to decrease with increasing molecular weight of the N-substituent, with the unsubstituted or N-methyl maleimide being the most active. The addition of a methyl radical to the succinimide nucleus has little effect, as the methylsuccinic imides are as inactive as the succinimides.

In contrast to Actidione, a substituted glutarimide, glutarimide itself is inactive as a repellent, and addition of an N-substituent seems to have little beneficiating effect.

Summary

Synthesis of thiouronium compounds and cyclic imides was undertaken to determine efficacy of these classes of compounds as rodent repellents. Nearly all thiouronium compounds were highly repellent, but the addition of another functional group appeared to reduce biological activity. Ten cyclic imides effectively decreased rodent consumption of treated food, and the repellent activity is attributed to the imide configuration. Activity of the imide group is affected by changes in molecular weight or spatial configuration of other portions of the molecule.

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CEREALS IN NUTRITION

Nutritive Value of Rice Germ

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Because little is known of the nutritive value of rice germ, a study was made, using the albino rat as the experimental animal. Data were obtained on the protein efficiency of rice germ in comparison with milled rice, the value of the proteins of rice germ supplementing those of milled rice, and the amino acid, vitamin, and mineral content of rice germ. The high nutritive value of rice germ merits its introduction for human foods and for animal feeds.

The nutritive value of wheat germ and corn germ has been well investigated. Both germs are good sources of high quality protein, ranging from 18 to 35%, depending on treatment before milling, type of milling process, and the variety of wheat and corn. Wheat germ is equal to the proteins of skim milk and boiled egg white, and wheat germ protein and casein are equally effective in supplementing diets low in protein (*2*). Similar values can be expected from germs or embryos from other cereals like rice, and an investigation was started to establish the nutritional value of rice germ.

The rice grain is made up of the hull, the seed coat (pericarp), the starchy endosperm, and the embryo or germ (*15*). The rice germ is situated at one end of the kernel and consists of five different parts—epiblast, coleorhiza, plumule, radicle, and scutellum. The scutellum is the most important from the vitamin standpoint.

By means of suitable milling equipment rough rice is separated into milled rice, hulls, bran, and polish. The milled or white rice is usually marketed for human consumption; rice bran and rice polish are used in the feeding of livestock, and the hulls are used as abrasives, as conditioners for commercial fertilizers, in the manufacture of furfural, and in Europe and the Orient for fuel to run the mills. One of the first products obtained in milling is so-called first-break bran, which is composed mainly of embryo and outer layers of the rice kernel. It is rich in members of the vitamin B complex, especially thiamine, riboflavin, and niacin, and in protein. The inner seed coat layers along with some starchy material compose rice polish.

Earlier studies on rice germ were mainly concerned with the protein, fat, ash, and fiber content (*5*). Studies on enzymes, sugar, and phosphorus compounds have also been reported (*9, 10*). Altson and Simpson (*1*) first drew attention to the fact that about 50% of the thiamine in the rice grain is concentrated in the embryo, which comprises only 2% of the whole kernel. Detailed studies by Hinton (*6*) confirmed this observation. He dissected out the various parts, analyzed them, and found that 44 to 50% of the total thiamine of the rice grain was located in the scutellum, which contained only 2% of the nicotinic acid (*7*). The germ as a whole contained 50% of the thiamine and 3% of the niacin; 81% of the niacin was found in the pericarp and aleurone portion. It is apparent, then, that the distribution of niacin in the rice grain is different from that of thiamine.

Simpson (*12*), using a photographic method, confirmed that the highest concentration of both thiamine and riboflavin exists in the germ; thiamine is largely concentrated in the scutellum, and riboflavin is more uniformly distributed throughout the tissues of the embryo. He also used this method in a study of distribution of thiamine in parboiled rice grains and observed that considerable diffusion of thiamine into the endosperm took place.

Small amounts of rice germ were obtained by carefully dissecting the germ from the whole grain with the aid of a small dissecting knife. Six hundred grains of short grain California rice (Caloro variety) yielded 17 grams of rice germ or 2.83%, which contained 65 γ of thiamine per gram and 17% protein. Average value for rice bran is 22 γ of thiamine per gram and 12% of protein.

Table II. Relative Efficiency of Proteins in Milled Rice and Rice Germ and Supplementary Value of Proteins in Rice Germ to Those in Milled Rice

(Experimental period, 10 weeks. 6 males and 6 females in each group. Average results per animal)

Ration	Type of Ration	Gains in Body Weight, G.	Gains in Body Weight, %	Protein Intake, G.	Protein in Rations, %	Protein Efficiency Ratio[a], G.	Protein Efficiency Ratio[a], Increase, %
1	Milled rice	80	...	45.4	5.7	1.76 ± 0.08[b]	...
2	Milled rice + 5% rice germ	103.8	29.7[c]	39.4	5.7	2.63 ± 0.11	49.4
3	Rice germ	105.0	31.2[c]	40.6	5.7	2.59 ± 0.06	47.1
4	Rice germ	114.0	...	60.0	9.0	1.90 ± 0.10	...

