cook, and, therefore, the preference for highly polished rice is not merely due to its clean white appearance, but to the good cooking qualities indicated by its appearance. It is doubtful whether we have as much reason for preferring white bread as the rice-eater has for preferring well-polished rice. The question of cooking quality in relation to extent of polishing is one that deserves some study by the millers. It may be just as possible to produce a good cooking rice without polishing quite so much as is the custom. A chemical test bearing on the cooking quality may be mentioned here. By means of dilute alkali, rice grains can be disintegrated and eventually gelatinized, but this does not take place at all until the outer layers of the grain have been gelatinized."

The above discussion shows that there are excellent reasons for advocating the use of brown rice as a human food. It also shows that the purchaser of polished rice has other reasons for his choice in addition to the clean white color.

RICE BY-PRODUCTS.

The most important of rice by-products are rice bran and rice polish. Rice bran is a mixture of the by-products from several machines, the stone bran, cone bran, and huller bran. In addition to the rice bran and rice polish, there is also the so-called "Chicken Feed," which consists of the screenings from rough rice. There are also hulls, light rice, dust from several dust collectors, and some intermediate products, such as chits. A comparison of the various by-products is give in Table No. 10.

Chicken Feed (Rough Rice Screenings).

The chicken feed consists of broken rice, weed seeds, mud balls, sand, and other material which passes through the screens in the preliminary cleaning of rough rice. It is really rough rice screenings. When any considerable proportion of broken rice (thresher broken rice, it is called) is present, the broken rice is separated as far as possible. The presence of certain weed seeds, however, renders the separation of the thresher broken rice from some rices, a matter of difficulty.

As its name indicates, the "chicken feed" is usually sold locally as a chicken feed. The quantity, as a rule, is small, usually less than 1 per cent., though in some lots of rice it may run to 6 or 7 per cent.

The composition of "chicken feed" will naturally vary considerably, according to the kind and character of the mixture. Table No. 9 contains analyses of several samples of chicken feed. There is a decided variation in the composition. The ash content varies from 2.89 to 33.36. The high ash is due to the presence of sand or mud balls. On account of the presence of sand and dirt, this product is not usually well suited to mix with other feeds for cattle feeding. The ether extract varies from 1.53 to 7.49. The high ether extract is due to weed seeds rich in oil. The crude fiber varies from 2.67 to 12.55.

Table No. 9 also contains an analysis of the seed of a weed found with rice in the Beaumont section, termed "Mexican weed." This seed consists of small black seed about the size of a radish seed. It contains

TABLE 9. "CHICKEN FEED" (ROUGH RICE SCREENINGS).

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9819	Honduras	7.72	1.61	2.67	46.17	8.47	33.36	29.09
9851	Blue Rose	13.64	7.49	12.55	49.65	9.91	6.76	3.98
9841	Honduras	9.69	2.40	3.25	57.25	10.25	17.16	15.46
9906	Honduras	9.24	3.43	8.90	63.37	12.17	2.89	.....
9878	Japan	7.94	1.53	5.37	48.96	9.43	26.77	26.28
11214	Chicken feed	9.75	2.76	5.61	57.56	10.76	13.56	10.85
11217	Chicken feed	8.88	1.95	3.47	57.63	10.88	17.19	13.90
	Average	9.55	3.02	5.97	54.38	10.27	16.81	16.59
	Mexican weed seed	16.78	30.90	35.16	6.76	7.06	3.34	.....

a high fat content. An oil is prepared from a seed similar to this, which is grown in Russia, and the oil is used in the lamps kept burning before the sacred images, or ikons.

Chicken feed has sometimes been ground and added to rice bran. Such an addition to rice bran must be considered as an adulteration, unless the fact of the addition is stated.

Stone Bran.

Stone bran is sifted out of the mixture of hulls and brown rice, coming from the stones which remove the hulls from the rough rice.

For this reason it is called stone bran. The mesh is usually 13x13, .028 gauge, tinned wire. Some mills use 14x14, .028 gauge. The quality of the stone bran depends upon the length of the reel and the rate at which the material passed through it. Towards the end of the wire, the material which comes through may consist almost entirely of rice hulls. Wooden valves, and two conveyors permit the product to be taken either to the bran mixer or to the hull house. The quantity of hulls in the stone bran may thus, to a certain extent, be regulated by the miller.

The stone bran consists of finely broken rice hulls, some rice bran, some of the germ broken from the end of the rice, dirt from mud balls, or that which adheres to the outside of the rough rice, and sometimes a little finely broken rice.

TABLE 10. COMPARATIVE AVERAGE COMPOSITION OF RICE BY-PRODUCTS.

	Number averaged.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
Chicken feed (rough rice screenings)	7	9.55	3.02	5.97	54.38	10.27	16.81	.....
Mexican weed seed	1	16.78	30.90	35.16	6.76	7.06	3.34	.....
Honduras stone bran	8	9.61	6.26	19.69	39.91	10.23	14.30	11.25
Japan stone bran	2	11.47	10.32	17.48	37.20	9.55	15.00	9.71
Blue Rose stone bran	12	9.60	8.16	22.33	34.49	9.35	16.07	12.93
All stone bran	22	9.77	7.66	20.92	36.73	9.69	15.23	12.06
Honduras huller bran	9	14.92	15.01	6.72	45.58	10.37	7.41	1.26
Japan huller bran	4	14.28	16.40	9.12	43.55	9.11	7.53	1.40
Blue Rose huller bran	10	15.29	18.78	8.47	38.13	9.65	7.38	1.55
Pearling cone bran	8	15.39	15.97	5.66	46.13	9.77	7.08	.92
Mixed bran	18	13.63	14.78	11.69	40.14	9.78	9.98	4.50
Rice hulls	14	3.56	.93	39.05	29.38	8.49	18.59	17.52
Rice polish	10	12.88	9.07	2.12	61.81	9.91	4.21	.....
Dust, various	9	6.36	3.62	23.54	30.75	8.09	27.63	.....

The composition of stone bran is shown in Table No. 10, and details in Table No. 11. The crude fiber content varies from 18.09 to 25.94 per cent., with an average of 19.15. The high crude fiber content is due to the presence of rice hulls.

The ether extract of the stone bran varies from 4.28 to 10.90, with an average of 7.33. This content of ether extract, taken in connection with the protein content, shows the presence of the germ and bran layers similar to those removed by the huller.

Stone bran from Blue Rose rice contains, on an average, more fat and more crude fiber than the average stone bran from Hoduras rice.

The stone bran is not rice bran, but a mixture of rice bran and rice hulls secured in the milling of rice. In a strict sense, a mixture of stone bran and rice bran should not be sold as rice bran. On the other hand, the stone bran may be regarded as containing some rice bran mixed with an unavoidable amount of rice hulls. From this viewpoint the sale of stone bran mixed with huller bran and cone bran, under the name of rice bran, may be permitted. The fact must fur-

TABLE 11. STONE BRAN (SO-CALLED).

