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ABSTRACT

Garbage is the main feed for swine in the Territory of Hawaii because of the high cost of other concentrates commonly fed to hogs. An extensive study has, therefore, been made of the value of garbage as a feed for swine. This study has included experiments with weanling pigs, with growing and fattening pigs, with brood sows, and supplementary experiments with rats.

Analyses of 622 samples of military garbage and of 50 samples from a civilian cafeteria indicate that military garbage is ordinarily well balanced, at least in respect to nutritive ratio. That from the cafeteria was considerably lower in protein.

If some care is taken to select garbage free from excessive amounts of green, leafy vegetables or fat, good gains can be obtained when feeding military garbage to weanling pigs. Supplementing the garbage with cane molasses gave poor results even when a high-protein supplement was added. The combination of garbage and molasses is apparently too laxative.

In studies with growing and fattening pigs, it was found that military garbage has a replacement value of about 40 percent of a grain ration in producing a pound of gain. Excellent gains were obtained with fresh garbage supplemented with grass. No significant difference was observed in gains obtained with cooked and uncooked garbage. It is recommended that cooking of carefully sorted garbage be practiced to aid in the control of trichinosis. Dried or dried and degreased garbage is an unsatisfactory hog feed when fed in large quantities, apparently because of unpalatability. When the supplies of garbage are inadequate, molasses in amounts to 10 percent can be added to garbage fed to growing and fattening pigs. A longer feeding period would result, however, for the pigs would gain a little less rapidly.

In a study of the reproduction and lactation performance of brood sows, it was found that the mortality and weaning weights of the pigs whose dams received garbage and 1 pound of green grass daily were just as good as those of pigs whose dams received either a grain ration and garbage or a grain ration with 1 pound of grass. Supplementation of these rations with larger quantities of green grass produced slightly larger pigs at weaning, but the increase was not significant. In a second experiment poor growth of the suckling pigs resulted when cafeteria garbage was fed even when an abundance of alfalfa meal was also fed to supply vitamins of the B complex. These poor results were attributed to the low protein content of the cafeteria garbage. It was concluded that satisfactory results can be expected when garbage of good quality is fed to brood sows. It is well, however, to supplement the garbage with liberal quantities of green grass or alfalfa meal.

In the first brood sow experiment described above, milk samples were collected from some of the sows and were analyzed for fat. As the garbage (or fat) intake of the sows increased, the fat content of the milk also increased. The average fat percentage rose from 6.1 percent with the grain ration to 9.6 percent with the garbage ration. Observations made during the trial indicated, however, that the incidence of diarrhea among the suckling pigs in the garbage-fed lots was no higher than among those in the grain-ration lots.

In an experiment with rats, the following diets were compared: dried garbage alone, dried garbage and grass, dried garbage and yeast, and a standard rat-breeding diet. These diets were fed through growth, reproduction, and lactation with three consecutive litters. The rats grew better when receiving either the garbage and yeast or the standard diet than they did when receiving the others. Good reproduction was maintained on all diets. None of the diets containing dried garbage supported normal lactation, however, and it appears that a deficiency of several factors of the vitamin B complex was responsible. Since rats reproduced normally when receiving the dried garbage, it can probably be concluded that sows can do likewise on either fresh or dried garbage. Observations made in the University piggery and in other piggeries of the Territory support this conclusion. It would appear inadvisable, however, to recommend the feeding of dried garbage as a major portion of a ration for brood sows until additional information is obtained concerning its nutritive value for this species in relation to lactation.

INTRODUCTION

IN FEBRUARY, 1942, there were 32,000 hogs over 3 months of age in the Territory of Hawaii. During the war years the numbers increased to a figure of 60,000 in December, 1944. This increase resulted from the large amounts of garbage obtainable from military establishments and from the Territory's efforts to produce as much of its own food as possible. Since the end of the war in the Pacific the garbage supplies and the number of hogs have been decreasing. Whether the hog population will drop to pre-war levels will depend largely upon the numbers of army and navy men garrisoned in the Territory.

As suggested in the statements above, garbage is the main feed of swine in the Territory. Some grains and other imported concentrates are fed, especially to brood sows and weanling pigs, but hogs are grown out and fattened almost entirely on garbage. Garbage is ordinarily a cheaper source of nutrients than the other concentrates, which must be imported from the Mainland or foreign countries. With the long shipping distances involved, these latter feeds are actually too expensive to enable profitable hog production when they comprise the major part of hog rations.

Although some study of the value of garbage as a feed for hogs had been made at the University of Hawaii Agricultural Experiment Station prior to the war, extensive studies were initiated after the attack on Pearl Harbor. Such work was done in keeping with the policy of the Experiment Station to aid the food production program as far as possible. The information obtained would also be of value during years of peace in enabling the most efficient use of the garbage supplies. The investigations included work with brood sows, weanling pigs, growing and fattening pigs, and rats. The latter animals were utilized to obtain, cheaply and quickly, data which could serve as a guide when applied to swine.

Although parts of this work have been reported previously in progress notes published by the Experiment Station, this bulletin is written to bring together the results of these extensive investigations.

I. CHEMICAL COMPOSITION OF GARBAGE AND GARBAGE PRODUCTS

By L. A. Henke, S. H. Work, E. L. Willett, and C. Maruyama

Garbage varies greatly in chemical composition and nutritive value because of the different sources and great variety of materials composing it. Fishwick (*15*) states that garbage from a given source will vary a little from day to day, and that the big differences are among the sources. He classifies garbage into three grades. The poorest is obtained from residences. The better grades of garbage are obtained from restaurants, institutions, and military units. As pointed out by Woodman (*54*), municipal garbage is ordinarily of poorer quality. This is as one would expect, for it is largely derived from residences. Smith (*42*) states that quality varies with general economic conditions. Prosperity brings good garbage, and depression poor garbage. Woodman and Evans (*56*) mention that there are seasonal variations, especially in the case of garbage from homes. During the summer large amounts of vegetable residues are present.

TABLE 1. Chemical composition of garbage and garbage products as reported by various workers and as analyzed at the University of Hawaii. Where no treatment is given, the data are on the fresh basis.

SOURCE AND TREATMENT, IF ANY	SAMPLES REPRESENTED	PROXIMATE ANALYSIS						AUTHOR
		Moisture	Protein	Ether extract	Fiber	N-free extract	Ash	
	Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
As reported by other workers								
Municipal	7	75	3.93	2.89	1.16	14.37	2.65	Woodman and Evans (*56*)
Municipal*	1	70.0	6.5	7.0	----------	12.5†	4.0	Ashbrook and Wilson (*1*)
Municipal, processed	11	68.10	4.70	3.76	1.83	18.47	3.14	Woodman and Evans (*56*)
Municipal, tankage	1	4.96	15.38	18.26	8.98	36.59	15.83	Weaver (*47*)
Municipal, dried and balanced	1	10.26	24.80	10.98	7.82	29.76	16.38	Woodman and Evans (*56*)
Residences and hotels	36	88.34	2.10	1.41	0.72	6.16	1.27	Lovatt *et al.* (*32*)
Restaurant	Composite	67.15	5.19	7.30	0.78	17.73	1.85	Hultz and Reeve (*29*)
Restaurant	Composite	62.70	3.95	11.10	0.50	20.46	1.29	Hultz and Reeve (*29*)
Hotels	18	76.53	5.90	5.38	0.54	9.58	2.07	Thomas and Hargrave (*45*)
Restaurants	18	69.63	5.18	5.97	0.55	16.81	1.86	Thomas and Hargrave (*45*)
First-class cafe	18	79.22	2.66	3.59	0.70	11.79	2.04	Thomas and Hargrave (*45*)
Second-class cafe	18	68.99	4.73	6.47	0.98	16.56	2.27	Thomas and Hargrave (*45*)
Military*	----------	70.0	4.5–5.4	3.9–9.9	----------	9.3–20.7†	4.8–10.8	Ashbrook and Wilson (*1*)
Military	16	68.60	6.40	8.94	0.49	13.69	1.88	Woodman and Evans (*56*)
Military, dried and degreased	7	11.46	26.97	4.62	1.96	43.78	11.20	Ayres (*2*)

TABLE 1. (*Continued.*)

SOURCE AND TREATMENT, IF ANY	SAMPLES REPRESENTED	PROXIMATE ANALYSIS						AUTHOR
		Moisture	Protein	Ether extract	Fiber	N-free extract	Ash	
	Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
As analyzed in studies reported in this bulletin								
Military, 1942	159							
Average		69.91	6.77	9.36	0.62	11.91	1.43	
Range		68.44 to 72.10	5.90 to 7.55	8.08 to 11.64	0.44 to 0.97	10.87 to 12.86	0.95 to 1.61	
Military, 1943	156							
Average		69.11	7.46	8.67	0.69	12.08	1.99	
Range		65.30 to 74.10	5.22 to 9.73	6.44 to 10.99	0.39 to 1.11	9.91 to 14.51	1.45 to 2.44	
Military, 1944	137							
Average		68.91	6.43	9.46	0.56	12.87	1.77	
Range		63.70 to 71.80	4.40 to 8.42	6.67 to 13.39	0.42 to 0.80	11.38 to 15.18	1.42 to 2.97	
Military, 1945	170							
Average		71.32	5.33	8.55	0.57	12.78	1.45	
Range		68.4 to 74.7	3.77 to 6.47	0.92 to 12.70	0.42 to 0.96	9.51 to 23.02	1.17 to 1.80	
Military, 4-year average	622	69.87	6.47	8.99	0.61	12.41	1.65	
Military, dried and degreased	1	11.90	21.02	6.81	4.64	42.00	13.63	
University cafeteria	50	73.40	4.28	8.89	0.85	11.81	0.77	

* The analysis was reported on oven-dry basis. The figures presented here have been adjusted to a 70-percent-moisture basis.
† Apparently includes the value for fiber.

Proximate Analysis

A number of workers have presented analyses of garbage. These analyses are presented in table 1 to enable comparison with each other and with analyses of garbage fed in tests at the Hawaii Agricultural Experiment Station. The processed municipal garbage described by Woodman and Evans (*56*) was prepared by stirring and evaporating in a steam-jacketed kettle for 2 hours. The product was a thick, pasty mass. Their dried and balanced municipal garbage was balanced by adding fish residues. The garbage tankage analyzed by Weaver (*47*) was "a sterilized garbage product made from ground bones, meat scraps, vegetables, fruits, breads, fish meal, ground corn, bran and middlings."