[a] Gains in body weight per grams of protein intake.
[b] Standard deviation of means.
[c] Significant for P = 0.05.

Table III. Biological Value of Milled Rice and Rice Germ as Determined by Nitrogen-Retention Method

(*Ad libitum* feeding. 24 animals on ration 1; 12 animals on ration 2. Protein in ration 5.70%. Average results per animal)

Ration	Type of Ration	Biological Value[a]	True Digestibility[b]	Net Utilization[c]
4	Rice germ	78.1 ± 1.3[d]	86.9 ± 0.43[d]	67.8
1	Milled rice	61.4 ± 1.7	96.9 ± 0.70	59.5

[a] % of absorbed nitrogen retained in animal body.
[b] True coefficient of digestibility obtained by subtracting nitrogen lost in feces from total nitrogen intake and dividing by 100.
[c] Obtained by multiplying true coefficient of digestibility by biological value and dividing by 100.
[d] Standard deviation of means.

Table I. Composition of Rations

	Ration, Grams 1	2	3	4
Milled rice	870	756	...	...
Rice germ	...	50	382	603
Cellu flour	20	20	20	20
Sure's salts No. 1 (*13*)	40	40	40	40
Vegetable shortening	40	40	40	40
Corn oil + vitamin mixture[a]	10	10	10	10
Sucrose + biotin mixture[b]	10	10	10	10
Sucrose–vitamin B complex[c]	10	10	10	10
Cerelose	...	64	488	267

[a] Containing DL-α-tocopherol 5.0 grams; fish liver concentrate 220,000 I. U. vitamin A per gram, 2275 grams; Delsterol 200,000 A.O.A.C. units of vitamin D_3 per gram, 0.375 gram; corn oil to a total of 500 grams.
[b] 20 mg. of D-biotin, sucrose to a total of 1000 grams.
[c] Thiamine chloride HCl 250 mg.; riboflavin 500 mg.; pyridoxine hydrochloride 250 mg.; calcium pantothenate 2.50 grams; nicotinic acid 1 gram; *i*-inositol 20 grams; choline chloride 50 grams; folic acid 10 mg.; *p*-aminobenzoic acid 500 mg.; 2-methyl-1,4-naphthoquinone 250 mg.; sucrose to a total of 1000 grams.

Separation of rice germ from rice bran particles is based on differences in density and particle size. A value of 1.29 was found for the density of first-break bran and 0.90 for that of rice germ.

Attempts to separate rice germ from rice bran were made using the Ro-Tap electric sieve shaker (Green Bros., Inc., Dallas, Tex.), which separates particles according to size and weight. This machine, using sieves of different mesh, yielded an end product containing 38 γ of thiamine per gram.

The Cyclon separator dust classifier (manufactured by Federal Classified Systems, Inc., Chicago, Ill.) separates lighter particles from heavier particles according to weight and uses an air current. Material containing 40 γ of thiamine per gram was obtained when this machine was employed.

The new Oliver Hi-Cap gravity separator (manufactured by Oliver Manufacturing Co., Rocky Ford, Colo.) for production of wheat germ was employed for the production of rice germ. One hundred pounds of first-break rice bran was separated in this machine in four fractions, labeled original bran, germ product, bran, and grits. Samples of this material contained 21.0, 17.0, 33.0, and 5.0 γ of thiamine per gram, respectively. Apparently the new "bran" product contained the germ material. When the bran was then put through screens of different mesh in the laboratory, a product containing 45 γ of thiamine per gram was obtained which was retained on a 40-mesh screen but went through a 20-mesh screen. The rice millers can therefore obtain a bran product containing 45 γ of thiamine per gram by using the Hi-Cap gravity separator, followed by further separation with 20- and 40-mesh screens.

Large batches of rice germ, containing 70 γ of thiamine per gram, were obtained from Japan, where rice germ is produced on a large scale as a by-product in the extraction of rice oil from rice bran. The germ is separated from the extracted bran with simple air-blowing equipment. Attempts are now being made to produce rice germ on a large scale at The Wonder Rice, Inc., Houston, Tex., where is extracted rice oil from bran.

In Italy rice germ is produced using a floating process (personal observation in Riseria Gariboldi, Via Pienza N20, Milan, Italy). The lighter rice germs float closer to the top and the heavier bran particles sink to the bottom. Rice germ from Italy contained somewhat less thiamine, probably because the final product is not entirely pure rice germ.