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.	Hulls.
9598	Honduras Rice	10.85	6.97	14.09	47.97	10.38	9.74	6.63	19.6
9602	Honduras Rice	9.13	4.28	19.81	39.21	10.84	16.73	14.36	38.1
9476	Honduras Rice	10.29	6.84	19.81	38.87	11.61	12.58	10.33	38.1
9823	Honduras Rice	9.33	6.07	23.87	37.21	9.29	14.23	11.51	51.2
9846	Honduras Rice	8.68	5.24	25.74	35.70	8.68	15.96	13.59	57.2
9907	Honduras Rice	8.19	6.46	22.32	38.75	9.04	15.24	12.55	46.2
11179	Honduras Rice	9.94	6.73	16.50	39.88	10.38	17.02	12.32	26.0
11192	Honduras Rice	10.50	7.48	15.83	41.66	11.64	12.89	9.67	25.3
	Average (8)	9.61	6.26	19.69	39.91	10.23	14.30	11.37	37.7
9887	Japan Rice	11.15	10.90	18.97	33.57	9.45	15.96	11.08	35.4
11154	Japan Rice	11.78	9.74	15.98	40.82	9.65	12.03	8.33	25.7
	Average (2)	11.47	10.32	17.48	37.20	9.55	14.00	9.71	30.6
9613	Blue Rose Rice	11.63	11.55	20.86	36.00	6.79	13.17	9.33	41.5
9857	Blue Rose Rice	8.48	6.57	24.80	34.71	9.13	16.31	13.33	54.2
11152	Blue Rose Rice	10.30	8.31	18.41	39.37	9.86	13.73	10.86	33.6
11153	Blue Rose Rice	9.39	7.21	24.07	33.03	9.75	16.55	13.79	51.8
11155	Blue Rose Rice	10.85	9.32	20.28	36.06	9.53	13.96	10.50	39.6
11156	Blue Rose Rice	7.75	9.83	25.94	29.63	8.58	18.27	14.79	57.9
11157	Blue Rose Rice	7.46	5.40	24.97	32.20	8.98	20.99	17.97	54.7
11166	Blue Rose Rice	9.06	6.09	22.83	34.40	10.04	17.58	14.80	47.8
11167	Blue Rose Rice	10.94	9.53	19.49	35.50	9.32	15.22	12.01	36.7
11168	Blue Rose Rice	10.04	8.09	21.60	35.47	9.57	15.23	12.22	43.9
11169	Blue Rose Rice	8.73	7.49	23.14	32.38	10.80	17.46	14.59	48.8
11220	Blue Rose Rice	10.53	8.57	21.49	35.18	8.89	14.34	10.92	43.5
	Average (12)	9.60	8.16	22.33	34.49	9.35	16.07	12.93	46.3
	Average of all (22)	9.77	7.66	20.92	36.73	9.69	15.23	12.06	41.7

ther be recognized that this mixture is, and has been for a number of years, sold under the name of rice bran. Further, the rice bran prepared by the old mortar and pestle method, always contained a certain amount of hulls.

If we assume that the stone bran consists of a mixture of rice hulls and huller bran of the average compositions given in Tables Nos. 13 and 15 it is possible to calculate the percentage of hulls from the crude fiber by means of the formula:

$$X = \frac{F - 8}{39 - 8} = \frac{F - 8}{31}$$

In this formula, F is the crude fiber content of the bran.

Calculated in this way, the stone bran contains from 19.6 to 57.2 per cent. hulls, with an average of 41.6 per cent. (Table No. 11.) Some of these samples of stone bran evidently contain excessive quantities of hulls.

If we assume that the stone bran is composed of hulls and another product, calculate the hulls, and subtract the material in the hulls from the remainder, we find that the residual stone bran has the composition given in Table No. 12. The table shows the method of calculation. The residue is lower in ether extract and higher in ash and insoluble ash than the average for huller bran. The lower fat is prob-

ably due to broken rice; the higher ash and insoluble ash, to the presence of dirt or sand. The stone bran may be regarded as a mixture of huller bran and hulls, with some dirt.

Chits.

The stone bran reel usually carries a section of so-called "chit" wire (8x8, No. 17 wire) after the stone bran wire. The chits consist of broken rice, and are removed at this point to avoid their being lifted out along with the hulls by the air blast which removes the hulls. Some hulls go along with the chits, and a large quantity of hulls may go with them, if it is desired, or if proper care is not exercised. Wooden valves above the conveyors permit the chits to be diverted either to the hull house, or to the huller, according to what they consist of. Some mills also lift almost all of the hulls out of the chits before milling them.

The chits are passed into the hullers. In some mills, they are milled on a separate huller, which is the better plan, but in many mills they are mixed with the whole brown rice in one or more hullers. It is of course difficult to mill the broken rice without breaking more of the whole rice, for which reason it is better to mill the chits separately.

TABLE 12. COMPOSITION OF RESIDUE FROM STONE BRAN AFTER HULLS HAVE BEEN DEDUCTED.

	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
In 100 lbs. stone bran (average)	9.77	7.66	20.92	36.73	9.69	15.23	12.06
In 41.6 lbs rice hulls (average)	1.48	.38	16.24	12.22	3.53	7.73	7.28
In 58.4 lbs residue	8.29	7.28	4.68	24.51	6.16	7.50	4.78
In 100 lbs. residue of stone bran	14.19	12.46	8.01	41.96	10.54	12.84	8.18
In bran from hullers (average)	14.97	16.89	7.90	42.98	9.84	7.42	1.41
						5.42	6.74
In 100 lbs rice hulls	3.56	.93	39.05	29.38	8.49	18.59	17.52

The rice bran from the huller milling chits alone, or with brown rice, contains hulls in addition to the true rice bran. The quantity of hulls will depend upon the amount present in the chits.

Table No. 23 shows the analyses of chits and of huller bran from a huller milling chits alone. The product contains 20.45 per cent. crude fiber. Calculating the hull content by the method previously given, we find that this huller bran contains 40 per cent. rice hulls. The quantity is, however, really larger, since the huller bran from the chits contains a larger proportion of ground or finely broken rice, than the ordinary huller bran, and as this rice contains less fiber than rice bran, the calculation gives low results.

Rice millers claim that the quantity of chits is small, and that the amount of hulls which get into rice bran in this way is not at all large. A miller may, however, run up the hull percentage in this way, either intentionally or through carelessness.

Huller Bran.

When the rice reaches the hullers, practically all the unhulled rice has been removed by the paddy machines, and only the brown rice is present. There may be some grains carrying hulls, but the percentage is small.

In the bottom of the huller is what is known as the huller bottom, or sieve, which allows the bran to discharge through it. It consists of sheet steel punctured with slits about one-half inch long, and from 3/64 to 4/64 inch wide. The bran which passes through contains some broken rice. This is removed in a reel with screen wire, 14x14, .028, and goes to the second huller or to the cones, as the case may be. Eventually a portion finds its way back to the bran.

Table No. 13 gives the composition of a number of samples of huller bran. One or two of these samples were evidently hullers receiving chits in addition to the brown rice. (See also comparsion in Table No. 10.)

TABLE 13. COMPOSITION OF RICE HULLER BRAN.

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9584	Honduras	14.72	16.38	7.32	44.02	9.96	7.60	.84
9606	Honduras	13.39	12.41	5.75	48.49	11.49	8.52	.....
9828	Honduras	16.16	15.84	6.75	44.20	9.85	7.20	1.43
9834	Honduras	16.37	18.30	8.32	41.55	8.81	6.65	.84
9903	Honduras	15.26	15.92	8.08	43.78	9.41	7.55	.89
9904	Honduras	17.35	18.08	7.18	40.29	10.10	7.00	1.00
11174	Honduras	12.26	9.65	4.14	56.35	10.70	6.90	1.76
11180	Honduras	15.56	16.07	6.40	42.98	10.74	8.25	1.56
11189	Honduras	13.25	12.40	6.57	48.52	12.28	6.98	1.75
	Average (9)	14.92	15.01	6.72	45.58	10.37	7.41	1.26
9648	Japan	13.40	15.03	7.06	48.10	8.50	7.91	1.58
9886	Japan	13.75	16.58	11.62	40.68	9.11	8.26	1.89
11159	Japan	14.91	16.27	9.92	41.97	9.70	7.23	1.53
11160	Japan	15.07	17.73	7.89	43.44	9.14	6.73	.60
	Average (4)	14.28	16.40	9.12	43.55	9.11	7.53	1.40
9614	Blue Rose	16.81	19.83	8.06	40.69	7.22	7.39	.....
9858	Blue Rose	15.56	20.29	8.48	38.67	8.83	5.17	.67
11158	Blue Rose	15.53	19.75	8.52	40.07	8.94	7.19	.96
11161	Blue Rose	15.87	18.55	9.13	37.95	10.92	7.58	1.48
11170	Blue Rose	15.19	18.61	7.50	41.86	9.81	7.03	1.01
11171	Blue Rose	15.88	19.43	8.51	38.04	10.19	7.95	1.89
11172	Blue Rose	13.59	17.45	11.54	37.80	10.19	9.43	3.68
11173	Blue Rose	14.88	18.06	8.05	21.26	10.08	7.67	1.36
11174	Blue Rose	14.19	14.98	6.38	46.92	10.50	7.03	1.38
11219	Blue Rose	15.44	20.86	8.51	38.01	9.80	7.38	.....
	Average (10)	15.29	18.78	8.47	38.13	9.65	7.38	1.55