In table 1 are also presented the analyses of garbage fed in the trials conducted at the Hawaii Station. All the military garbage fed in the trials since the early part of 1942 is represented. A sample was taken from each can or drum of garbage used in any experiment. Each sample was dried, and the samples collected during each month were composited and analyzed. The ranges presented in the table, therefore, actually represent the ranges of the analyses of the monthly composites. In 1942 there were 7 composite samples; in 1943, 10; and in 1944 and 1945, 12 each. The analysis of the cafeteria garbage represents four composites. The dried, degreased military garbage was air-dried, the fat removed with a commercial paint solvent, and the product then aerated. This degreasing procedure was developed at the Hawaii Station by Ayres (*2*).

Digestibility

Woodman and Evans (*56*) conducted trials with pigs to determine the digestibility of military garbage, processed municipal garbage, and dried, balanced municipal garbage. The digestion coefficients are presented in table 2. Two trials were conducted with each feed.

TABLE 2. Digestion coefficients of military garbage, processed municipal garbage, and dried, balanced municipal garbage as determined by Woodman and Evans (*56*).

SOURCE AND TREATMENT	DIGESTION COEFFICIENTS			
	Protein	Ether extract	Fiber	N-free extract
	Percent	*Percent*	*Percent*	*Percent*
Military, fresh	90.3	95.5	68.8	98.7
Municipal, processed	61.0	77.0	56.6	95.8
Municipal, dried and balanced	75.5	81.3	46.6	64.6

Additional information concerning the chemical composition of garbage, fresh and processed, is given by Smith (*42*) and Morrison (*38*). The latter also gives additional digestion coefficients.

Vitamins

That garbage may be low in vitamins A and D is suggested by Duck and Gilmore (*9*), who report that pigs fed garbage alone during the winter in the northern states may suffer from deficiencies of these vitamins.

Studies have been conducted at the Hawaii Agricultural Experiment Station to determine the effect of garbage feeding upon the B-vitamin con-

tent of pork.[1] In this work analyses were made of the thiamine content of the garbage. Sixteen samples of military garbage averaged 0.29 milligrams of thiamine per pound and 70.1 percent moisture.

Minerals

Several workers have reported analyses of calcium, phosphorus, and chloride in garbage or garbage products. These data are presented in table 3. On the assumption that most of the chloride is in the form of the sodium salt, the values for this element are expressed in the table as sodium chloride. In this table are also presented values for calcium and phosphorus as determined for the dried garbage used in the rat studies reported in section V of this bulletin.

TABLE 3. Calcium, phosphorus, and sodium chloride in garbage or garbage products.

SOURCE AND TREATMENT, IF ANY	SAMPLES	MOISTURE	Ca	P	NaCl	AUTHOR
	Number	*Percent*	*Percent*	*Percent*	*Percent*	
As reported by other workers						
Residences and hotels	36	88.34	0.11	0.07	.....	Lovatt *et al.* (*32*)
Municipal	7	75	.....	.....	0.30	Woodman and Evans (*56*)
Municipal, processed	11	68.10	0.21	0.10	0.40	Woodman and Evans (*56*)
Municipal, dried and balanced	1	10.26	3.33	1.47	1.20	Woodman and Evans (*56*)
Military	16	68.60	0.12	0.11	0.30	Woodman and Evans (*56*)
Military, dried and degreased	2	12.74	2.02	0.99	2.70	Ayres (*2*)
As analyzed in studies reported in this bulletin						
Military, dried	9	7.93	0.54	0.37	.....	

DISCUSSION AND CONCLUSIONS

Garbage as a whole is variable in composition. From an inspection of table 1 it appears that garbage from a given source will, ordinarily, not vary greatly. It is interesting to note that, in general, the protein content of the garbage analyzed at the University of Hawaii Agricultural Experiment Station decreased in protein content with the successive years. This fact may be explained by measures taken by military authorities to reduce food waste in their kitchens.

Using the protein content as a criterion of quality, it can be said that military garbage is superior, followed in order by that from civilian eating places, municipalities, and residences. The low quality of garbage from residences can probably be explained by the fact that thrifty housewives throw very little meat and other nutritious foods into the garbage can. In agreement with experimental evidence to be presented later in this bulletin, it appears from chemical analyses that military garbage is well balanced for most classes of swine as far as the ratio of protein to carbohydrate-equiva-

[1] Department of Nutrition. Manuscript in press.

lent is concerned. It would appear, therefore, that garbage from sources other than military in most cases would need to be supplemented by high-protein feeds. Demonstration feeding trials conducted by the Agricultural Extension Service in the Territory have indicated that such is the case with garbage from residences.

As pointed out by Woodman and Evans (*56*) good quality garbage is ordinarily low in fiber. They, therefore, recommend supplementing with roughage or with wheat middlings to avoid constipation.

The military garbage used by Woodman and Evans was highly digestible. The same can probably be said of military garbage in general, for it is ordinarily of high nutritive value with very small amounts of indigestible or inedible material if the kitchen wastes have been properly sorted at the military establishment. With processed garbage, the coefficients for fat and for nitrogen-free extract as determined by Woodman and Evans are similar to those given by Morrison (*38*). The coefficient for protein is considerably higher and that for fiber lower, however. The low digestibility of the dried and balanced municipal garbage is probably due to the presence of fish residues.

The amount of vitamin A in garbage would, of course, depend upon the amount present of green, leafy vegetables and other vegetables containing large amounts of the vitamin or of carotene. Since garbage is ordinarily low in fiber, it would be well to supplement with good quality roughages which would not only supply vitamins but would also prevent constipation.

The thiamine content of garbage is considerably lower, on an equal-moisture basis, than figures given by Hughes *et al.* (*28*) for grains and other concentrates commonly fed hogs. According to the requirements as given by Hughes and co-workers, garbage, however, contains enough for all classes of swine except, possibly, lactating sows. It would appear that garbage provides enough thiamine for growth, but not enough for maximum storage in the tissues. Studies conducted at the Hawaii Station[2] have shown that pork from garbage-fed hogs contains considerably less thiamine than pork from grain-fed hogs.

Some of the values for calcium and phosphorus in garbage as given in table 3 are below the amounts needed for swine according to the recommendations of Hughes *et al.* (*28*). The military garbage that has been fed to hogs in the Territory has apparently met requirements, for no symptoms of deficiencies have been observed by the authors among pigs in the University herd or in other herds in the Territory receiving garbage as the only concentrate. When garbage contains limited quantities of bones that are soft enough to be chewed and consumed, it would be well to supply additional calcium and phosphorus.

The quantities of sodium chloride in garbage are more than adequate to supply the needs of all classes of swine, according to the requirements outlined by Morrison (*38*).

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[2] See footnote 1, page 9.

II. GARBAGE AS A FEED FOR WEANLING PIGS

By E. L. Willett, L. A. Henke, and C. Maruyama

Although, as mentioned in the introduction to this bulletin, some grains and other imported concentrates are fed to weanling pigs in the Territory, considerable garbage is also fed. Because garbage is a cheaper source of nutrients, it would be profitable for the hog raiser to feed as much to his weanling pigs as feasible. In a survey of the literature the authors could find no data concerning the feeding of garbage to weanling pigs. Hunter (*30*) conducted trials with pigs starting at weaning weights, but the data presented cover the period from weaning weight to 200 pounds or more. Investigations were, therefore, initiated at the Hawaii Station to determine the value of garbage for weanling pigs.

EXPERIMENTAL

The first three trials were similar in that the following rations were compared in continuous feeding trials:

Lot I. Check ration 15
Lot II. Garbage only
Lot III. 90 percent garbage and 10 percent cane molasses

Ration 15 consisted of the following ingredients:

	Pounds	
Rolled barley	53	
Cane molasses	20	
Meat and bone meal	19	
Soybean oil meal	7	
Salt	1	
Total	100	
Estimated total crude protein		17.9 percent
Estimated nutritive ratio		3.7

In the three trials a total of 45 pigs began the trials. Each trial was continued until the most rapidly gaining lot averaged close to 70 pounds. Some selection was made of the garbage fed. Care was taken to avoid the occasional can of garbage containing large amounts of leafy vegetables or of fat.

The ration consisting of garbage and molasses was included in the comparisons because cane molasses is cheap and available in large quantities and because it was expected that after the end of the war, garbage supplies would decrease. If satisfactory growth could be obtained when feeding a combination of garbage and molasses, a greater number of pigs could be raised on a given amount of garbage than if garbage alone were fed. The pigs were hand fed to the limit of appetite. Each pig received 1 pound of fresh, green grass each day. In accordance with the regular practice followed when conducting feeding trials with swine at this Station, the pigs were weighed for 3 consecutive days at the beginning and end of the experiment, and single weighings were made at bi-weekly intervals during the trial. The averages of the weights taken on 3 consecutive days were used as the initial and final weights of the pigs.

TABLE 4. Comparison of results with weanling pigs fed a grain ration, garbage alone, and garbage with 10 percent cane molasses.

DATA TAKEN	TRIAL I			TRIAL II			TRIAL III			TOTALS AND WEIGHTED AVERAGES		
	No. 15	Garbage	Garbage and molasses	No. 15	Garbage	Garbage and molasses	No. 15	Garbage	Garbage and molasses	No. 15	Garbage	Garbage and molasses
Duration (*days*) . . .	63	63	63	63	63	63	42	42	42	56.7	57.7	56.5
Pigs beginning trial (*no.*)	6	6	6	5	5	5	4	4	4	15	15	15
Pigs completing trial (*no.*)	4	6	6	3	3	3	4	3	3	11	12	12
Average body weight (*lbs.*)												
Beginning	29.7	30.7	30.6	21.2	23.6	23.7	33.1	33.2	34.0	28.6	29.5	29.7
End	66.5	79.5	75.8	39.9	69.3	53.8	53.4	67.1	54.7	54.5	73.8	65.0
Gain (*lbs.*)												
Total	147.4	292.9	271.6	56.2	137.0	90.4	81.4	101.7	61.9	285.0	531.6	423.9
Average daily per pig .	0.58	0.77	0.72	0.30	0.72	0.48	0.48	0.81	0.49	0.47	0.77	0.61
Feed consumed (*lbs.*)												
Total	690	2975	2988	420	1174	1156	385	904	870	1495	5053	5014
Average daily per pig .	2.7	7.9	7.9	2.2	6.2	6.1	2.3	7.2	6.9	2.5	7.3	7.2
Pounds consumed per lb. gain												
Total feed	4.68	10.15	10.97	7.47	8.57	12.77	4.73	8.89	14.05	5.25	9.51	11.83
Total nutrients . . .	3.39	3.86	4.51	5.73	3.30	5.32	3.80	3.82	6.41	3.97	3.71	4.97
Total crude protein consumed per pig per day (*lbs.*) .	0.39	0.40	0.39	0.35	0.31	0.29	0.35	0.43	0.38	0.37	0.38	0.36
Feed cost per lb. gain (*cents*) *	15.1	5.1	5.6	24.1	4.3	6.5	15.2	4.4	7.2	16.9	4.8	6.0

* Feed prices used in this and the following tables were as follows: barley, $83.20 per ton; cane molasses, $12.80; wheat standard middlings, $63.00; soybean oil meal, $89.00; meat and bone meal, $58.00; salt, $48.00; bone meal, $56.80; linseed oil meal, $75.00; pineapple bran, $22.00; coconut oil meal, $65.00; garbage, $10.00; wheat, $106.20; skim milk powder, $75.00; and alfalfa meal, $72.40 per ton.

