HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

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CANE MOLASSES AS A SUPPLEMENT TO FATTENING RATIONS FOR SWINE

By
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INTRODUCTION

The Territory of Hawaii produces about one million tons of sugar annually. As a by-product of this sugar manufacture, about 225,000 tons of cane molasses are produced each year.

Molasses is, and has been, used in various ways in Hawaii. It has been made into alcohol, burned to make potash fertilizer or applied directly as a fertilizer, thus greatly increasing the bacterial activity of the soil. It has long been fed in considerable quantity to plantation work animals and to a less extent to dairy cows. It is appetizing to most animals, and in mixtures may result in increasing the consumption of unpalatable feeds. Most of the molasses shipped away from Hawaii becomes a component part of mixed feeds and in this form some of it is returned to the Territory.

In view of the fact that hogs and hog products valued at more than a million dollars are shipped into Hawaii each year, the Hawaii Agricultural Experiment Station undertook to determine the extent to which the by-product, cane molasses, may be used profitably as a feed for the fattening of swine.

WORK OF OTHER INVESTIGATORS

In the nineties many European beet sugar factories recommended the use of molasses as a stock feed. It was generally found to be satisfactory for various classes of animals, including swine, but when fed in too large amounts proved to be rather laxative.

Burns *(3)*[1] found that a mixture of corn chop and cane molasses 3:1 produced an average daily gain of 1.45 pounds when fed to 8 to 10 months old Yorkshire hogs.

Fjeldsted and Potter *(4)* showed that pigs receiving 4 parts of mill run and 1 part of cane molasses consumed as much mill run as did similar lots receiving the mill run alone. In another test, 183-pound hogs consumed daily 10.7 pounds of a mixture of ground barley 72 percent, tankage 8 percent, and molasses 20 percent, and made an average daily gain of 2.11 pounds in the 50 days covered by the test. Molasses proved to be practically equal, pound for pound, to ground barley.

Hackedorn and Sotola *(5)* concluded that cane molasses was an efficient substitute, pound for pound, for one half the barley when fed to hogs on pea forage, but was less efficient in dry-lot feeding.

Barnett and Goodell *(1)*, experimenting with 160-pound 12-month old pigs, found an average daily gain of 1.12 pounds on a basal ration of corn, shorts, and tankage 5:5:1. When 3 and 4.5 parts of molasses replaced 2 and 3 parts of the corn, respectively, the average daily gains were 0.98 and 1.08 pounds.

Nelson, Heller, and Fulmer *(11)*, experimenting with rats, found cane molasses to be much richer in vitamin B than is either beet molasses or sorghum molasses. They found yeast to be richer than cane molasses in vitamin B, but the molasses was better for the rearing of young rats.

Taylor and Nelson *(12)* found that the addition of crude cane molasses to a synthetic vitamin E free diet furnished a good source of the vitamin on a 3 percent level. On a 5 percent level, 92 percent of the young were successfully weaned as compared with 58 percent on a 3 percent level.

Krauss *(10)* found that cane molasses as a supplement to milk produced excellent growth and prevented nutritional anemia, and was of value for haemoglobin regeneration in anemia. Beet molasses did not prevent anemia and had no beneficial effects on rats suffering from nutritional anemia. Chemical analyses showed that the cane molasses contained larger quantities of iron and copper than did the beet molasses.

Hughes and Lindsay *(9)* fed one lot of 6 pigs, averaging 97 pounds in initial weight, a 10 percent cane molasses mixture and another lot,

[1] Italic numbers in parentheses refer to Literature cited, p. 11.

averaging 94 pounds in weight, a 25 percent mixture. The basal ration was made up of barley with 10 percent of coarsely ground alfalfa and some minerals. The molasses used was reported to have been imported from Hawaii. During the 56-day test period an average of 7.52 and 7.7 pounds was fed daily. The pigs made an average daily gain of 1.53 and 1.28 pounds and required 5.79 and 6.02 pounds of feed to produce one pound of gain for the 10 and the 25 percent molasses mixtures, respectively. Another lot of 99-pound pigs, fed only barley with 9 percent of alfalfa and some minerals, averaged 7.24 pounds of daily feed consumption, 1.60 pounds of daily gain, and required 4.53 pounds of feed for each pound of gain. The dressed weights were 74.6, 75.7, and 76.3 for the control lot, and for the 10 and 25 percent molasses-fed lots, respectively. The fat was described as hard in each of these three lots.