Averages are made separately for the Honduras rice, Blue Rose, and Japan. The bran from the Blue Rose and the Japan rice contains a higher average percentage of crude fiber. According to some rice millers, Blue Rose rice is covered with a hard, thin coating, and not only does not yield as much bran, but does not break or rub off as much as does the Honduras rice. Thus, the average crude fiber in the nine Hon-

duras huller brans is 6.72 per cent., and the average combined protein and fat is 29.93. The average crude fiber in the four Japan huller brans is 9.12, or 2.40 per cent. more than the Honduras, with 30.68 per cent. combined protein and fat. The average crude fiber in the ten Blue Rose huller brans is 8.47, or 1.75 per cent. more than in the Honduras huller bran, with 34.07 per cent. combined protein and fat, which is 4.14 more than that in the Honduras, and 3.39 more than that in the Japan. Individual analyses differ quite decidedly from these averages, but it is clear that the Blue Rose huller bran is richer in protein and fat than either of the other varieties. The difference in crude fiber is perhaps due partly to a higher hull content. The Blue Rose huller bran averages 1.55 per cent. insoluble ash and the Honduras 1.26 per cent. The difference is 0.29 per cent., which, if due to the presence of rice hulls, would equal $0.29 \times 2.15 = 0.62$ per cent. crude fiber difference in the rice hulls. The total difference in crude fiber is, however, 1.75. The huller bran of the Blue Rose in itself contains more crude fiber than the huller bran of Honduras rice. This may be due to the fact that more of the rice itself goes into the Honduras huller bran. If the insoluble ash in the huller bran is assumed to come from rice hulls, as it probably does, then the average crude fiber from rice hullls in the brans would be:

Honduras	2.70%
Japan	3.01%
Blue Rose	3.33%

The net average crude fiber in the huller bran, free from hulls, would then be:

Honduras	4.02%
Japan	6.11%
Blue Rose	5.14%

We prefer, however, to base calculations upon the huller bran as actually secured from the machines.

Cone Bran.

The cones usually take the place of the second break hullers. Some mills have no cones, but use second, or more rarely, third break hullers, and then the brushes. For this reason, the by-product belongs with the rice bran rather than with the polish. If cone bran is sold separately, a more appropriate term is rice cone meal. Most mills mix it in with the huller bran and the stone bran.

Table No. 14 shows the composition and the average composition of the cone bran. As compared with the huller bran, it contains less crude fiber and slightly less ash. As compared with the rice polish, it contains more protein, fat, fiber, and ash, and less nitrogen-free extract.

TABLE 14. BRAN FROM PEARLING CONES.

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9593	Honduras	16.52	20.32	8.00	38.35	8.84	7.97	.51
9483	Honduras	16.49	11.78	3.23	52.03	11.08	5.39	.39
9820	Honduras	15.66	16.83	7.90	44.15	8.54	6.92	1.09
9844	Honduras	15.63	14.77	3.49	50.56	8.83	6.72	.....
9899	Honduras	12.50	13.00	2.50	55.94	10.64	5.42	.67
11194	Honduras	14.06	12.63	3.35	50.84	11.50	7.62	1.77
9859	Blue Rose	16.52	20.32	8.00	38.35	8.84	7.97	.82
9884	Japan	15.70	18.11	8.79	38.93	9.86	8.61	.94
	Average (8)	15.39	15.97	5.66	46.13	9.77	7.08	.88

Rice Hulls.

Rice hulls have a very low feeding value, as they are digested to a very small extent by animals. It has even been claimed that they are irritating and dangerous to the stomach and intestines of animals, but there is no definite evidence that such is the case. They have, however, a very low feeding value, and may be considered more of a filler than anything else. Rice hulls contain about 0.3 pound digestible protein in every 100 pounds, which is about one-tenth of the digestible protein in Johnson grass hay, or one one-hundred-twentieth of that in cottonseed meal. They have a productive value of approximately 3.2 pounds per hundred. That is to say, 100 pounds ground rice hulls will produce 3.2 pounds fat on an animal already receiving enough feed for maintenance. This is about two-fifths the productive value of Johnson grass hay, one-fourth the productive value of wheat bran, and one-sixth the productive value of cottonseed meal. Rice hulls have a lower feeding value than any hay, straw, or fodder sold in Texas.

Table No. 15 shows the composition of some samples of rice hulls

TABLE 15. RICE HULLS.

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
9585	Honduras	3.21	1.08	39.10	29.05	9.15	18.41	17.43
9608	Honduras	4.56	.54	38.85	26.23	10.30	19.52	18.43
9477	Honduras	4.57	.76	31.43	36.83	10.95	15.83	14.55
9818	Honduras	3.00	.97	39.24	31.70	8.38	16.67	15.78
9835	Honduras	2.45	.65	40.14	28.58	8.69	19.49	18.60
9902	Honduras	2.88	.72	40.19	27.63	8.88	19.70	18.86
9839	Honduras	4.88	.80	36.72	30.59	7.98	19.03	17.82
9611	Blue Rose	1.78	.63	46.37	25.98	6.11	19.13	18.18
9850	Blue Rose	5.00	.94	42.09	24.56	7.98	19.43	18.30
9880	Japan	3.85	1.98	40.55	25.51	8.33	19.78	18.07
9642	Red	2.51	.78	38.08	29.67	6.76	22.00	20.84
11193	Rice hulls	3.19	.70	36.03	30.64	10.48	18.96	18.01
11205	Rice hulls	4.88	1.67	35.22	34.64	8.76	14.83	13.69
11204	Ground hulls	3.06	.77	42.69	29.91	6.09	17.48	16.75
	Average (14)	3.56	.93	39.05	29.38	8.49	18.59	17.52
	Average (3) (Bulletin 73)	3.67	1.50	39.37	29.27	8.42	17.77	.....

collected in the course of this investigation. The quantity of crude fiber varies from 35.22 to 46.37 per cent. The average is 39.05, and we will base our calculations upon 39 per cent.

Rice hulls contain high quantities of ash, most of which is silica, and, therefore, appears as *insoluble ash*. The insoluble ash varies from 13.69 to 20.84 with an average of 17.52 per cent. The average ratio of crude fiber to insoluble ash is 2.15 to 1. The percentage of insoluble ash may be used to estimate the quantity of rice hulls in a feed. In the case of rice bran, however, insoluble ash from the dirt in the stone bran is also present. (See under stone bran.)

RICE BRAN.

Commercial rice bran consists of a mixture of the stone bran, the bran from the hullers, and the cone bran. Some mills mix the cone bran with the rice polish and sell it as polish, and some sell it separately as cone meal, but since the cones take the place of a huller, the product is really bran and belongs with the bran. When the cone bran is omitted, the mixed bran contains a larger proportion of the inferior product, stone bran, than it otherwise would contain.

Some few rice millers also have a tendency to consider the rice bran as a mixture of all by-products of the rice milling supposed to have a feeding value, and accordingly wish to put in it dust, light rice, or a portion of the light rice, and sometimes ground chicken feed, or other by-products of the milling. Such additions would be considered as adulterants, since these by-products can in no sense be considered as rice bran. If any such by-products are added, the product should be sold as a mixed feed.