In these trials two pigs died because of an inflamed condition of the intestinal tract caused by foreign material in the garbage, and a number were removed because of necrotic enteritis. All data concerning these pigs are omitted from the results presented.

The results of the three trials are presented in table 4 (facing page). The best gains were obtained with the pigs receiving garbage alone, and these gains were fairly satisfactory. Ration 15 did not support growth as well as expected, and the pigs receiving the garbage and molasses combination also made inferior gains.

Because of differences in dry matter and fat contents of the three rations, the comparison of the amounts of feed consumed per pound of gain gives little information. In an attempt to compensate for these differences in table 4 the total nutrients[3] consumed per pound of gain are also presented. On this basis, it can be seen that the pigs receiving garbage utilized feed nutrients more efficiently than the others. The pigs receiving the garbage and molasses combination were especially inefficient.

Statistical analyses[4] of the individual average daily gains showed a highly significant difference between the garbage ration and ration 15 and a significant difference between the garbage ration and the garbage-molasses ration. The difference between the latter and ration 15 is not significant.

After the above three trials were completed, a fourth was conducted. Some modifications were made. Because powdered skim milk and alfalfa meal had become available, they were included in the check ration. The powdered skim milk had been condemned as human food by the army. Wheat replaced barley because the latter was unavailable at the time. In the new check ration no cane molasses was included. The ingredients and the amounts in the modified check ration, number 25, are given below:

	Pounds	
Ground wheat	66	
Soybean oil meal	14	
Meat meal	7	
Skim milk powder	7	
Alfalfa meal	5	
Salt	1	
Total	100	
Estimated total crude protein		19.2 percent
Estimated nutritive ratio		3.7

The third lot received 1¼ pounds of meat and bone meals with each 10 pounds of a mixture of 80 percent garbage and 20 percent molasses. This combination was calculated to provide the amounts of protein recommended by Morrison *(38)*. The pigs were, as in the previous trials, hand-fed to the limit of appetite. Each pig received 1 pound of green grass per day.

[3] Total nutrients=crude protein+fat×2.25+fiber+nitrogen-free extract. The total nutrient values presented in this bulletin, unless otherwise stated, are all based upon analyses of the feeds actually fed and do not include those present in the fresh, green grass.

[4] Statistical analyses of the data presented in this bulletin were carried out in accordance with the methods outlined by Snedecor *(43)*. The term "significant" is used to indicate a probability of less than 5 percent, and "highly significant" to indicate a probability of less than 1 percent that a difference is due to chance variation.

The results are presented in table 5.

TABLE 5. Results from trial IV with weanling pigs. Comparison of check ration No. 25, garbage alone, and garbage with cane molasses and meat and bone meals.

DATA TAKEN	RATION 25	GARBAGE	GARBAGE, MOLASSES, MEAT AND BONE MEALS
Duration (*days*)	42	42	42
Pigs beginning trial (*number*)	5*	5	5
Average body weight (*pounds*)			
Beginning	30.5	32.4	31.4
End	76.2	61.9	48.6
Gain (*pounds*)			
Total	182.8	147.2	86.2
Average daily per pig	1.09	0.70	0.41
Feed consumed (*pounds*)			
Total	573	1583	1088
Average daily per pig	3.41	7.5	5.2
Pounds consumed per pound gain			
Total feed	3.13	10.76	12.6
Total nutrients	2.79	3.55	5.5
Total crude protein consumed per day per pig (*lbs.*)	0.69	0.31	0.21
Feed cost per pound gain (*cents*)	15.0	5.38	6.4

* One pig died because of necrotic enteritis. All data concerning this pig were discarded.

The rates of gain of the pigs receiving garbage in this trial were similar to those in the previous trials. It would appear that ration 25 was much superior to ration 15 used in the preceding trials. Unsatisfactory gains were obtained when the garbage and molasses combination was fed, even though it was supplemented with meat and bone meal to provide additional protein. Because of a shortage of military garbage, part of that fed in this trial was from a cafeteria; so the average protein intake was lower than had been anticipated. The experiment could not be repeated because of this shortage.

Discussion and Conclusions

Good gains were obtained when garbage and grass were fed. The pigs receiving the garbage and molasses combination made inferior gains, however. Very likely the amount of protein in the ration was inadequate, for the percentage content of protein would decrease with the addition of molasses. When fed alone, the garbage provided approximately the levels of protein recommended by Morrison *(38)* for pigs of this size.

Unexpectedly poor results were obtained when feeding ration 15. This ration had been fed with good results in other trials conducted at this station *(49)*. It is possible that there had been some change in the quality of the ingredients. During the war variations were observed in the appearance and quality of soybean oil meal and meat and bone meal. The latter was produced at a local slaughterhouse.

In the fourth trial excellent gains were made with ration 25 and fairly good gains with the garbage alone. The pigs receiving the garbage and molasses combination, however, failed to make good gains even though these two feeds were supplemented with meat and bone meal. As suggested by the investigations conducted by Ferrin *(12, 13)* and by other trials with molasses conducted by workers cited by Willet and associates *(49)*, possi-

bly better results would have been obtained if some high-fiber feed, such as millrun or pineapple bran (also termed dried pineapple pulp), had been added as a fourth ingredient.

In general, these four trials did not give all the information desired because of necrotic enteritis and because of unexpectedly poor gains with ration 15. It is shown quite conclusively, however, that at least reasonably good gains can be expected when feeding garbage to weanling pigs, especially if care is taken to avoid the feeding of garbage containing excessive amounts of green, leafy vegetables or of fat. It also appears that garbage cannot be supplemented with cane molasses.

III. GARBAGE AS A FEED FOR GROWING AND FATTENING PIGS

By L. A. Henke, E. L. Willett, S. H. Work, and C. Maruyama

By far the largest use of garbage in the Territory, as well as elsewhere, is as feed for growing and fattening pigs at weights of 60 or 70 pounds and over. For this reason more study has been made of the value of garbage as a feed for growing and fattening pigs than for other classes of swine.

In this bulletin are reported the results from one feeding trial conducted in 1927 with garbage obtained from the University cafeteria and from a series of trials initiated in 1942 using garbage from military sources.

Review of Literature

Comparison of garbage with dry concentrate rations

A number of investigations have been conducted in the United States to determine the value of garbage from civilian mess halls, most of them operated by universities. In early trials conducted with growing and fattening pigs at the Arizona Agricultural Experiment Station by Williams and associates (*50, 51, 52, 53*), excellent gains were obtained when feeding garbage alone. In one trial (*52*) the rate of gain was increased by supplementing the garbage with alfalfa. In these investigations, however, no control lots receiving well-balanced grain rations were included; so the garbage cannot be definitely evaluated on a comparative basis. Thompson (*46*) compared garbage fed alone with four rations consisting of different cereal grains and tankage. Each lot included 10 pigs. The rate of gain of the pigs receiving garbage was greater than that of any of the other four lots. The fresh garbage had from 35 to 57 percent (average 44 percent) of the value of the different cereal rations in producing a pound of gain.

Hultz and Reeve (*29*) also obtained satisfactory gains from pigs fed cafeteria garbage alone. They concluded that when fed alone garbage had a value 25 percent that of barley supplemented by tankage. When fed with barley, garbage had a value of about 50 percent. Barnett and Goodell (*3*) obtained considerably lower gains from pigs receiving only garbage from civilian eating places than from pigs receiving corn and tankage. Somewhat better gains were obtained when the garbage was fed in combination with these other feeds. When fed alone, the garbage had a replacement value of 38 percent and when fed in combination with these feeds, a value of 27 percent that of corn and tankage in producing a pound of gain. Miller (*36*) obtained considerably greater gains when feeding

corn, garbage, and tankage than when feeding corn and garbage or corn and tankage. The garbage was worth about 47 percent that of corn and tankage. Hays *(19)* fed a ration consisting of corn, tankage, and linseed oil meal to one lot of six pigs. To another lot these feeds and garbage were fed. The source of the garbage was not given. The garbage had a value of 29 percent that of the dry concentrate mixture in producing a pound of gain. The average daily gain was almost twice as great when the garbage was added.

In a trial conducted by Hunter *(30)* with six lots of 10 pigs each, garbage had a value of only about 17 percent that of a ration consisting of corn, middlings, and tankage. The source of the garbage was not given. Somewhat better gains were obtained with the dry concentrate mixture. Still better gains were obtained when a small amount of corn was fed with garbage.

Good *(16)* conducted feeding trials in which he fed cantonment garbage, which was "very much better than that obtained from cities—it contained a large amount of refuse potatoes, bread, meat and beans." He obtained better gains when he fed this garbage alone than when he fed it in combination with corn, or with corn and soybean oil meal. He concluded that it did not pay to supplement the garbage with these other feedstuffs. According to the data presented, the garbage had a value about three times greater than that of the corn and soybean oil meal.

The results obtained in the above trials were highly variable. In addition to normal variation, some variation can undoubtedly be attributed to differences in chemical composition. Only Hultz and Reeve *(29)* gave the analyses of the garbage fed in their trials. From the information given, it would appear that most of the rations compared by the various workers cited above were not supplemented with a green roughage to supply vitamin A. Some of the dry concentrate rations fed as controls would be deficient in this vitamin. Under such conditions the beneficial effects of adding garbage, or the comparatively better gains obtained by feeding it alone, could at least partly be due to the presence of green, leafy vegetables in the garbage.