COMPOSITION OF CANE MOLASSES

Cane molasses varies somewhat in composition, depending on the kind of soil on which the cane is grown and the fertilizers used, the variety of cane, and the stage of maturity at which it is harvested. It is low in protein, rich in carbohydrates largely in the form of easily digestible sugars, and high in mineral content. Results of detailed analyses of 14 samples of cane molasses made by the experiment station of the Hawaiian Sugar Planters' Association, showing different forms of sugars and other constituents, are given in table 1.

TABLE 1

Composition of cane molasses

	HIGH	LOW	AVERAGE
	Percent	*Percent*	*Percent*
Total solids	83.80	75.06	79.70
Sucrose	40.04	32.71	36.88
Glucose	21.55	6.04	13.99
Dextrose	11.05	3.00	6.76
Levulose	10.50	2.87	6.76
Ash (sulphate)	14.49	8.36	10.15
Gums	12.63	4.89	8.79
Total nitrogen	.996	.274	.563
Iron and alumina	.443	.075	.214
Lime	2.34	.291	1.129
Magnesia	1.384	.270	.727
Potash	5.218	2.43	4.76
Soda	.428	.121	.228

Typical analyses of this product expressed in terms most commonly used in referring to feedstuffs are as follows:

TABLE 2

Feed analyses of typical samples of cane molasses

	A[1]	B[2]	C[3]
	Percent	*Percent*	*Percent*
Moisture	25.7	27.23	20.30
Carbohydrates	65.0	59.04	64.39
Protein	3.2	4.19	3.52
Ether extract	.....	.25	.....
Ash	6.1	9.29	10.52

Digestible nutrients in cane molasses are shown in table 3.

TABLE 3

Digestible nutrients in cane molasses

	A[1]	B[2]
	Percent	*Percent*
Dry matter	74.3	72.77
Crude protein	1.0	1.34
Carbohydrates	58.5	46.64
Fat	.....	.....
Total nutrients	59.5	47.98

Browne *(2, p. 380)* gives the following detailed ash analysis of cane molasses:

TABLE 4

Mineral constituents of cane molasses

	Percent
Potassium oxide (K_2O)	50.83
Sodium oxide (Na_2O)	.78
Calcium oxide (CaO)	7.09
Iron oxide (Fe_2O_3)	.32
Aluminum oxide (Al_2O_3)	.24
Silica (SiO_2)	3.91
Phosphoric acid (P_2O_5)	2.64

[1] Average of 21 analyses *(8, pp. 712 and 731)*.

[2] *(9, p. 2)*.

[3] Calculated from detailed analyses made by the Association of the Hawaiian Sugar Planters' Experiment Station.

FEEDING EXPERIMENTS

EARLIER EXPERIMENTS

In earlier experiments *(6)* at the University of Hawaii, pineapple bran in amounts up to 50 percent of the concentrate mixture proved to be an economical feed for the fattening of swine at the prices prevailing. An attempt was made to combine the maximum amount of pineapple bran with cane molasses so that the ration would consist largely of locally produced feeds. The mixture was made up of 40 pounds of pineapple bran, 25 pounds of cane molasses, 20 pounds of wheat middlings, 12 pounds of tankage, 3 pounds of linseed oil cake meal, and 1 pound each of salt and of raw rock phosphate. This was fed for 126 days to a lot of 6 somewhat unthrifty pigs, averaging 50 pounds each in weight. During this time they averaged only 0.62 pound of daily gain and required 7.06 pounds of concentrates to make a pound of gain. The control lot of 6 pigs was fed a mixture of 90 pounds of barley, 7 pounds of tankage, 3 pounds of linseed oil cake meal, and 1 pound each of salt and of raw rock phosphate, and averaged 1.11 pounds of daily gain and required 4.25 pounds of concentrates to make a pound of gain. While the pigs were none too thrifty at the beginning of the test, the mixture of 40 percent of pineapple bran and 25 percent of cane molasses appeared unsuitable, at least for pigs of the size of those tested.

LATER EXPERIMENTS

Rations and methods of feeding.—In later experiments the following feed mixtures were used:

Control Ration:

88 lbs. rolled barley
8 " tankage
2 " linseed oil cake meal
1 " salt
1 " steamed bone meal
(Nutritive ratio 1 :5.1)

10 percent Cane Molasses Ration:

78 lbs. rolled barley
10 " cane molasses
8 " tankage
2 " linseed oil cake meal
1 " salt
1 " steamed bone meal
(Nutritive ratio 1 :5.5)

20 percent Cane Molasses Ration:

68 lbs. rolled barley
20 " cane molasses

8 " tankage
2 " linseed oil cake meal
1 " salt
1 " steamed bone meal
(Nutritive ratio 1 :5.8)

It will be noticed that the rations are identical except that in one case 10 percent and in another 20 percent of cane molasses was used to replace a like amount of barley. Adding cane molasses had the effect of widening the nutritive ratio. One pound of green alfalfa was also fed to each pig daily and this had the effect of narrowing the nutritive ratio to 1 :4.9, 1 :5.3, and 1 :5.5 for the control lot and for the lots fed 10 and 20 percent of cane molasses, respectively. Since all of these are well within the Morrison standard for the fattening of swine, it seemed better not to further complicate matters by varying the amounts of tankage but rather to substitute cane molasses for barley. The cane molasses was mixed with the other ingredients and fed from a self-feeder. The ration containing 20 percent of molasses was somewhat sticky, and required some attention to keep it from clogging the feeder.