There is also a tendency on the part of some mills to introduce as much hulls, directly or indirectly, as they can get by with. Some attempt to justify such additions by a claim that the rice hulls prevent the rice bran from souring or heating, and keep it in better condition. If rice hulls had this effect, of course their addition would be justified, but the mixture would not be rice bran, and the purchaser would still have the right to know what he was getting, and how much excess hulls were present. The objection would not be to making the mixture, but to misrepresentation, or deceit in selling the goods. However, the fact has not been well established that the addition of rice hulls helps to keep the bran.

In November, 1915, the Texas rice millers at a public hearing in regard to rice by-products, held at their request, asked that the crude fiber in the definition of rice bran be raised from 12 per cent. to 15 per cent. The standard had been 15 per cent. for a number of years, but had been lowered to 12 per cent. about a year previous. The rice millers stated that bran with 12 per cent. crude fiber could be made from Honduras rice, but that a new variety of rice, Blue Rose, was now extensively grown, which produced a bran containing more crude fiber than the Honduras. They also represented that the standard of 12 per cent. did not allow a sufficient margin for variation in the composition of the bran, due to variations in the milling properties of different lots of rice. A number of the samples reported in this bulletin

were collected for the purpose of studying the questions raised at this hearing.

On December 30, 1915, the definition of rice bran was changed by the Texas Feed Control Service to read as follows:

"Rice bran is the cuticle of the rice grain with only such quantity of hulls as is unavoidable in the regular milling of rice. It must contain not less than 11 per cent. protein, 10 per cent. fat, and not more than 15 per cent. crude fiber."

This definition requires the rice miller to exercise due care to keep as much hulls as possible out of rice bran. Rice bran is considered as adulterated if it contains an excess of hulls, excess of stone bran, immature rice, so-called chicken feed, dust, or any other milling product not properly belonging to rice bran as defined above, regardless of the protein, fat, or crude fiber present.

Composition of Rice Bran.

Rice bran is variable in composition, the variations depending on the milling properties of the rice and the milling conditions. The relative proportion of stone bran to huller bran also influences the composition.

The crude fiber content indicates the quantity of hulls present. The quantity of hulls also influences the protein and fat, since the higher the hulls, the lower the protein and fat. Rice bran also contains pulverized or broken rice. The quantity of broken rice may at times be 10 to 15 per cent. The broken rice also decreases the protein, fat, and ash, but does not increase the crude fiber.

Table No. 16 shows the composition of rice bran collected for the purpose of this investigation. Bran from Blue Rose or Japan rice runs somewhat higher in fiber than that from Honduras. The Blue

TABLE 16. MIXED RICE BRAN.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.	Digestible Protein.	Productive value.
9601	Honduras	13.09	10.38	8.45	47.59	10.39	10.10	4.55	8.68	18.16
9479	Honduras	14.50	12.62	11.75	41.21	11.95	7.97	3.18	9.34	17.24
9845	Honduras	14.24	12.96	13.01	41.87	8.95	8.97	.....	8.91	16.83
11177	Honduras	13.50	14.13	7.39	44.61	10.89	9.48	2.30	8.95	19.57
11190	Honduras	13.94	13.78	7.22	44.68	12.15	8.23	2.48	9.24	19.47
9618	Blue Rose*	12.41	14.94	17.82	35.28	7.16	12.39	7.10	7.50	15.50
9860	Blue Rose	13.26	14.42	11.33	41.65	9.17	10.17	5.23	8.54	18.12
11147	Blue Rose	13.69	16.32	13.04	34.17	9.11	13.67	7.39	8.57	17.04
11148	Blue Rose	12.71	14.08	13.36	38.97	9.96	10.92	6.39	7.96	16.63
11149	Blue Rose	14.93	17.63	10.90	37.60	9.91	9.03	3.46	9.61	19.71
11162	Blue Rose	14.66	16.71	8.88	41.15	10.60	8.00	2.25	9.72	20.42
11163	Blue Rose	11.69	13.82	15.47	35.62	10.19	13.21	8.34	7.32	15.61
11164	Blue Rose	13.25	15.02	15.23	36.86	8.76	10.88	5.90	8.29	16.73
11165	Blue Rose	13.79	16.73	10.62	40.07	9.77	9.02	3.65	9.02	19.58
11218	Blue Rose	14.35	16.96	14.29	35.18	9.82	9.40	4.38	8.98	17.64
9883	Japan	14.92	16.32	10.24	39.61	9.34	9.57	2.63	9.78	19.44
11145	Japan	13.62	15.10	11.46	42.09	9.69	8.04	2.91	8.77	18.63
9646	Red	12.73	14.20	10.01	44.38	8.15	10.53	4.36	8.33	18.96
	Average (18)	13.63	14.78	11.69	40.14	9.78	9.98	4.50	8.75	18.07

*Excess of hulls present.

Rose rice is usually hard and flinty, and does not rub off or break up finely in milling. This causes the huller bran to contain more crude fiber and also decreases its quantity relatively to the stone bran, which thus causes another increase in fiber, on account of the greater proportion of stone bran present.

Table No. 17 contains the composition of rice brans averaged by periods of six months from samples collected by the Feed Control Service. The tables from which these averages were calculated contain some illegal samples, which affect the average to some extent.

TABLE 17. AVERAGE COMPOSITION OF RICE BRAN BY PERIODS OF SIX MONTHS (FEED CONTROL SAMPLES).

Period.	Number averaged.	Protein.	Ether extract.	Crude fiber.	Nitrogen free extract.	Water.	Ash.	Digestible protein.	Productive value.
July 1, 1907 to Jan. 1, 1908	22	12.34	11.49	9.73	46.38	11.21	8.85	8.07	17.87
Jan. 1, 1908 to July 1, 1908	5	13.13	12.49	12.64	41.51	10.57	9.66	8.46	17.01
July 1, 1908 to Jan. 1, 1909	15	12.51	11.84	9.89	47.14	10.29	8.32	8.18	18.24
Jan. 1, 1909 to July 1, 1909	3	11.37	9.10	14.80	43.03	10.57	11.13	7.12	14.51
July 1, 1909 to Jan. 1, 1910	16	12.96	12.16	12.16	42.69	9.44	10.59	8.35	17.06
Jan. 1, 1910 to July 1, 1910	14	11.91	10.81	12.45	44.93	10.31	9.59	7.67	16.62
July 1, 1910 to Jan. 1, 1911	10	12.19	11.85	10.61	47.05	9.11	9.19	7.97	18.19
Jan. 1, 1911 to July 1, 1911	19	12.13	11.04	11.75	46.33	9.51	9.24	7.81	17.08
July 1, 1911 to Jan. 1, 1912	5	11.84	11.56	11.80	44.15	11.43	9.22	7.62	16.47
Jan. 1, 1912 to July 1, 1912	2	10.88	8.25	8.38	51.17	12.90	8.42	7.21	17.44
July 1, 1912 to Jan. 1, 1913	19	12.37	13.11	11.61	43.74	9.42	9.75	7.97	17.80
Jan. 1, 1913 to July 1, 1913	14	12.08	11.53	13.11	42.71	10.30	10.27	7.56	15.91
July 1, 1913 to Jan. 1, 1914	26	11.74	10.12	12.97	42.87	11.88	10.42	7.35	15.84
Jan. 1, 1914 to July 1, 1914	26	12.05	9.74	11.19	44.45	11.04	11.53	7.76	15.99
July 1, 1914 to Jan. 1, 1915	21	12.88	12.49	11.58	42.49	10.49	10.17	8.29	17.18
Jan. 1, 1915 to July 1, 1915	33	11.62	10.25	15.82	41.65	9.54	11.12	7.27	14.85
July 1, 1915 to Jan. 1, 1916	26	12.41	13.00	14.58	39.45	9.33	11.23	7.77	16.05

The table also shows the average productive values and the average digestible protein present. These will be discussed in a subsequent section.

HULLS IN RICE BRAN.

The quantity of hulls in rice bran may be estimated from the quantity of crude fiber present. This estimate may be based upon the average composition of huller bran and the average composition of rice hulls. If broken rice is present in addition to the hulls and huller bran, the figures for hulls will be too low.