The results described above would indicate that garbage from civilian eating places has an over-all replacement value averaging about 37 percent that of a dry concentrate mixture in producing a pound of gain.

Soft pork

The statement is commonly made that garbage feeding results in soft pork. This belief probably prevails because of the high fat content of the feed. In trials where garbage was fed and observations made on the resulting carcasses, those from pigs receiving garbage were not appreciably softer than those from pigs fed grain rations *(1, 3, 29, 30, 32, 37, 56)*. Any differences that were observed were of little economic importance. Hunter *(30)* and Lovatt and co-workers *(32)* substantiated their observations by the determination of iodine numbers of the fat. The former found "about equal" values for the fat from pigs receiving garbage and non-garbage rations. The latter workers obtained iodine values of 70 with garbage-fed pork, which was "at least ten points too high by normal standards." On the other hand, Guyselman *(17)* states that the pigs fed

municipal garbage in Colorado and at the large hog feeding establishment at Fontana, California, have softer carcasses than grain-fed hogs. He recommends that pigs be finished 30 to 40 days on grain mixtures.

If garbage from a given source contained low-melting fat, the pigs eating it would, of course, produce soft pork. Apparently, however, most garbage produces reasonably firm pork.

Disease and the cooking of garbage

The feeding of uncooked garbage to swine is said by various workers (*18, 40, 41, 58*) to result in transmission of trichinosis to swine by their eating of raw, infected pork scraps. Hall (*18*), on the basis of a compilation of data by various workers, stated: "Garbage-fed swine have trichinae between three and five times as frequently as do grain-fed swine." In an extensive study of the carcasses from thousands of pigs, Schwartz (*40*) found that 3.4 percent of the diaphragms from pigs fed raw garbage and 0.59 percent of those receiving cooked garbage were infected. In a later report (*41*), 10 percent of the diaphragms from garbage-fed hogs and 1 percent of those from grain-fed hogs were found infected. The number of larvae in individual diaphragms was also much greater when the pigs had received garbage. The maximum numbers were 77,100 in garbage-fed and 1,033 in grain-fed hogs.

Wright and Bozicevich (*59*) determined the length of time garbage should be boiled in order to kill trichinae in the pork scraps contained therein. They concluded that the "boiling of garbage for 30 minutes in an open container will effect the destruction of trichina larvae in pieces of pork up to 3 inches in thickness and probably in pieces of pork of greater thickness provided the garbage is allowed to cool gradually. Such procedure would seem to constitute an effective measure for preventing the transmission of trichina infection to swine on garbage and thus aid in the control of swine trichinosis primarily and human trichinosis secondarily."

General disease problems encountered when feeding garbage to hogs.

Guyselman (*17*) has presented a discussion from the veterinarian's viewpoint of the general disease problem encountered when feeding garbage to hogs. Concerning cholera, he states that greater precautions have to be taken, including immunization of the pigs at an earlier age, when feeding garbage than when feeding grain. Pigs can apparently be infected by eating pork scraps in uncooked garbage. Guyselman, however, observed that the cooking of municipal garbage greatly decreased its feeding value. In one trial with 10 pigs per lot Hunter (*30*) obtained somewhat lower gains and efficiency of feed utilization when feeding cooked as compared with raw garbage. He did not give the source of the garbage he fed. Ashbrook and Wilson (*1*) state: "Sterilization of garbage causes injurious acids or other soluble substances of harmful nature to spread throughout the garbage. Raw garbage, on the other hand, better enables the hog to use his powers of feed selection and to refuse any ingredients that are unappetizing or are an unnatural feed. These remarks apply especially to soap, coffee grounds, acids in fruit skins, and spoiled products . . . . As

regards carefully graded garbage from hotels, restaurants, and army camps, sterilization does not seem to be so objectionable. This, however, is a special type of garbage."

Dried or concentrated garbage

Evvard and co-workers *(10)*, Minkler *(37)*, and Weaver *(47)* describe the feeding of products termed "garbage tankage" or "table scrap meal." None or some of the fat may be removed. It is concentrated in various ways. In general, it would appear that the product is unpalatable and is not satisfactory as the only supplement fed with corn. When combined with corn and digester tankage, satisfactory results were obtained. Morrison *(38)* and Smith *(42)* cite additional workers who fed various types of processed garbage.

Woodman and Evans *(54, 55, 56)* described a product termed "processed urban swill." It was garbage concentrated by evaporating and stirring in steam-jacketed kettles for 2 hours. The residue was a thick, pasty mass. They also described "artificially dried, balanced swill" made from urban sources. The protein level was raised by adding fish residues. The whole material was concentrated by drying after which it was ground to a meal. The material could be stored in sacks for several months. Woodman recommended, on the basis of a feeding trial with four 10-pig lots receiving three different levels of the dried product, that it not be fed above a level of 35 percent of the ration.

Any of these processes would undoubtedly kill all disease organisms in the garbage. The statements by Ashbrook and Wilson *(1)*, concerning the mixing of harmful materials throughout cooked garbage and quoted in the preceding section, would certainly also apply to garbage processed in any way.

FEEDING TRIALS

Cafeteria garbage

In 1928 one of the authors (L.A.H.) conducted a feeding trial to compare garbage from the University cafeteria with a dry concentrate mixture serving as a check. This mixture consisted of the following ingredients:

	Pounds
Pineapple bran	50
Wheat middlings	30
Coconut meal	10
Tankage	7
Linseed oil meal	3
Salt	1
Raw rock phosphate	1
Total	102

Two lots of six Tamworth pigs each received in self-feeders all the dry concentrate they could consume and also 1 pound of green alfalfa per day per head. Lot I received garbage in addition. The pigs averaged about 45 pounds each at the beginning and were on test for 63 days. The results are presented in table 6.

TABLE 6. Comparison of results when growing and fattening pigs were fed cafeteria garbage and a check ration and a check ration alone.

DATA TAKEN	CHECK	CHECK AND GARBAGE
Duration (*days*)	63	63
Pigs beginning trial (*number*)	6	6*
Average body weight		
Beginning (*pounds*)	44.8	44.8
End (*pounds*)	89.7	100.8
Gain		
Total (*pounds*)	269	336
Daily per pig (*pounds*)	0.71	0.98
Total feed consumed		
Grain mixture (*pounds*)	1450	1085
Garbage (*pounds*)	----------	755
Consumed daily per pig		
Grain mixture (*pounds*)	3.83	3.18
Garbage (*pounds*)	----------	2.21
Consumed per pound gain		
Grain mixture (*pounds*)	5.39	3.22
Garbage (*pounds*)	----------	2.25
Feed cost per pound gain (*cents*)	11.6	8.1

* One pig died during the trial.

The pigs receiving the check and garbage mixture made more rapid gains than those receiving the check ration only. This difference is significant. The feed cost per pound of gain was considerably lower when the garbage was fed. The data indicate that when fed in combination with the check mixture, the cafeteria garbage had a replacement value of 96 percent that of the dry concentrate mixture in producing a pound of gain. This figure is much higher than those obtained in the other trials reported in this bulletin or by other workers. Since no chemical analyses were made of the feeds, no data concerning the efficiency of utilization of total nutrients in the rations are presented in the table.

Fresh military garbage

When large amounts of garbage from military sources became available after the entry of the United States into the war, feeding trials were initiated by one of the authors (S.H.W.) to compare the value of military garbage with that of a grain ration. The pigs in the control lot were hand-fed all of the following check ration 31 they could consume:

	Pounds
Barley	64
Cane molasses	20
Tankage	7
Soybean oil meal	7
Steamed bone meal	1
Salt	1
Total	100
Estimated total crude protein	12.75 percent
Estimated nutritive ratio	6.04

The other lot was fed, until the pigs reached an average weight of 150 pounds, two-thirds of the amount of the check ration consumed by the control group. After the pigs averaged 150 pounds the amount of the check ration was reduced to one-third. The remainder of the ration throughout the trial consisted of garbage fed to the limit of appetite. Each pig in both lots received, in addition to the respective concentrate mixtures, 1 pound

of fresh, green grass daily. Five trials, utilizing a total of 35 pigs, were completed.

The results are presented in table 7. The pigs receiving the check and garbage combination made consistently more rapid gains than those receiving the check ration alone. This difference in rate of gain was very highly significant. Although the pigs receiving the check and garbage ration utilized the total nutrients less efficiently, their average feed cost per pound of gain was a little over one-half that of the pigs receiving the check ration alone. On the basis of the average figures, the garbage fed had a value 40 percent that of the check ration in producing a pound of gain.

TABLE 7. Results when growing and fattening pigs were fed garbage with a dry concentrate ration (check ration No. 31).

DATA TAKEN	TRIAL I		TRIAL II		TRIAL III	
	Check	Check and garbage	Check	Check and garbage	Check	Check and garbage
Duration (*days*)	49		86		71	
Pigs beginning trial (*no.*)	3	3	4	4	4	3
Average body weight (*lbs.*)						
Beginning	132.2	132.5	87.6	87.4	91.1	94.1
End	190.7	205.8	204.4	212.0	172.6	218.7
Weight gain (*lbs.*)						
Total	175	220	467	498	326	374
Daily per pig	1.19	1.50	1.36	1.45	1.15	1.75
Total feed consumed (*lbs.*)						
Check	1,043	438	2,379	761	1,893	701
Garbage	.....	2,159	.....	5,373	.....	3,095
Consumed daily per pig (*lbs.*)						
Check	7.1	3.0	6.9	2.2	6.7	3.3
Garbage	.....	14.7	.....	15.6	.....	14.5
Consumed per pound gain (*lbs.*)						
Check	5.94	1.99	5.09	1.52	5.80	1.88
Garbage	.....	9.81	.....	10.79	.....	8.28
Total nutrients	4.63	5.39	3.98	5.29	4.56	4.93
Feed cost per pound gain (*cents*)	20.0	11.6	17.1	10.5	19.5	10.4

	TRIAL IV		TRIAL V		WEIGHTED TOTALS AND AVERAGES	
Duration (*days*)	111		63		75.5	75.8
Pigs beginning trial (*no.*)	3	3	4	4	18	17
Average body weight (*lbs.*)						
Beginning	73.9	81.0	79.9	79.4	91.8	93.5
End	199.2	210.0	146.2	175.0	181.3	214.8
Weight gain (*lbs.*)						
Total	376	387	265	383	1,610	1,862
Daily per pig	1.13	1.16	1.05	1.52	1.18	1.44
Total feed consumed (*lbs.*)						
Check	2,364	970	1,153	577	8,833	3,447
Garbage	.....	3,749	.....	2,677	.....	17,053
Consumed daily per pig (*lbs.*)						
Check	7.1	2.9	4.6	2.3	6.5	2.7
Garbage	.....	11.3	.....	10.6	.....	13.2
Consumed per pound gain (*lbs.*)						
Check	6.28	2.51	4.36	1.51	5.49	1.85
Garbage	.....	9.68	.....	6.99	.....	9.16
Total nutrients	4.88	5.91	3.31	3.88	4.27	5.07
Feed cost per pound gain (*cents*)	21.1	13.3	14.7	8.6	18.4	10.8

Cooked military garbage

Regulations of the Board of Health of the Territory of Hawaii require the cooking of all garbage fed to swine. The purpose of this ruling is to prevent the spread of trichinosis and hog cholera. Since the cooking of garbage apparently decreases its nutritive value (*1, 30*), three trials were conducted to determine the loss in value that occurred when military garbage was cooked under Hawaiian conditions.