All pigs used in these experiments were raised on the university farm, and in dividing them into lots for experimental purposes not only were weight, sex, condition, and probable outcome considered and balanced as equally as possible, but also ancestry and age, information on which is frequently not available about purchased pigs.

Cost of feed.—Since the feed prices varied greatly from time to time the costs are comparable only within different lots fed at the same time and not with lots perhaps similarly fed but at a time when feed prices had changed. At the local market prices prevailing during the different experiments the cost of the feeds used per ton was as follows:

TABLE 5

Cost per ton of feed at the time the experiments were in progress

	Experiment II March, 1929	Experiment III June, 1931	Experiment IV October, 1931	Experiment V May, 1932
Barley (rolled)	$50.00	$35.00	$32.00	$25.00
Cane molasses[1]	12.00	10.00	10.00	10.00
Linseed oil cake meal	72.00	54.00	46.00	41.00
Tankage	95.00	70.00	58.00	40.00
Salt	16.00	15.00	15.00	14.00
Bone meal (steamed)	65.00	50.00	56.00	60.00
Alfalfa (green)	10.00	10.00	10.00	10.00

[1] Cane molasses does not have a well-established price. It may be purchased on some plantations for $5 per ton, but the cost of hauling is additional.

Summary of results.—The results of the later experiments are summarized in tables 6, 7, 8 and 9.

TABLE 6

Weights, gains, feeds consumed and cost of gains in Experiment II (7)

70-day test, starting March 8, 1929
Six Tamworth pigs used in each lot

	Lot fed control ration	Lot fed 10 percent cane molasses ration	Lot fed 20 percent cane molasses ration
Average initial weight	70.33 lbs.	70.50 lbs.	70.16 lbs.
Average final weight	170.16 "	151.67 "	134.33 "
Average total gain per pig	99.83 "	81.17 "	64.17 "
Average daily gain per pig	1.43 "	1.16 "	.92 "
Total concentrate feed consumed	2990.00 "	2444.00 "	2182.00 "
Average concentrate feed consumed per pig per day	7.12 "	5.82 "	5.20 "
Concentrate feed required per pound of gain	4.99 "	5.02 "	5.65 "
Total green alfalfa consumed	420.00 "	420.00 "	420.00 "
Total feed cost	$82.60	$63.02	$52.56
Feed cost per pound of gain	$ .138	$ .129	$ .136
Value of cane molasses compared with barley, pound for pound, under conditions of this test		99.4%	88.3%

TABLE 7

Weights, gains, feeds consumed and cost of gains in Experiment III

70-day test, starting June 16, 1931
Four Tamworth and Duroc-Jersey-Berkshire crossbred pigs used in each lot

	Lot fed control ration	Lot fed 10 percent cane molasses ration
Average initial weight	103.1 lbs.	100.6 lbs.
Average final weight	207.9 "	215.1 "
Average total gain per pig	104.8 "	114.5 "
Average daily gain per pig	1.50 "	1.64 "
Total concentrate feed consumed	1965.00 "	1937.00 "
Average concentrate feed consumed per pig per day	7.02 "	6.92 "
Concentrate feed required per pound of gain	4.69 "	4.23 "
Total green alfalfa consumed	280.00 "	280.00 "
Total feed cost	$38.86	$35.91
Feed cost per pound of gain	$ .093	$ .078
Value of cane molasses compared with barley, pound for pound, under conditions of this test		110.9%

TABLE 8

Weights, gains, feeds consumed and cost of gains in Experiment IV[1]

126-day test, starting October 16, 1931
Five Berkshires and Tamworths used in each lot

	Lot fed control ration	Lot fed 10 percent cane molasses ration
Average initial weight	48.8 lbs.	49.2 lbs.
Average final weight	176.2 "	191.4 "
Average total gain per pig	127.4 "	142.2 "
Average daily gain per pig	1.03 "	1.12 "
Total concentrate feed consumed	2757.00 "	2759.00 "
Average concentrate feed consumed per pig per day	4.34 "	4.34 "
Concentrate feed required per pound of gain	4.33 "	3.88 "
Total green alfalfa consumed	630.00 "	630.00 "
Total feed cost	$50.60	$47.60
Feed cost per pound of gain	$ .079	$ .067
Value of cane molasses compared with barley, pound for pound, under conditions of this test		111.6%