The percentage of hulls may be calculated by the formula:

$$X = \frac{F-R}{H-R}$$

when X = per cent. hulls
F = per cent. fiber in the bran
R = per cent fiber in the huller bran
H = per cent. fiber in hulls.

If we assume the average fiber in huller bran to be 8 per cent. (Table No. 13) and that of hulls to be 39 per cent. (Table No. 15), the formula becomes

$$X = \frac{F-8}{39-8} = \frac{F-8}{31}$$

The quantity of hulls present for various grades would then be approximately:

Crude Fiber Per Cent.	Hulls Per Cent.
8	0
10	6.4
12	12.9
15	22.6

RICE POLISH.

The composition of rice polish is somewhat variable, depending on the kind of rice to be milled. If the rice is soft and breaks up finely, or rubs off, it goes into the polish. As the rice itself is low in fat and protein, its presence reduces the protein and fat content of the polish. If, on the other hand, the rice is hard or flinty, and does not break up finely or rub off, the polish consists more largely of the outer coating of the rice and contains a comparatively high percentage of fat. The presence of pulverized or broken rice accounts for the low fat in some samples of rice polish. It is not to the interest of the miller for rice to go into the polish, as even brewer's rice has a higher commercial value than rice polish.

Table No. 18 shows the composition of the samples of rice polish collected along with the samples of rice studied in this bulletin. Table

TABLE 18. RICE POLISH, FROM BRUSHES.

Laboratory No.	Variety.	Protein.	Ether extract.	Crude fiber.	Nitrogen free extract.	Water.	Ash.	Pentosans.
9586	Honduras	12.91	5.62	2.18	66.17	9.84	3.26	.76
9605	Honduras	12.79	7.75	2.79	60.34	10.76	5.57	1.36
9484	Honduras	13.02	6.23	1.52	66.25	10.57	2.41	.12
9826	Honduras	14.45	11.35	1.90	58.44	10.31	3.55	.....
9837	Honduras	11.13	6.71	1.63	67.28	10.30	2.95	.53
9908	Honduras	14.24	9.22	2.28	59.43	10.14	4.69	.....
9615	Blue Rose	14.03	12.95	2.53	55.70	8.86	5.93	.....
9852	Blue Rose	11.39	11.27	2.00	61.46	9.91	3.97	.33
9888	Japan	12.59	10.23	2.13	60.33	9.98	4.74	.48
9641	Red Rice Series	12.24	9.34	2.20	62.76	8.46	5.00	.....
	Average (10)	12.88	9.07	2.12	61.81	9.91	4.21	.60

No. 19 contains the composition of rice polish averaged by periods of six months, from samples collected for the Feed Control Service. The average digestible protein and productive values are also given; these are discussed in the next section.

TABLE 19. AVERAGE COMPOSITION OF RICE POLISH BY PERIODS OF SIX MONTHS (FEED CONTROL SAMPLES).

Period.	Number averaged.	Protein.	Ether extract.	Crude fiber.	Nitrogen free extract.	Water.	Ash.	Digestible protein.	Productive value.
July 1, 1907 to Jan. 1, 1908	20	11.97	9.18	2.63	61.46	9.79	4.97	8.06	20.31
Jan. 1, 1908 to July 1, 1908	3	12.39	10.72	3.62	59.07	9.49	4.71	8.34	20.58
July 1, 1908 to Jan. 1, 1909	16	12.68	9.12	2.72	61.53	9.31	4.64	8.53	20.41
Jan. 1, 1909 to July 1, 1909	2	12.75	9.01	2.58	59.15	10.46	6.05	8.58	19.82
July 1, 1909 to Jan. 1, 1910	16	13.23	10.87	3.40	58.23	9.02	5.25	8.90	20.61
Jan. 1, 1910 to July 1, 1910	4	12.13	8.36	2.26	62.97	10.22	4.06	8.16	20.28
July 1, 1910 to Jan. 1, 1911	5	12.10	9.87	2.70	60.78	9.87	4.68	8.14	20.52
Jan. 1, 1911 to July 1, 1911	9	12.56	10.58	3.37	57.49	9.81	6.19	8.45	20.13
July 1, 1911 to Jan. 1, 1912	6	11.56	8.11	2.52	62.45	10.89	4.47	7.78	19.95
July 1, 1912 to Jan. 1, 1913	14	11.81	10.21	2.88	60.84	8.90	5.36	7.95	20.65
Jan. 1, 1913 to July 1, 1913	2	12.80	10.95	2.79	58.94	9.69	4.83	8.61	20.74
Jan. 1, 1914 to July 1, 1914	15	11.52	7.40	2.38	62.20	11.39	5.11	7.75	19.55
July 1, 1914 to Jan. 1, 1915	20	12.29	9.45	2.53	39.80	10.36	5.57	8.27	20.11
Jan. 1, 1915 to July 1, 1915	2	12.41	7.79	1.88	63.65	10.30	3.91	8.35	20.21
July 1, 1915 to Jan. 1, 1916	13	12.85	10.17	2.61	59.63	9.32	5.42	8.65	20.52

THE FEEDING VALUE OF BRAN AND POLISH.

The feeding value of rice bran and rice polish depends upon (a) the quantity of digestible protein, (b) the productive value, and (c) the suitability to the animal.

The digestible protein is used for the purpose of building or repair of muscle, cell tissue, and organs of the body, which are chiefly composed of proteids. It is also used for hair, wool, and for the casein of milk.

The productive value is expressed in terms of fat, and is the quantity of fat that would be produced on a fattening animal when added to a ration already sufficient to supply the needs of the animal for maintenance. It represents the part of the feed available for body uses, after all losses have been deducted, due to digestion, fermentation, and body activities necessary to prepare the food for the use of the animal.

The productive value is used for heating the animal body and for supplying it with energy to be used in body motions, beating of the heart, and other vital activities. It is also used for the production of body fat, or the sugar and fat of milk. It also furnishes the energy used when an animal works.

Animals require more productive value in their food than they do protein. For example, while a fattening steer that weighs 1000 pounds requires only 1.8 pounds of digestible protein, he should receive from 2.8 to 3.6 pounds productive value.

The digestible protein and the productive values are ascertained by means of digestion experiments and other tests with animals. Diges-

tion experiments with rice bran and rice polish are given in bulletin No. 166 of this Station. The digestible protein of a given feed is found by multiplying the protein by the coefficient of digestibility of the protein. The productive value is ascertained by multiplying each constituent of the feed by its production factor, and adding the products. If the value for crude fiber is negative, it is subtracted. (See Bulletin No. 185 for a discussion of these factors.)

Since the values of rice bran and rice hulls are different, the proportion of hulls in rice bran, which can be judged by the crude fiber content, affects the production coefficients. The production coefficients for different grades of rice are given in Table No. 20.

TABLE 20. PRODUCTIVE COEFFICIENTS OF RICE BY-PRODUCTS.

	Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Coefficient of digestibility of protein.
Rice bran, 8 per cent fiber (7-9), 0 hulls	.155	.540	.023	.217	.663
Rice bran, 10 per cent fiber (9-11), 6.4 hulls	.153	.539	0	.211	.654
Rice bran, 12 per cent fiber (11-13), 12.9 hulls	.151	.538	—.016	.205	.644
Rice bran, 15 per cent fiber (13-16.5), 22.6 hulls	.147	.536	—.032	.196	.626
Rice bran, 19 per cent fiber (16.5–19), 32.3 hulls	.142	.533	—.042	.185	.604
Rice bran, 20 per cent fiber (19–21)	.138	.530	—.048	.178	.588
Hulls	.024	.318	—.070	.087	.10
Polish	.158	.490	—.010	.227	.673

The methods used in working these out are readily seen by reference to Table No. 21 and are described in a subsequent section.

TABLE 21. COMPOSITION AND PRODUCTIVE VALUES OF BRAN AND HULLS (CALCULATIONS).