In the first trial small amounts of check ration 31 were fed in addition to the garbage. In the second and third trials no check ration was fed in addition. In the second, however, a third lot receiving the check ration alone was included. In all three trials a given amount of garbage, enough for 2 days, was divided into two equal portions. To one portion enough water was added to avoid burning during the ½-hour boiling period. An equal amount of water was also added to the uncooked portion. The pigs were offered amounts of each ration such that the consumption of each feed by the two lots receiving garbage in a trial would be equal. Since there were some weighbacks, the actual consumption was not exactly equal.

The results are presented in table 8. In rate of gain, there appears to be a trend in favor of the pigs receiving the uncooked garbage when compared with those receiving the cooked garbage. The difference is not significant, and can be attributed to normal variation. In reference to utilization of total nutrients and to cost per pound of gain, there appears to be a trend, also, in favor of uncooked garbage. The differences are not great, however.

The two pigs which died in the second trial were autopsied. The digestive tracts of both were traumatized or inflamed. These conditions could be attributed to some material in the garbage.

Although the cooking of garbage requires a capital outlay for equipment and fuel, the practice is undoubtedly justified in view of the benefits derived therefrom in terms of human health through the prevention of trichinosis. On the basis of the data presented, little, if any, loss is assumed by the hog raiser because of loss in nutritive value of the garbage from cooking. As pointed out by Ashbrook and Wilson (*1*) this conclusion may not apply to garbage not carefully sorted to prevent the inclusion of injurious material.

Dried, degreased military garbage

During the early period of United States participation in the war, there was a great surplus of garbage in the Territory because of insufficient numbers of swine to consume it. If this surplus could have been dried, it could have been readily transported to areas in the Territory where it could be utilized. More sanitary conditions could, also, be maintained in a piggery feeding the dried product than when feeding the wet slop. Furthermore, extracted fat could be sold. For these reasons, a feeding trial was conducted to determine the feeding value of dried and of dried and degreased garbage.

A method of drying the garbage, extracting the fat, and grinding the resulting product was developed on a small scale by Ayres (*2*). Facilities were not available, however, for drying a sufficient quantity for a feeding trial with swine. The garbage was, therefore, sun- and air-dried on con-

TABLE 8. Comparison of results when growing and fattening pigs were fed cooked and uncooked garbage, and a comparison in one trial of garbage, cooked and uncooked, with a dry concentrate ration (check ration No. 31).

DATA TAKEN	TRIAL I		TRIAL II			TRIAL III		WEIGHTED TOTALS AND AVERAGES	
	Cooked garbage and check ration	Uncooked garbage and check	Cooked garbage	Uncooked garbage	Ration 31	Cooked garbage	Uncooked garbage	Cooked garbage and check	Uncooked garbage and check
Duration (*days*)	86			105		77		89	
Pigs beginning trial (*no.*)	4	4	5*	5†	5	3	3	12	12
Average body weight									
Beginning (*lbs.*)	111.2	110.5	73.8	78.1	75.2	72.0	71.5	88.2	89.1
End (*lbs.*)	216.4	221.8	221.1	235.6	205.7	184.6	182.4	208.3	214.1
Gain									
Total (*lbs.*)	421	445	442	473	653	338	333	1200	1251
Daily per pig (*lbs.*)	1.22	1.29	1.40	1.50	1.24	1.46	1.44	1.35	1.41
Total feed consumed									
Check ration (*lbs.*)	280	222	----	----	4556	----	----	280	222
Garbage (*lbs.*)	3672	3587	3847	3839	----	3140	3105	10659	10531
Consumed daily per pig									
Check ration (*lbs.*)	0.8	0.6	----	----	8.7	----	----	0.3	0.3
Garbage (*lbs.*)	10.7	10.4	12.2	12.2	----	13.6	13.4	12.0	11.8
Consumed per pound gain									
Check ration (*lbs.*)	0.66	0.50	----	----	6.98	----	----	0.23	0.18
Garbage (*lbs.*)	8.73	8.06	8.71	8.12	----	9.31	9.33	8.88	8.42
Total nutrients (*lbs.*)	4.32	3.42	3.32	3.10	5.40	3.60	3.61	3.57	3.35
Feed cost per pound gain (*cents*)	6.60	5.71	4.35	4.06	23.5	4.66	4.67	5.22	4.81

* Two pigs died during the trial.
† Two pigs were removed to retain equal numbers in the two lots receiving garbage.

crete floors in the driest section of Oahu.[5] Under the best of conditions, 5 or 6 days were required for drying. Two batches required a considerably longer time, for they were rained on when almost dry. Fat was extracted from a portion of the dried product. The proximate analysis of this degreased garbage has been given in table 1.

In the feeding trial four rations were fed:

1. Cooked, fresh garbage.
2. Dried garbage.
3. Fifty-five percent dried, degreased garbage plus 45 percent pineapple syrup.[6] Nutritive ratio same as that of the dried garbage.
4. Sixty percent dried, degreased garbage plus 40 percent pineapple syrup. Nutritive ratio same as that recommended by Morrison (*38*) for pigs of the weight used in the trial.

Each ration was fed to two lots of two pigs each. Each pair of pigs was hand-fed to limit of appetite. Each pig received 1 pound of green grass daily.

The results are presented in table 9. None of the lots receiving the dried products made satisfactory gains. Their rates of gain and efficiency of utilization of total nutrients were much less than the lot receiving the fresh garbage. These differences can be explained largely by the unpalatability of

TABLE 9. Comparison of results when growing and fattening pigs were fed fresh cooked garbage, dried garbage, and dried, degreased garbage supplemented with pineapple syrup at two different levels.

DATA TAKEN	FRESH GARBAGE	DRIED GARBAGE	55% DRIED, DE-GREASED GAR-BAGE; 45% PINE. SYRUP	60% DRIED, DE-GREASED GAR-BAGE; 40% PINE. SYRUP
Duration (*days*)	70	70	70	70
Pigs beginning trial (*no.*)	4	4	4	4
Average body weight				
Beginning (*lbs.*)	74.3	73.6	74.4	74.5
End (*lbs.*)	175.0	120.9	121.2	115.3
Gain				
Total (*lbs.*)	403	189	187	163
Daily per pig (*lbs.*)	1.44	0.68	0.67	0.58
Total feed consumed (*lbs.*)	4167	1005	1558	1597
Feed consumed daily per pig (*lbs.*)	14.9	3.6	5.6	5.7
Total nutrients consumed daily per pig (*lbs.*)	6.25	3.95	4.47	4.57
Consumed per pound gain				
Feed (*lbs.*)	10.35	5.32	8.33	9.80
Total nutrients (*lbs.*)	4.34	5.85	6.65	7.86

the dried products. Upon the termination of this trial, one of the pigs receiving the fresh garbage was changed to the ration containing 55 percent

[5] The authors are indebted to Richard Penhallow, then with the Office of Food Production and now manager of the Honolulu Plantation Co., for providing the facilities and the labor for drying the garbage.

[6] The Hawaiian Pineapple Co. provided the pineapple syrup, a by-product of the pineapple industry. The chemical composition of the syrup averages: moisture, 23.7; protein, 2.1; fat, 1.6; ash, 2.3; nitrogen-free extract, 70.3 percent.

dried and degreased garbage and another to the dried product alone. The daily total nutrient intake immediately dropped 20 percent. Furthermore, the pigs which had been receiving one of the dried products were changed to fresh garbage. Their total nutrient intake immediately doubled. It had been expected that the pineapple syrup, an extremely palatable and a non-laxative feed, would improve the palatability of the dried, degreased garbage. It had very little, if any, effect. Undoubtedly, the slow drying process used did not enhance the palatability.

If the dried garbage had comprised only a small portion of the ration, it could possibly have been used with better success, as was demonstrated by Evvard *et al.* (*10*), Minkler (*37*), and Woodman and Evans (*56*).

Supplementing military garbage with cane molasses

Because of the large amounts of cane molasses obtainable in the Territory and its low cost, one of the ways that has been considered to make the garbage supply feed the maximum number of pigs was to supplement it with cane molasses. In order to determine how much could be fed with garbage to growing and fattening pigs and still obtain satisfactory and efficient gains, a feeding trial was conducted.

Twenty-eight feeder pigs were divided into four lots. The lots were fed different proportions of garbage and molasses, with the latter making up 0, 10, 20, and 30 percent of the ration, respectively. Fresh green grass was also fed at the rate of 1 pound per head per day.

The results are presented in table 10. With increasing amounts of molasses there was a definite decrease in rate of gain, a lowering of the efficiency of utilization of total nutrients, and an increase in feed cost per pound of gain. The differences between the lots receiving no molasses and 10 percent molasses were not great, however. The pigs receiving 20 and 30 percent molasses were subject to diarrhea.

TABLE 10. Comparison of results when growing and fattening pigs were fed garbage supplemented with cane molasses at levels of 0, 10, 20, and 30 percent.