Experimental Procedure and Results

Growth and supplementary value, biological value, and true digestibility were determined in studies of growth and metabolism using albino rats as experimental animals, fed rice rations containing 5.7% protein. All rations were supplemented with adequate amounts of salts and vitamins and the animals were fed ad libitum for 70 days in the growth experiments. Twelve animals, six males and six females, were fed each ration in the growth studies, and in the metabolism studies 24 animals were employed. In the supplementary ration an equivalent amount of the proteins of milled rice was replaced by 5% of rice germ, leaving the protein level at 5.7%. The composition of the rations is given in Table I. The water-soluble and fat-soluble vitamins used in the rations were those of Schultze (*11*). The protein in all rations was at the 5.7% level, except in ration 4, which was 9%. The protein content of the other ingredients was: milled rice 6.55%, rice germ 14.93%.

The results of growth experiments are given in Table II and those of the metabolism experiments in Table III.

From the gains in body weight per gram of protein intake the protein efficiency ratios were calculated and the results in Table II are expressed as average growth per animal during a 10-week experimental period.

Table II indicates that when rice germ replaced an equivalent amount of protein of milled rice, the animals showed a 29.7% increase in body weight and a 49.4% increase in protein efficiency ratio (ration 2). An increase of 31.2% in growth and of 47.1% in protein efficiency was found in animals fed ration 3 containing 5.7% protein derived from rice germ alone, which indicates that rice germ has better nutritive values than milled rice at that level of protein intake. These differences were tested statistically and found to be significant for P --- 0.05. Animals fed ration 4 at a 9% rice germ protein level made an average gain of 114 grams and the protein efficiency ratio was 1.90, which is less than at the 5.7% level. This decreased protein efficiency at the higher level can be explained by the greater protein intake per gram gain of body weight.

Table IV. Determination of Amino Acids

	In Rice Germ, %	*In Milled Rice (8),* %
Arginine[a]	1.56	0.75
Aspartic acid	1.31	. . .
Cystine	0.17	. . .
Glutamic acid	1.25	. . .
Glycine	1.03	. . .
Histidine[a]	0.43	0.23
Isoleucine[a]	0.63	0.33
Leucine[a]	0.84	0.60
Lysine[a]	1.71	0.20
Methionine[a]	0.42	0.21
Phenylalanine[a]	0.75	0.39
Proline	0.87	. . .
Serine	0.93	. . .
Threonine[a]	2.18	0.30
Tryptophan[a]	0.27	. . .
Tyrosine	0.93	. . .
Valine[a]	0.94	0.49

[a] Nutritionally essential.

Table III shows that rice germ at a 9% protein level has a biological value of 78.1%, which is a fairly good value.

Amino Acid Content Amino acids were determined in protein extracts of hydrolyzed rice germ, 2 grams of which were hydrolyzed for 16 hours at 15 pounds pressure with 50 ml. of 3N hydrochloric acid in 125-ml. Erlenmeyer flasks which were covered with small beakers. The amino acids were determined by the detailed technique described by Barton-Wright (*4*) using biological micro procedures. *Lactobacillus arabinosus* 17-5 was used to determine leucine, valine, isoleucine, and tryptophan. *Streptococcus faecalis* R was employed for the determination of arginine and threonine. Lysine, glycine, methionine, glutamic acid, aspartic acid, tyrosine, proline, cystine, phenylalanine, and serine were tested with *Leuconostoc mesenteroides* P-60. The results of the amino acid determinations expressed percentagewise, calculated on the air-dried samples, are given in Table IV.

It will be noted from Table IV that the content of essential amino acids in rice germs is considerably higher than in milled rice.

A number of vitamins were determined according to methods described by Barton-Wright (*4*)—thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxine, biotin, *p*-aminobenzoic acid, inositol, folic acid, and choline. Pantothenic acid (free and total) was determined by the new procedure of Toepfer (*14*). The results of these tests are given in Table V, which also contains data on calcium, phosphorus, iron, and other constituents, all determined by official methods (*3*).

Comparison with Wheat Germ and Corn Germ

Anderson (*2*) reports for wheat germ, a range of 19 to 44 γ of thiamine per gram, 5 to 12 γ of riboflavin, and 34 to 69 γ of niacin. For corn germ, a range of 25 to 35 γ of thiamine per gram, 6 γ of riboflavin, and 45 γ of niacin was found. The values of 5 γ of riboflavin and 33 γ of niacin for rice germ fall within the range reported for wheat germ and corn germ. The value of 65 γ of thiamine for rice germ is higher than those found for the other cereal germs.

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Table V. Vitamins and Other Constituents in Rice Germ

	γ/G.		%
Thiamine	65.0	Calcium	0.275
Riboflavin	5.0	Phosphorus	2.10
Nicotinic acid	33.0	Iron	0.013
Pantothenic acid	30.0 (total) 7.0 (free)	Available iron (61.5% of total)	0.008
Pyridoxine	16.0	Protein	14.93
Biotin	0 58	Fat	11.52
p-Aminobenzoic acid	1.0	Moisture	10.9
Inositol	3725.0	Ash	6.2
Folic acid	4.3		
Choline	3000.0		