		Protein.	Ether Extract.	Crude Fiber.	Nitrogen free extract.	Water.	Ash.
Rice bran, 12 per cent fiber, 100 lbs.	L	13.0	12.5	12.0	42.0	10.5	10.0
Hulls, 12.9 lbs.	.129B	.45	.13	5.03	3.81	1.10	2.39
Residue, 87.1 lbs.	C	12.55	12.37	6.97	38.19	9.40	7.61
Per cent in residue	$A=\frac{C}{.871}$	14.41	14.20	8.00	43.85	10.79	8.74
Hulls, 100 lbs.	B	3.5	1.0	38.0	29.5	8.5	18.5
Rice bran, 8 per cent fiber, 93.6 lbs.	.936A	13.49	13.29	7.49	41.04	10.10	8.18
Hulls, 6.4 lbs.	.064B	.22	.06	2.50	1.89	.54	1.18
Composition 10 per cent fiber (total 100 lbs.)	S	13.71	13.35	9.99	42.93	10.64	9.36
Rice bran, 8 per cent fiber, 77.4 lbs.	.774A	11.15	10.99	6.19	33.94	8.35	6.76
Hulls, 22.6 lbs.	.226B	.79	.23	8.81	6.67	1.92	4.18
Composition, 15 per cent fiber (total 100 lbs)	D	11.94	11.22	15.00	40.61	10.27	10.94
Rice bran, 8 per cent fiber, 67.7 lbs.	.677A	9.76	9.61	5.42	29.69	7.30	5.92
Hulls, 32.3 lbs.	.323B	1.13	.32	12.59	9.53	2.74	5.97
Composition 18 per cent fiber, total 100 lbs.	E	10.89	9.93	18.01	39.22	10.04	11.89
Rice bran, 8 per cent fiber, 61.3 lbs.	.613A	8.83	8.70	4.90	26.88	6.61	5.36
Hulls, 38.7 lbs.	.387B	1.35	.39	15.09	11.42	3.29	7.16
Composition 20 per cent fiber, total 100 lbs.	F	10.18	9.09	19.99	38.30	9.90	12.52

TABLE 21. COMPOSITION AND PRODUCTIVE VALUES OF BRAN AND HULLS (CALCULATIONS).

	Ash.	Protein.	Ether Extract.	Crude Fiber.	Nitrogen free extract.	Digestible protein.
Production coefficient, 12 per cent fiber	H	.151	.538	—.016	.205	.644
Production coefficient, hulls	I	.024	.318	—.070	.087	.10
Productive value, 12 per cent fiber	HL	1.963	6.725	—.192	8.610	8.37
Productive value, hulls	IB=K	.084	.318	—2.730	2.567	.35
Productive value, 100 lbs., 12 per cent	HL	1.963	6.725	—.192	8.610	8.37
Productive value, 12.9 lbs., hulls	.129K	.011	.041	—.352	.331	.05
Residue 87.1 lbs.	M	1.952	6.684	.160	8.279	8.32
Productive coefficient, 8 per cent fiber	M/C	.155	.540	.023	.217	.663
Productive value, 100 lbs., 8 per cent	$\frac{M}{.871}$=P	2.098	7.182	.173	8.896	8.94
Productive value, 93.6 lbs. 8 per cent	.936P	2.098	7.182	.173	8.896	8.94
Productive value, 6.4 lbs, hulls	.064K	.005	.020	—.175	.164	.02
Productive value, total 100 lbs	R	2.103	7.202	0	9.060	8.96
Productive coefficient, 10 per cent fiber	R/S	.153	.540	0	.211	.654
Productive value, 77.4 lbs, 8 per cent	.774P	1.73	5.94	.142	7.36	7.39
Productive value, 22.6 lbs., hulls	.226K	.02	.07	—.620	.58	.08
Productive value, total	T	1.75	6.01	—.478	7.94	7.47
Productive coefficient, 15 per cent fiber	T/D	.147	.536	—.032	.196	.626
Productive value, 67.7 lbs., 8 per cent	.677P	1.52	5.19	.13	6.43	6.47
Productive value, 32.3 lbs., hulls	.323K	.03	.10	—.88	.83	.11
Productive value, total	U	1.55	5.29	—.75	7.26	6.58
Production coefficient, 18 per cent fiber	U/E	.142	.533	—.042	.185	.604
Productive value, 61.3 lbs., 8 per cent	.613P	1.37	4.70	.07	5.83	5.85
Productive value, 38.7 lbs., hulls	.387K	.03	.12	—1.06	.99	.14
Productive value, total 100 lbs	V	1.40	4.82	—.99	6.82	5.99
Production coefficient 20 per cent fiber	V/F	.138	.530	—.048	.178	.588

The productive values and digestible protein of the average rice brans and rice polish are given in Tables Nos. 17 and 19, in connection with the average composition. Table No. 16 also shows the composition of the rice bran collected in connection with these studies.

Excluding 9618, which contains an excess of hulls, the mixed bran samples collected vary in digestible protein from 7.32 to 9.78 pounds in 100 pounds, and the productive values from 15.61 to 20.42 pounds per 100 pounds. This is quite a decided variation in feeding value, especially in productive value.

The averages for the rice bran (Table No. 17) vary from 7.12 to 8.46 pounds digestible protein in 100 pounds, and from 14.85 to 18.24 pounds productive value expressed as fat. This is also a decided average variation in feeding value. Some of the samples included in the averages were adulterated with hulls.

The variations are due chiefly to variations in fat and crude fiber. Increase in crude fiber decreases the feeding value; increase in fat increases the feeding value.

The average digestible protein in rice polish (Table No. 19) varies from 7.75 to 8.90, and the productive value from 19.55 to 20.74. The rice polish does not, therefore, vary in average yearly composition as much as does the rice bran, and it has a higher productive value.

Calculation of Production Coefficients.—The method of calculating the production coefficients of various grades of rice bran is as follows (see Table No. 21):

Starting with rice bran containing 12 per cent. fiber, and of the assumed average composition (L), we estimate that it contains in 100 pounds, 12.9 pounds hulls of the composition (B). Subtracting the constituents calculated to be present in this quantity of hulls from the constituents in 100 pounds bran (L), we have 87.1 pounds residue, containing the nutrients (C), which, calculated to 100 pounds, gives the composition of rice bran assumed to contain 8 per cent. crude fiber, to be A = C, as given in the table.

87.1

The composition of other grades of rice bran are then calculated on the basis of the quantity of hulls (B) and of bran containing 8 per cent. fiber (A), necessary to give the desired fiber content.

Next, using the production coefficients found for 12 per cent. fiber bran (H) and for hulls (I), the productive values of 12 per cent. fiber bran (HL) and of hulls (IB=K), are calculated.

Then from the productive values of each constituent of 100 pounds of 12 per cent. bran (HL), we subtract the productive value of each constituent in 12.9 pounds hulls (.129K). The residue (M) shows the productive value of each constituent of the quantity (C), and dividing M by C, we obtain the production coefficients of the constituents of 8 per cent. fiber bran (M/C). The productive values of each constituent in 100 pounds (P) is secured by dividing M by .871.

The production coefficients of the other grades are now secured by using the production coefficients (P) of the 8 per cent. bran. Thus for 10 per cent. fiber bran, we calculate the productive values of 93.6 pounds of 8 per cent. bran (.936P) and add the productive value of

6.4 pounds hulls (.064K). The sum is the productive value of the constituents of 10 per cent. bran of the composition S, and by dividing by S, we secure the values for the production coefficients of 10 per cent. fiber bran (R/S). See Table No. 21.

The productive values of the other grades are secured in the same way.

THE EXTRACTION OF FAT FROM RICE BRAN.