DATA TAKEN	LOT 1	LOT 2	LOT 3	LOT 4
Ration				
Garbage (*percent*)	100	90	80	70
Molasses (*percent*)	0	10	20	30
Duration (*days*)	154	154	154	154
Pigs beginning trial (*no.*)	7*	7	7	7
Average body weight				
Beginning (*lbs.*)	44.8	41.3	42.1	42.5
End (*lbs.*)	227.8	205.0	186.3	169.1
Gain				
Total (*lbs.*)	1,098	1,146	1,009	886
Daily per pig (*lbs.*)	1.19	1.06	0.94	0.82
Total feed consumed (*lbs.*)	14,319	15,072	14,727	14,418
Consumed daily per pig				
Feed (*lbs.*)	15.5	14.0	13.7	13.4
Total nutrients (*lbs.*)	5.65	5.56	5.89	6.21
Total crude protein (*lbs.*)	0.89	0.78	0.73	0.68
Consumed per pound gain				
Feed (*lbs.*)	13.0	13.2	14.6	16.3
Total nutrients (*lbs.*)	4.75	5.25	6.27	7.57
Feed cost per pound gain (*cents*)	6.51	6.79	7.69	8.85

* One pig died during the trial.

Discussion and Conclusions

The feeding value of garbage is variable and depends upon its composition. In feeding trials conducted at the Hawaii Station with garbage from a civilian cafeteria and from military sources, excellent gains have been obtained. Each pound of gain from garbage was made at a fraction of the cost of that from grain rations with prevailing feed costs. It is interesting to note that, with the prevailing feed costs, when grain rations were fed the feed cost per pound of gain approached the market price of butcher hogs in the Territory.

Military garbage fed in these trials had a value approximately 40 percent that of a grain ration in producing a pound of gain. This is in rather close agreement with the results, in general, obtained by other investigators with garbage from either military or civilian eating places.

The cooking of military garbage did not lower its feeding value significantly. Care is usually taken at military mess halls to keep coffee, soap, alkali, and other harmful material out of the wastes intended for pig feed. Where such care is not taken, cooking would undoubtedly tend to disperse such material through the garbage and the resulting product would be unsatisfactory. No data are available concerning the vitamin loss during cooking. In piggeries of the Territory the practice is to allow the boiled garbage to cool slowly. Since it is usually cooked in large vats, the cooling process must be a slow one, and considerable destruction of heat-labile vitamins must result. The destruction must not be complete, however, for good growth is still attained, although maximum tissue storage does not take place. Cooking is undoubtedly desirable to prevent the spread of trichinosis from one pig to another and thence to man.

In light of trials conducted at the Hawaii Station and in trials reported in the literature, it appears that dried garbage is definitely not palatable. It should, therefore, not be fed alone or as one of the major ingredients of a ration. In Hawaii trials the addition of pineapple syrup did not remedy the condition, but the product used was definitely of poor quality because of the unsatisfactory method of drying.

In the trial comparing different amounts of molasses fed with the garbage, it would appear that the reason for the reduced and less efficient gains as the amount of molasses increased is the decrease in protein intake with the increase in consumption of molasses, which is low in protein. The protein content of the garbage fed in these trials was close to that required by growing and fattening pigs. If high protein supplements had been added to the garbage and molasses, more satisfactory results would likely have been obtained. That protein alone was not the sole limiting factor is suggested by the fact that the relative gains between the lots did not change appreciably as the pigs became larger and the level of protein required in the ration became lower. Previous studies conducted at this Station by Henke (*20*) have indicated that molasses at a 20 percent level with cereal grains and other dry feeds could be fed to growing and fattening pigs with satisfactory results. The investigations by Ferrin (*12, 13*) and others reviewed by Willett and associates (*49*) suggest also that, in general, better results can be expected when large amounts of molasses are fed with high-fiber than with low-fiber feeds. Garbage is low in fiber.

In the feeding trials conducted at the Hawaii Station, no evidence of soft pork, as far as could be determined by handling the pigs in the pens or by limited study of the carcasses, could be found.

If a pig raiser is short of garbage he could add molasses to a level of 10 percent. In doing so he must expect a longer feeding period before the pigs attain market weight than if an all-garbage ration had been fed.

IV. GARBAGE AS A FEED FOR BROOD SOWS[7]

By E. L. Willett, L. A. Henke, and C. Maruyama

During the war emergency, efforts were made to make the Hawaiian Islands as self-sufficient as possible. One step in this direction was to increase the number of hogs in order to utilize all of the large quantities of garbage available. As a consequence, the number of brood sows was increased, but there was not a proportionate increase in number of feeder pigs. At least part of the apparent increase in mortality of young pigs was attributed to the feeding of proportionately greater quantities of garbage to brood sows because of the decreased supplies of other concentrates. Many farmers also claimed that sows receiving garbage produced milk that was too "rich" for their nursing pigs.

No information could be found in the literature concerning the feeding of garbage to brood sows. Most sows in the Territory receive very limited amounts of good quality roughage of any kind. Studies by Fishwick (*14*), by Hogan and co-workers (*21, 22, 23, 24, 25, 26, 27*), by Martin (*33, 34, 35*), by workers at Illinois (*11, 31*), and by workers at Wisconsin (*7, 8, 39*) have shown that large amounts of good quality roughage, preferably green grass or alfalfa hay, are essential in ordinary mainland rations of brood sows during pregnancy and lactation for efficient reproduction and for optimum lactation. The more recent work (*7, 8, 11, 31, 39*) indicates that, in addition to vitamin A and if sun-dried, vitamin D, the roughage supplies various factors of the B-complex.

Hughes *et al.* (*28*) and Sure (*44*) recommend considerably more B-complex vitamins for lactation than for growth or pregnancy when feeding swine and rats, respectively.

Some of the work cited above was published after the initiation in 1944 of the brood-sow experiments to be reported below. Enough information was available at the time, however, to indicate the desirability of comparing military garbage with a grain ration and determining if the inclusion of abundant green roughage in brood-sow rations would be helpful in reducing the mortality of suckling pigs under Hawaiian conditions. The information obtained would be useful during years of peace as well as during the war, for some garbage is always fed to sows in the Territory. The results are reported below.

Experimental

Sows of the Berkshire, Duroc Jersey, Hampshire, and Tamworth breeds in the University herd were used in these studies. A few were gilts with their first litters, but most were older and had farrowed previously.

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[7] Supported by Purnell Funds.

The first experiment was of a factorial design. Six lots receiving six different treatments during lactation were as follows:

I. Ration 16. Liberal panicum grass.
II. Ration 16. One pound panicum grass daily.
III. Garbage and ration 16. Liberal panicum grass.
IV. Garbage and ration 16. One pound panicum grass daily.
V. Garbage. Liberal panicum grass.
VI. Garbage. One pound panicum grass daily.

Panicum grass (*Panicum purpurascens*) was selected because it is readily available in the Territory, is fine stemmed, and is fairly palatable. The sows receiving "liberal" amounts were offered from 5 to 8 pounds daily. These amounts constituted approximately the maximum levels that would be largely consumed. The pound of grass fed daily to the other sows would insure adequate vitamin A and probably approximates the amount commonly fed in the Territory.

During the month prior to her expected farrowing each sow was fed the concentrate ration she was to receive while lactating along with 1 pound of grass daily. During the remainder of the time while not lactating she was fed garbage as the only concentrate and 1 pound of panicum grass daily. Each sow was fed amounts in accordance with her body weight, age, and size of litter.

Ration 16 consisted of the following ingredients:

	Pounds
Rolled barley	66
Cane molasses	10
Ground pineapple bran or pulp	5
Meat and bone meal	9
Soybean oil meal	9
Salt	1
Total	100

This ration was estimated to contain 12 percent digestible crude protein and 74 percent total digestible nutrients.

During advanced pregnancy and lactation each sow in lots III and IV received garbage and ration 16 in amounts such that each would provide one-half of the total nutrients received by the sow from the concentrates. The proportion approximated 2 pounds of garbage to 1 pound of ration 16.

The concentrate mixture fed to the sows for several days before and after farrowing time included: (1) wheat bran, (2) linseed oil meal, and (3) the concentrate to be fed during lactation, namely, ration 16, garbage and ration 16, or garbage alone.

While not lactating, all sows were housed either in large concrete-floored pens or in small yards kept free from vegetation. During lactation the sows and their litters were kept entirely on concrete floors. Breeding swine are commonly housed in this manner in the Territory due to the scarcity of land.

The concentrate mixture provided for the suckling pigs in creep feeders contained the following ingredients:

	Pounds
Rolled barley	62.5
Cane molasses	10.0
Meat and bone meal	16.0
Soybean oil meal	11.0
Salt	0.5
Total	100.0

Although rolled barley may not be an ideal feed for this purpose (*5*), it was the only cereal of which there were dependable supplies. All pigs were given ferrous sulfate, and all were weaned at 8 weeks of age.

During successive lactations the individual sows were changed from one lot to another to make the different lots as equal as possible in regard to breed, age, previous reproductive performance, and size of the sows.

The results of this first experiment are summarized in table 11. There were no significant differences in average weaning weights between the three concentrate treatments. The difference between the two grass treatments was slightly too small to be significant at the 5 percent level of probability. This fact suggests that if more litters had been used a significant difference might have been obtained. There was a significant interaction between the concentrate and grass treatments. When the lot means were adjusted to the same litter size by covariance, however, the interaction was no longer significant.

When the above trials were completed, alfalfa meal was available in dependable quantities. Since mainland investigations cited above had demonstrated such good results with alfalfa meal, it was decided to conduct a second experiment. A number of sows were fed garbage supplemented with alfalfa meal in liberal quantities, namely, 1½ pounds per day. Although this group of sows, designated as lot VII, would not be comparable with the other lots in point of time, with the exception of one gilt, the sows were the same as had been used previously. It developed, however, that insufficient military garbage was available and garbage from the Universtiy cafeteria had to be fed. The data are presented in table 11.

Upon an inspection of the data it can be seen that the numbers of pigs per litter, both at farrowing and at weaning, were larger and average weaning weights were lower in the alfalfa-fed lot than in the first experiment. There was little difference in mortality.

During the first experiment, milk samples were collected from some of the sows to determine the effect, if any, of the high fat content of the garbage upon the fat content of the milk. The details of this study, including the procedure and the results, were published elsewhere (*48*). Milk was collected from sows in the various lots during the third and seventh weeks of lactation in most cases. Fat determinations were made with a Babcock tester. The results are summarized in table 12.

TABLE 11. Results of feeding garbage and/or ration 16 and different amounts of green grass or alfalfa meal to brood sows. Number of pigs farrowed and weaned per litter and their weights and mortality.