TABLE 9

Weights, gains, feeds consumed and cost of gains in Experiment V[1]

76-day test, starting May 26, 1932
Five Tamworth and Berkshire pigs used in each lot

	Lot fed control ration	Lot fed 10 percent cane molasses ration	Lot fed 20 percent cane molasses ration
Average initial weight	81.5 lbs.	79.8 lbs.	81.0 lbs.
Average final weight	184.8 "	189.0 "	191.2 "
Average total gain per pig	103.3 "	109.2 "	110.2 "
Average daily gain per pig	1.36 "	1.44 "	1.45 "
Total concentrate feed consumed	2345.00 "	2405.00 "	2392.00 "
Average concentrate feed consumed per pig per day	6.17 "	6.32 "	6.29 "
Concentrate feed required per pound of gain	4.54 "	4.40 "	4.34 "
Total green alfalfa consumed	380.00 "	380.00 "	380.00 "
Total feed cost	$33.28	$32.27	$30.32
Feed cost per pound of gain	$ .064	$ .059	$ .055
Value of cane molasses compared with barley, pound for pound, under conditions of this test		103.2%	104.6%

[1] The writer wishes to acknowledge the valuable help of G. W. H. Goo in carrying out and compiling the results of these experiments.

The essential data given in the preceding tables are summarized for ready comparison in table 10.

TABLE 10

Results of feeding four groups of pigs a cane molasses ration

	Average daily gain	Daily concentrate feed consumed per pig	Amount of concentrate feed per pound of gain	Cost per pound of gain	Value of molasses as compared with barley pound for pound
	Pounds	*Pounds*	*Pounds*	*Cents*	*Percent*
Experiment II, 6 pigs, initial weight 70 pounds, 70-day test:					
Control (no molasses) .	1.43	7.12	4.99	13.8	.....
Fed 10 percent molasses	1.16	5.82	5.02	12.9	99.4
Fed 20 percent molasses	.92	5.20	5.65	13.6	88.3
Experiment III, 4 pigs, initial weight 102 pounds, 70-day test:					
Control (no molasses) .	1.50	7.02	4.69	9.3	.....
Fed 10 percent molasses	1.64	6.92	4.23	7.8	110.9
Fed 20 percent molasses	.....	.....	.....	....	.....
Experiment IV, 5 pigs, initial weight 49 pounds, 126-day test:					
Control (no molasses) .	1.03	4.34	4.33	7.9	.....
Fed 10 percent molasses	1.12	4.34	3.88	6.7	111.6
Fed 20 percent molasses	.....	.....	.....	....	.....
Experiment V, 5 pigs, initial weight 81 pounds, 76-day test:					
Control (no molasses) .	1.36	6.17	4.54	6.4	.....
Fed 10 percent molasses	1.44	6.32	4.40	5.9	103.2
Fed 20 percent molasses	1.45	6.29	4.34	5.5	104.6

Conclusions.—In four experiments with a total of 51 pigs, cane molasses in amounts up to 20 percent of the concentrate ration was worth —under conditions of the experiments, using dry lots, self-feeders, and 1 pound of green alfalfa per pig daily—about as much, pound for pound, as rolled barley when fed to fattening pigs having an initial weight ranging from 50 to 100 pounds.

Except in one experiment, the results of which are somewhat at variance with those of the other experiments, the addition of cane molasses in amounts up to 20 percent of the ration resulted in slightly greater daily gains from about the same daily feed consumption; required slightly less concentrates, including cane molasses, to make a pound of gain; and gave a marked reduction in feed costs per pound of gain. The cane molasses in these experiments was worth slightly more, pound for pound, than rolled barley.

The pigs readily ate the molasses mixtures and no bad physiological effects were observed. The feces of the molasses fed lots was darker and softer.

SUMMARY

Nearly one quarter of a million tons of cane molasses are annually produced in Hawaii.

Cane molasses is a palatable feed low in protein, but high in sugars, and in mixtures increases consumption of feeds none too palatable in themselves. It has long been used as part of the ration fed to plantation work animals.

Investigators elsewhere have shown cane molasses to be a good source of vitamins B and E, and of value in preventing and curing nutritional anemia. Results of experiments by this station indicate that in amounts up to 20 percent of the mixture fed fattening hogs, cane molasses was worth approximately as much or more, pound for pound, as the rolled barley which it replaced.

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