Rice bran contains fairly large quantities of fat, and rice huller bran still larger percentages. The matter of extracting this fat commercially has been considered. In order to extract the oil, it would be necessary to erect a separate plant and take it out by means of gasoline or some other solvent. It is hardly likely that such arrangements in connection with a rice mill would give satisfactory results. This process is somewhat expensive. It is also claimed that the oil is suitable only for the purpose of making soap. A plant was erected at Crowley, Louisiana, for the purpose of extracting the fat from rice bran, but for some reason or other the venture did not prove profitable and the project was abandoned.

MINERAL CONSTITUENTS OF BY-PRODUCTS.

Table No. 22 shows the mineral constituents of the by-products analyzed in connection with this investigation, variable numbers being averaged. See Table No. 26 for details.

TABLE 22.—AVERAGE COMPOSITION OF RICE BY-PRODUCTS.

	Phosphoric acid.	Potash.	Insoluble ash.	Lime.	Magnesia.	Reducing sugar.	Di. sugar.	Pentosans.
Hull ashes	0.57	0.58	96.97	.57	0.12	.....	.....	.....
Stone bran	1.39	0.61	.....	.16	0.52	0.78	1.15	13.87
Huller bran	3.47	1.42	.....	.12	1.21	1.20	4.51	7.76
Cone meal	3.19	1.58	.....	.09	1.21	1.55	2.15	5.81
Mixed bran	2.84	1.09	.....	.13	0.93	1.71	3.12	10.13
Hulls	.....	0.24	.....	.11	0.09	0.24	0.43	18.14
Polish	1.73	0.66	.....	.09	0.62	1.27	2.26	3.47

The mixed bran contains on an average 2.84 per cent. phosphoric acid and 1.09 per cent. potash. There is also present 2.18 per cent. nitrogen. With phosphoric acid and potash at 6 cents and nitrogen at 20 cents, the mixed rice bran would have a fertilizer valuation of $13.43 per ton. Spoiled rice bran, unsuitable for feeding, could thus be used for fertilizing purposes.

By properly saving the manure, it ought to be possible to recover from 50 to 75 per cent. of the fertilizing value of rice bran. In order to do this, the liquid manure must be saved as well as the solid manure. If one-half of the fertilizing value were saved, this would represent $6.72 for each ton of rice bran fed, a value well worth saving.

Rice polish would have a fertilizer valuation of $10.89 per ton if we use the same valuations as those above. It contains on an average 2.00 per cent. nitrogen.

Rice by-products contain more magnesia than lime. This is evident in all the analyses, except those of the hulls.

SUGARS AND PENTOSANS.

See Table No. 22 for averages, and Table No. 26 for details. The mixed bran is richest in reducing sugars, perhaps on account of the inversion of some of the disaccharoses. The huller bran is richest in disaccharoses. The hulls contain the most pentosans, as might be expected from their woody nature. The by-products (except hulls) are also rich in starch, which was not determined in this work.

DUST.

Analyses of various samples of dust are given in Table No. 23. These samples are all high in ash and insoluble ash, with the exception of that from the aspirator on stone bran reel, showing the presence of considerable amounts of dirt. They are also low in protein and

TABLE 23. DUST.

Laboratory No.		Protein.	Ether extract.	Crude fibre.	Nitrogen free extract.	Water.	Ash.	Insoluble ash
9617	From rough dryers, Blue Rose	5.58	2.56	16.03	25.50	7.37	32.96	29.58
9827	Honduras	9.68	3.08	27.28	32.00	9.01	18.95	17.69
9836	From chaff grinder	4.97	1.80	22.40	25.67	7.05	38.11	36.21
9896	From rough monitor, Honduras	6.46	4.12	19.83	36.29	8.80	24.50	21.75
9865	Dust	4.73	2.05	30.12	30.66	8.24	24.20	22.59
9889	Dust	6.15	2.46	29.01	31.87	7.51	23.00	21.61
11186	From cyclone from rough rice shaker	3.69	1.97	24.31	30.55	8.16	31.32	29.42
11191	From aspirator on stone bran reel	12.00	13.48	13.96	39.58	9.50	11.48	5.57
11203	From cyclone from rough rice shaker	3.94	1.10	18.94	24.64	7.19	44.19	42.11
	Average (9)	6.36	3.62	23.54	30.76	8.09	27.63	25.17

fat, and high in fiber, showing the presence of much woody material. On account of the quantity of dirt, the high fiber, and the low feeding value shown thereby, the dust from rough rice must be considered of very inferior feeding value and not at all a desirable feed.

The addition of such dust to rice bran or other rice by-products, must, therefore, be considered as a serious adulteration. The presence of this dust in a feed is highly objectionable.

MISCELLANEOUS.

Table No. 24 shows analyses of some miscellanous samples.

The fiber and insoluble ash in the chits going to the hullers show the presence of rice hulls.

Light rice consists largely of hulls and has a low feeding value. The same is true of immature rice, which is another name for the same thing. Light rice, ground, and separated partly from the hulls,

TABLE 24. MISCELLANEOUS.

Laboratory No.		Protein.	Ether extract.	Crude fiber.	Nitrogen free extract.	Water.	Ash.	Insoluble ash.
11185	Chits, goes to huller	8.69	4.88	10.88	57.78	10.93	6.84	4.90
11197	Light rice	5.44	1.96	34.57	32.68	7.74	17.61	16.31
11199	Light rice tailings	6.78	1.77	25.11	32.06	7.28	27.00	21.55
11201	Immature rice	7.45	1.88	20.70	47.48	8.53	13.96	12.33
11202	Chits going into huller	8.94	7.22	8.49	56.94	10.52	7.89	5.03
11200	Huller bran from huller receiving chits	9.81	10.32	20.45	39.73	7.15	12.54	9.04
11215	Light rice after being ground	4.75	2.70	35.30	30.07	9.06	18.12	16.86
11216	Light rice, tailings discarded	2.75	0.94	42.34	25.89	9.26	18.82	17.82
	Average	6.83	3.96	24.73	40.32	8.81	15.35	12.98

consists chiefly of rice hulls. The addition of light rice to rice bran is, therefore, practically equivalent to adulteration with rice hulls.

RICE HULL ASHES.

Rice hull ashes consist chiefly of silica and contain little plant food. Analyses of several samples are given in Table No. 25. They contain, on an average, in 100 pounds, 0.58 pound phosphoric acid and 0.57 pound potash. If we assume a valuation of 6 cents a pound for phosphoric acid and 6 cents for potash, the valuation per ton would be

TABLE 25. HULL ASHES.

Laboratory No.		Insoluble ash.	Lime.	Magnesia.	Potash.	Phosphoric acid.
9610		97.85	.24	.01	.08	.36
186					.62	1.73
193					.80	.21
191					.71	.41
9564		95.28	.90	.23	.39	.44
11221					1.01	.20
11379					.35	.60
11380					.71	.63
	Average	96.97	0.57	0.12	0.58	0.57

$1.38. This would be above the normal value, as all the phosphoric acid is not available. If we assume a valuation of 40 cents for potash (which price has been reached under war conditions), the rice hull ashes would have a valuation of $5.26 per ton. Polish at 40 cents a pound is, however, entirely too expensive to use as a fertilizer, and we consider the first valuation ($1.38 per ton) to represent more nearly the fertilizing value of the ashes. Although this value is low, farmers

could afford to haul the ashes home, if they were given to them, when their wagons would otherwise return empty.

TABLE 26. MISCELLANEOUS.