TREATMENT	LITTERS	PIGS FARROWED PER LITTER		AVERAGE BIRTH WEIGHT	PIGS WEANED PER LITTER	MORTALITY*	AVERAGE WEANING WEIGHT
		Alive	Dead				
	No.	*No.*	*No.*	*Pounds*	*No.*	*Percent*	*Pounds*
Comparison of individual lots. Experiment I.							
Lot I. Ration 16. Liberal grass	6	6.2	0.5	2.7	5.0	19	24.3
Lot II. Ration 16. 1 pound grass	6	8.0	0.7	2.6	5.3	33	24.9
Lot III. Garbage and ration 16. Liberal grass	6	6.2	1.2	2.7	4.3	30	28.7
Lot IV. Garbage and ration 16. 1 pound grass	5	7.6	0.0	2.7	6.0	21	22.5
Lot V. Garbage. Liberal grass	6	8.2	0.7	2.7	6.0	27	24.6
Lot VI. Garbage. 1 pound grass	6	6.3	0.5	2.5	4.8	24	25.2
Comparison of concentrate treatments. Experiment I.							
Lots I, II. Ration 16	12	7.1	0.6	2.7	5.2	27	24.6
Lots III, IV. Garbage and ration 16	11	6.8	0.6	2.7	5.1	25	25.4
Lots V, VI. Garbage	12	7.3	0.6	2.6	5.4	25	24.9
Comparison of grass treatments. Experiment I.							
Lots I, III, V. Liberal grass	18	6.8	0.8	2.7	5.1	25	25.7
Lots II, IV, VI. 1 pound grass	17	7.3	0.4	2.6	5.3	27	24.2
Results from feeding alfalfa meal. Experiment II.							
Lot VII. Cafeteria garbage and alfalfa meal	9	7.9	1.1	2.6	5.9	25	20.3

* Percentage of those born alive which were weaned.

TABLE 12. Fat tests and sample volumes of milk collected at two different stages of each lactation from sows receiving different amounts of garbage.

CONCENTRATE	STAGE OF LACTATION	LACTATIONS	AVERAGE MILK FAT	AVERAGE SAMPLE VOLUME
		No.	*Percent*	*cc.*
Ration 16	Early	8	5.9	6.9
	Advanced		6.3	6.1
Garbage and ration 16 . .	Early	7	7.0	6.8
	Advanced		8.5	4.6
Garbage	Early	11	7.7	6.2*
	Advanced		11.5	4.8

* Does not include one sample of 20.6 cc.

It can be seen that the fat in the milk increased with the increase in garbage (or fat) consumption and with the advance of lactation. The differences in fat tests due to the rations fed were very highly significant. The differences due to stage of lactation were highly significant.

The sample volumes show some differences due to rations, but these differences were not significant. There was a highly significant decrease in volume with advance of lactation.

DISCUSSION AND CONCLUSIONS

Under the conditions of the experiment, no real differences were demonstrated between the concentrate and grass treatments in the first six lots. The experiment, however, could have been a more critical test of the relative values of the different treatments. Wisconsin and Illinois workers (*7, 11*) have shown that the ration during gestation, and even during growth, can greatly influence the lactation performance of the sow. In the studies reported in this bulletin, sufficient pens to permit feeding of the different experimental rations during the full gestation period were not available. As will also be shown with rats later in this bulletin, differences can sometimes be demonstrated between rations only after the breeding females have been receiving the different diets for two or more successive lactations. Some of the gilts used in these studies, however, had been raised almost entirely on garbage with some grass. Since no abnormal young or extremely high mortality of suckling pigs reported by other workers were observed, it can be assumed that the ration is at least fairly adequate for normal reproduction and lactation.

The low weaning weights of the pigs in general were probably due to the method of feeding. Rather than feeding to limit of appetite of the individual sows, the feed was restricted somewhat and, as previously mentioned, was fed in accordance with age, body weight, and number of pigs per litter. This was done to equalize nutrient intake between the different lots.

The lower weaning weights of the pigs in lot VII whose dams received alfalfa meal can probably be explained, as can be seen in table 1, by the low protein content of the cafeteria garbage. While military garbage fed at the Hawaii Station undoubtedly contained adequate protein, the ratio of crude protein to the carbohydrate-equivalent portion of cafeteria garbage is considerably wider than the nutritive ratio recommended by Morrison (*38*) for brood sows. Work and associates (*57*) demonstrated a marked reduction in weight of pigs at weaning when sows received a low-protein ration.

The sows lost more weight when receiving the cafeteria garbage and alfalfa than when receiving the other rations, in agreement with observations made by Work and associates when comparing the different protein levels. Low-protein garbage such as that fed in this trial should be supplemented with high-protein concentrates when fed to brood sows.

In light of the almost significant difference in weaning weights between grass treatments and of the extensive investigations conducted on the Mainland by workers previously cited, it would appear advisable to supplement garbage with larger amounts of green grass or of good-quality alfalfa meal than is commonly practiced with brood sows in the Territory. Although some garbage undoubtedly contains adequate amounts of green feed in the form of leafy vegetables, the amounts are variable. Regular feeding of suitable roughage would not only insure a supply of needed vitamins but would also guard against constipation resulting from highly concentrated garbage.

Although the fat content of the sows' milk increased with increased garbage consumption, no detrimental effects upon the nursing pigs could be observed. The incidence of diarrhea was no higher among those in the garbage-only lots than among those in the grain-fed lots. Based on this evidence, it is the opinion of the authors that garbage feeding is a relatively unimportant factor in the etiology of diarrhea among suckling pigs in the Territory. Other factors, including unsanitary quarters, anemia, and inclement weather are primarily responsible. It should be stated, however, that some selection of garbage was made when feeding the sows in the investigations reported in this bulletin. This was done to avoid the feeding of an occasional can of garbage containing very large amounts of fat. Such garbage can cause digestive disturbances and diarrhea among the sows and possibly also among the nursing pigs.

It can be concluded that hog raisers in the Territory can greatly reduce their feed costs by feeding fresh garbage, if sufficient quantities are available, rather than grain to their brood sows. This is at least the case with prevailing prices and if hauling costs are not too high. In doing so they must be certain, however, that the garbage is of suitable quality, especially in regard to level of protein and freedom from excessive vegetable refuse and fat, and that sufficient green grass or alfalfa meal is supplied. The amount of protein can be judged roughly by the quantities of meat present in the garbage.

V. GROWTH, REPRODUCTION, AND LACTATION OF RATS FED DRIED GARBAGE[8]

By E. L. Willett and Winifred Ross

While the investigation with brood sows, described in the preceding section of this bulletin, was being conducted, a similar experiment with rats was outlined. By using these small laboratory animals, results could be obtained much more quickly and inexpensively, and tests more critical in nature could be made. The information, although not entirely applicable to another species, could serve as a guide in future experimentation or in making sow-feeding recommendations, for the digestive and reproductive systems of rats and pigs are similar.

[8] Supported by Adams Funds.

The rat experiment was designed to determine whether dried garbage alone would support normal reproduction and lactation of rats and whether grass or yeast contained supplementary factors if the garbage should prove deficient.

EXPERIMENTAL

As various litters in the breeding colony were weaned at 21 days of age, the experimental weanling females were selected from them and placed upon their respective diets. Thus, four female rats from a given litter were started at the same time, and each of the four was placed on a different diet and was fed individually throughout the experiment. Each rat received the same diet throughout growth, pregnancy, and lactation for three litters.

The diets received by the different lots of 13 rats each were as follows:

Lot I. Dried garbage only.
Lot II. Dried garbage and fresh green grass.
Lot III. Dried garbage and 5 percent of a standardized dried yeast.
Lot IV. Diet 11 and fresh green grass.

The garbage, from military sources, was procured at the University piggery at weekly or bi-weekly intervals. Each batch consisted of portions taken from a number of cans in order to obtain a representative sample. It was dried in a forced-draft oven at about 65° C. Usually about 18 hours were required. After being ground it was stored in a refrigerator. The green grass was honohono (*Commelina diffusa*), which was selected because it is low in fiber and was readily consumed by the rats. Only the leaves and the growing tips of the plants were fed. The yeast was Anheuser-Busch Strain G, a high-thiamine yeast. Diet 11, used as the control, is the standard breeding-rat diet used in the Nutrition Laboratory of the University of Hawaii and consists of the following ingredients:

	Grams
Whole milk powder	300
Skim milk powder	100
Whole wheat flour	700
Yellow corn meal	325
Soybean meal	100
Wheat germ or standard yeast	40
Calcium carbonate	9
Ferric citrate	1
Sodium chloride	10

The soybean meal was prepared in the laboratory by cooking the whole soybeans in a pressure cooker, then drying and grinding them. Wheat germ was included in the diet during the early part of the growth study, but it became unavailable so was replaced by standard yeast during the remainder of the experiment. Since breeding rats in this laboratory were fed about 0.5 gm. of grass twice a week, the controls in this experiment were fed in the same manner.

All lots were supplied with viosterol at weekly intervals. Lot II was fed 0.5 gm. grass daily through growth and the weaning of the second litters. At this time, since no measurable benefit had occurred, the grass content of the diet was considerably increased by replacing the fresh grass with dried, finely ground leaves of Napier grass (*Pennisetum purpureum*) mixed with the garbage at the rate of 10 percent. The leaves were air-dried in the shade.

The experimental growth period terminated after 79 days, or when the rats were 100 days old, the age at which breeding rats in this laboratory are considered mature. They were bred at the next estrus. Estrus was determined by the vaginal smear, and males were with the females only at time of estrus. Tocopherol was given to all the females during pregnancy. The services of eight males were distributed to minimize differences between lots due to possible differences in fertility of the males. A 3-week rest period was allowed between the time the litters were weaned and the females were rebred.

The following data were recorded: weaning weights, weights during the growth period at weekly intervals, and weights at 100 days of age; weights of mothers on first and last days of pregnancy, on first and last days of lactation, and at weekly intervals during lactation; weight of young at birth and at weekly intervals until weaning at 21 days of age; and feed consumption.

The criterion of growth was weight gain from weaning to maturity; of reproduction, the number of young born per litter; and of lactation, the growth and mortality of suckling rats to 2 weeks of age.

TABLE 13. Weight gains and feed consumption from 21 days to 100 days of age of rats receiving four different diets.