Laboratory No.		Lime.	Magnesia.	Potash.	Phosphoric acid.	Pentosans.	R. Sugar.	Di. Sugar.
	Stone Bran.							
9590		.15	.52	.72	1.55	10.43	.82	2.36
9613		.13	.70	.....	.....	.....	.....	.....
9602		.20	.47	.60	1.21	13.77	.48	.50
9476		.21	.43	.60	.50	14.53	1.04	.59
9823		.13	.41	.....	1.10	16.44	.....	.....
9857		.15	.46	.....	.....	15.37	.....	.....
9846		.11	.38	.52	.....	16.60	.....	.....
9907		.17	.38	.....	.....	14.61	.....	.....
9887		.17	.92	.....	.....	13.37	.....	.....
11152		.....	.....	.....	1.32	12.02	.....	.....
11153		.....	.....	.....	1.13	14.48	.....	.....
11154		.....	.....	.....	1.74	12.01	.....	.....
11155		.....	.....	.....	1.67	12.85	.....	.....
11156		.....	.....	.....	1.75	.....	.....	.....
11157		.....	.....	.....	1.06	.....	.....	.....
11166		.....	.....	.....	.....	.....	.....	.....
11168		.....	.....	.....	1.48	.....	.....	.....
11169		.....	.....	.....	1.19	.....	.....	.....
11179		.....	.....	.....	2.33	.....	.....	.....
	Average	.16	.52	.61	1.39	13.87	.78	1.15
	Cone Meal.							
9593		.11	1.10	1.18	2.96	4.54	1.34	3.43
9483		.10	1.10	1.08	2.49	4.90	1.48	2.35
9820		.06	1.13	.....	3.59	8.99	.....	.....
9859		.01	1.29	.....	2.35	5.65	.....	.....
9844		.....	.....	1.32	3.08	4.63	.....	.....
9899		.....	.....	1.08	.....	4.18	.....	.....
9884		.19	1.42	3.40	4.35	8.72	1.83	.66
11194		.....	.....	1.39	3.49	4.83	.....	.....
	Average	.09	1.21	1.58	3.19	5.81	1.55	2.15
	Bran from First Huller.							
9584		.12	1.29	1.51	3.48	7.60	1.02	4.04
9614		.....	.....	.....	3.26	.....	.....	.....
9606		.....	.....	1.28	3.22	.....	.....	.....
9648		.10	1.16	.....	3.57	6.67	.64	5.09
9828		.12	1.06	.....	3.40	7.15	.....	.....
9858		.14	1.39	.....	4.44	8.15	.....	.....
9834		.12	1.17	1.46	3.91	8.48	.....	.....
9904		.17	1.13	.....	3.35	7.71	.....	.....
9886		.10	1.26	.....	3.28	.....	1.93	.....
11158		.....	.....	.....	3.44	7.65	.....	.....
11159		.....	.....	.....	3.14	8.08	.....	.....
11160		.....	.....	.....	3.38	7.91	.....	.....
11161		.....	.....	.....	3.41	8.04	.....	.....
11170		.....	.....	.....	3.37	.....	.....	.....
11171		.....	.....	.....	3.69	7.82	.....	.....
11172		.....	.....	.....	3.23	.....	.....	.....
11173		.....	.....	.....	3.39	.....	.....	.....
11178		.....	.....	.....	3.03	.....	.....	.....
11180		.....	.....	.....	4.05	.....	.....	.....
	Average	0.12	1.21	1.42	3.47	7.76	1.20	4.57

TABLE 26. MISCELLANEOUS—Continued.

Laboratory No.		Lime.	Magnesia.	Potash.	Phosphoric acid.	Pentosans.	R. Sugar.	Di. Sugar.
	Mixed Bran.							
9618		.16	.92	.....	.....	11.80	.....	.....
9601		.13	.83	1.09	2.75	7.69	1.54	2.03
9646		.14	1.14	.....	3.36	8.43	.....	.....
9479		.13	.83	1.07	2.21	14.39	1.63	1.71
9845		.....	.....	1.12	.....	.....	.....	.....
9883		.10	1.28	.....	.....	.....	1.97	5.58
9860		.03	.99	.....	.....	.....	.....	.....
11145		.14	1.00	.....	2.85	8.74	.....	.....
11147		.18	1.28	.....	3.43	9.79	.....	.....
11148		.12	.88	.....	2.33	9.92	.....	.....
11149		.14	1.04	.....	3.01	.....	.....	.....
11162		.....	.....	.....	3.07	.....	.....	.....
11163		.....	.....	.....	2.58	.....	.....	.....
11164		.....	.....	.....	2.52	.....	.....	.....
11165		.....	.....	.....	2.08	.....	.....	.....
11177		.....	.....	.....	3.87	.....	.....	.....
11146		.14	.79	.....	.....	10.27	.....	.....
	Average	.13	.93	1.09	2.84	10.13	1.71	3.12
	Hulls.							
9585		.14	.10	.30	.32	19.13	.10	.44
9611		.13	.12	.....	.....	19.66	.....	.....
9608		.11	.17	.25	.31	18.26	.08	.49
9642		.13	.09	.....	.13	18.00	.....	.....
9477		.10	.11	.27	.36	17.30	.33	.32
9818		.09	.08	.....	.....	19 04	.....	.....
9850		.09	.05	.23	.....	16.98	.....	.....
9835		.11	.06	.16	.....	19.66	.....	.....
9902		.11	.04	.....	.....	19.40	.....	.....
9880		.11	.14	.....	.....	17.12	.46	.56
11193		.....	.....	.....	.....	17.72	.....	.....
11205		.....	.....	.....	.....	15.26	.....	.....
9839		.13	.07	.21	.....	18.24	.....	.....
	Average	.11	.09	.24	.28	18.14	.24	.45
	Polish, Brush.							
9586		.09	.45	.48	1.16	3.38	.85	1.61
9615		.....	.....	.....	.....	.....	.....	.....
9605		.10	.80	.78	2.33	3.43	1.40	2.20
9641		.....	.....	.....	2.63	.....	.....	.....
9484		.06	.22	.55	1.21	3.06	.84	1.70
9826		.....	.....	.....	.....	.....	.....	.....
9852		.07	.72	.92	1.54	3.79	.....	.....
9837		.....	.....	.55	1.49	3.22	.....	.....
9908		.....	.....	.....	.....	.....	.....	.....
9888		.13	.90	.....	.....	3.93	1.99	3.52
	Average	.09	.62	.66	1.73	3.47	1.27	2.26

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SUMMARY AND CONCLUSIONS.

1. A description of the process of rice milling is given.

2. Milling of rice partly removes phosphoric acid, potash, vitamines, and other constituents of the rice, and gives it a whiter and more attractive appearance.

3. Rice has a high food value, and is used almost exclusively as a food by some Eastern nations.

4. Brown rice has a brown color, with perhaps some greenish immature grains, and consists of the rice that has not been milled to remove the outer coating. It is richer in phosphoric acid and vitamines than polished rice, and its use cures or prevents certain diseases consequent on the almost exclusive use of polished rice. White rice cooks better and has a different taste.

5. Chicken feed, or rough rice screenings, contains chiefly weed seeds, broken rice, and dirt, and is variable in composition.

6. So-called stone bran is the sifting from rice hulls and rice, and consists largely of rice hulls, with some rice bran, germ, and broken rice.

7. Stone bran from Blue Rose rice contains more fat and more fiber on an average than that from Honduras rice.

8. Rice hulls also get into rice bran with the so-called chits.

9. Huller bran, or rice bran removed by the huller is rich in protein and fat and is practically free from hulls.

10. Rice hulls have a very low feeding value, but there is no evidence that they are actually poisonous or injurious to animals.

11. The rice bran on the market consists of a mixture of huller bran, cone bran, and stone bran. The addition of hulls, immature rice, inferior stone bran, excessive amounts of stone bran, chicken feed, dust, or any other milling by-product, is an adulteration.

12. Tables are given showing composition and productive values of rice bran and rice polish. These two products compare favorably with corn.

13. A method is given for calculating the hull content from the fiber content.

14. The production coefficients vary with the grade of the product, and so does the productive value and the digestible protein.

15. The extraction of fat from the rice bran has not been commercially successful.

16. Mineral and sugar contents of rice and its by-products are given.

17. Dust from rough rice contains much dirt and hulls, and its presence in a feed is highly objectionable.

18. Light rice consists chiefly of hulls, and the addition of light rice or the grindings from it, to rice bran, is an adulteration.

19. Rice hull ashes consist mostly of silica and have an average fertilizer valuation of $1.38 per ton.