DATA TAKEN	LOT I	LOT II	LOT III	LOT IV
Diet	Garbage	Garbage and grass	Garbage and yeast	Diet 11
Rats beginning experiment (*no.*)	13*	13*	13	13
Average gain per rat (*gms.*)	167	168	204	215
Average feed consumed per rat (*gms.*)	831	854	878	1133
Grams feed per gram gain	4.98	5.08	4.30	5.27
Grams total nutrients† per gram gain	6.10	6.23	5.20	5.19

* One rat died during the experiment.
† See footnote 3, page 13.

RESULTS

The growth results are presented in table 13. By analysis of variance it was found that there was a highly significant difference in mean gains between either of lots I and II and either of lots III and IV. The differences between lots I and II and between III and IV were not significant, however. The adjustment of the lot mean gains to the same total nutrient intake by means of covariance made no difference in the interpretation of the results. During the experiment two rats, each in different groups of four litter mates, died. Missing values were estimated for these rats and used in the statistical analysis of the data. In the covariance analysis total nutrient intake (see p. 13) for each rat, rather than actual feed intake, was used. This value was used to compensate for the high fat content of the garbage. The amount of total nutrients from the fresh green grass was so extremely small that it was ignored.

The data measuring the reproductive and lactating performance of the female rats are presented in table 14. The litter data to 2 weeks of age, rather than to 3 weeks, are presented because it was thought that growth up to this time was a better measure of lactation performance of the mothers. After the second week, young rats eat appreciable amounts of

their mother's feed. The average mortality and the number of rats per litter did not materially change between the second and third weeks.

In lot II there were 13 rats with litters, while only 12 are shown in the growth experiment. This difference is due to one rat being reared to replace the one that died during the growth period.

The average number of young in the first litters at birth was significantly smaller in lot I than in lot IV. Litter sizes of lots II and III were intermediate. These differences may be explained by the retarded growth of the mothers receiving garbage, as shown in table 15. The differences largely disappeared with the second litters, and the trend was actually reversed with the third. The differences in the second and third litters were not significant. With successive litters the previously retarded rats attained a size comparable to those on the standard diet.

TABLE 14. Reproduction and lactation performance of female rats fed four different diets as indicated by number and weight of young per litter born and raised to 2 weeks of age.

DIET	AT BIRTH				AT TWO WEEKS OF AGE			
	Litters	Average young per litter		Average weight of young	Litters	Average young per litter	Average weight of young	Mortality
		Alive	Dead					
	No.	*No.*	*No.*	*Gms.*	*No.*	*No.*	*Gms.*	*Per-cent*
First litters								
Lot I. Garbage . . .	12	5.8	0.3	5.3	7	5.1	18.6	49
Lot II. Garbage and grass	13	6.9	0.0	5.6	5	5.8	20.6	68
Lot III. Garbage and yeast	13	8.4	0.0	5.4	6	6.0	21.4	67
Lot IV. Diet 11 . . .	13	9.0	0.3	5.4	8	5.5	22.1	62
Second litters								
Lot I. Garbage . . .	12	7.4	0.1	5.6	10	7.1	21.9	20
Lot II. Garbage and grass	13	8.8	0.1	5.3	10	7.2	21.7	37
Lot III. Garbage and yeast	12*	9.3	0.2	5.5	11	7.6	22.8	25
Lot IV. Diet 11 . . .	13	8.1	0.3	5.1	12	6.5	27.6	26
Third litters								
Lot I. Garbage . . .	12	8.9	0.4	5.5	12	7.3	17.5	18
Lot II. Garbage and grass	11†	8.2	0.3	5.3	10	6.8	19.1	24
Lot III. Garbage and yeast	13	8.1	0.2	5.2	12	5.8	20.8	33
Lot IV. Diet 11 . . .	13	6.8	0.2	5.8	13	6.0	28.1	12

* One additional litter was eaten before the young were counted or weighed.
† Two rats had died.

When weights of the first litters at 2 weeks of age are compared, there is a highly significant difference only between lot I (garbage only) and any one of the other three. There is a significant difference only between the garbage-plus-grass and the diet 11 lot. Correcting for litter size by covariance makes no change in the interpretation of the results. As with litter size, this smaller average weight of the young at 2 weeks may be attributable to the retarded growth of the mothers.

A comparison of the second litters shows a highly significant difference in average weights of young at 2 weeks between the control and any other lot. There is no significant difference between lots I and II, but there is between either of these and the third lot. Adjusting the lot mean weights to the same litter size makes no appreciable change in the results.

TABLE 15. Average body weights of parental rats after parturition.

DATA TAKEN	LOT I	LOT II	LOT III	LOT IV
Diet	Garbage	Garbage and grass	Garbage and yeast	Diet 11
First litters				
Rats (*no.*)	12	13	13	13
Average body weight (*gms.*)	262	263	318	316
Second litters				
Rats (*no.*)	12	13	13	13
Average body weight (*gms.*)	338	332	361	353
Third litters				
Rats (*no.*)	12	11*	13	13
Average body weight (*gms.*)	371	359	402	374

* Two rats in this group had died.

Analysis of the data on average weaning weights of the third litters revealed significant differences between all of the lot mean weights. When corrected for litter size by covariance, however, there is no significant difference between the first two lots, but, as in the case of the second litters, a significant difference exists between either of these lots and the third one. The difference between the control lot and any of the others remains highly significant.

Mortality was excessively high among the young in all of the first litters, as shown in table 14. During the time most of these litters were born and reared, the weather was windy and cold. After the weather improved, satisfactory results were obtained. It can be seen that there was considerable variation in mortality between the lots. The only significant difference, however, is between the control and the garbage-yeast lots with the third litters. The probability, determined by Bliss's chi-square table (*4*), is 0.3 percent. Loss of weight during lactation of the mothers receiving the different garbage diets was also greater than that of those receiving the control diet, especially with the third litters.

The average feed consumed and the average total nutrient intake of the lots during the first two weeks of the three successive lactations are presented in table 16. There is considerable variation between lots, but there does not appear to be any consistent trend.

DISCUSSION AND CONCLUSIONS

It appears that some factor or factors, present in yeast and necessary for normal growth of rats, were lacking or present in insufficient amounts in garbage. Fresh green grass did not contain these factors, or at least not in sufficient amounts at the rate fed. The variations in growth between lots were not caused by different energy intakes, for significant differences existed after corrections were made for total nutrient intake. The poor growth with garbage was due to inherent characteristics of the garbage, probably a deficiency of one or more of the vitamins of the B-complex.

The dried garbage was able to support normal reproduction, as measured by size of litters at birth. After retardation of growth was overcome, there were just as many young in the litters of the garbage-only lot as in

TABLE 16. Average feed consumption and total nutrient intake of rats on the different diets during the first 2 weeks of the first, second, and third lactations.

DATA TAKEN	LOT I	LOT II	LOT III	LOT IV
Diet	Garbage	Garbage and grass	Garbage and yeast	Diet 11
First litters				
Litters (*no.*)	6	4	6	7
Average feed consumed (*gms.*)	268	269	278	258
Average total nutrient intake (*gms.*)	312	313	330	254
Second litters				
Litters (*no.*)	10	10	10	11
Average feed consumed (*gms.*)	299	379	320	381
Average total nutrient intake (*gms.*)	348	440	379	374
Third litters				
Litters (*no.*)	12	10	12	13
Average feed consumed (*gms.*)	301	346	266	351
Average total nutrient intake (*gms.*)	349	402	316	346

the control lot. The third litters in the garbage lot were actually larger, but not significantly so.

The dried garbage definitely did not support normal lactation. Grass was apparently beneficial with the first litters, but the second and third litters derived no measurable benefit from it. The inclusion of large amounts of dried grass in the feed did not make any improvement. Yeast consistently enabled the mothers to wean heavier young than when garbage alone was fed; but the resulting young were still much smaller than those whose mothers received diet 11. It would appear, therefore, that yeast contains some essential factor or factors absent in garbage and grass, but it either does not provide enough or it lacks some additional factor.

From data presented in section I of this bulletin, it can be determined that garbage of the average moisture content (29.9 percent) fed the rats contained 1.6 micrograms thiamine per gram. Analyses made before and after drying of three samples of garbage used in these rat studies indicated that only 18 percent of the thiamine was destroyed. It would appear, therefore, that the lactating rats averaged as little as 31 micrograms of thiamine per day from the garbage-only diet. This figure is far below the 120 micrograms recommended by Sure (*44*). The garbage-yeast diet contained 16.4 micrograms per gram and supplied almost three times the amount recommended. The specified thiamine content of the yeast was checked with experimental animals in this laboratory. The lactation performance of the mothers receiving garbage and yeast was, nevertheless, only slightly better than that of those receiving garbage alone. A factor, or factors, other than thiamine were responsible for the poor lactation performance obtained with the three diets containing dried garbage. It is possible that these factors are present in fresh garbage but were destroyed when the garbage was dried. Possibly a combination of garbage, grass, and yeast would have given good results. The yeast would have provided sufficient thiamine, and the grass might have provided other essential factors.

It cannot be determined from the data whether these factors are different from the ones required for reproduction or whether the requirements for lactation are simply greater. Ross and co-workers (*39*) have suggested, as a result of studies with sows and rats, that different factors were required for gestation and for lactation. The study made by Cerecedo and Vinson (*6*) suggests that mice need folic acid in their diet only during lactation. Sure (*44*), in reproduction and lactation studies with rats, provides considerably more vitamins of the B-complex during lactation than during pregnancy. Hughes *et al.* (*28*) recommend over twice as much thiamine for sows during lactation as during pregnancy.

By referring to table 16 it can be seen that the differences in growth of the young can hardly be attributable to differences in energy intake of the mothers. Neither can they be attributable to insufficient protein, for the rats fed these diets averaged 18.7 percent crude protein. There is every reason to believe that this protein was of good quality because of the large amounts of meat and the great variety of foods present in the garbage.

The fact that rats do not grow well when receiving dried garbage is in agreement with results obtained by various workers cited in section III who fed various dried garbage products in large quantities to hogs. Since rats reproduced normally when receiving the dried garbage, it can probably be concluded that sows can do likewise on fresh garbage. Evidence presented in section IV of this bulletin and other observations made in the University piggery and in other piggeries of the Territory support this conclusion. Experiments reported in section IV of this bulletin, although not making as critical a test of the garbage as the rat study, indicate that at least fairly satisfactory lactation performance can be expected from sows fed fresh garbage, especially if it is supplemented with green grass or alfalfa meal.

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