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A STUDY OF MOLASSES YEAST IN POULTRY RATIONS

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INTRODUCTION

The economic status of an island economy, such as that which exists in Hawaii, is directly influenced by its balance of trade; i.e., income from all sources, particularly from the sale of its products outside Hawaii, versus expenditures for imported products. Among the several alternatives that may be employed to strengthen its economy, the reduction in imports through greater utilization of locally produced products is a direct means of conserving funds. The poultry industry lends itself to this approach since practically all commercially mixed feed sold in Hawaii is compounded of ingredients produced elsewhere. In 1958, a total of 34,443 tons of poultry feed was used and valued at approximately 3.77 million dollars. Although it may not be economically feasible to exclude all of the imported ingredients, studies have shown that cane final molasses (Rosenberg, 1954*a*, 1955; Rosenberg and Palafox, 1956), B-grade molasses (Rosenberg, 1953, 1954*b*, 1954*c*), low-grade sugar (Rosenberg, 1953*a*; Palafox and Rosenberg, 1954), meat and bone meal (Palafox and Rosenberg, 1955), and other local feedstuffs may be used to replace a portion of the feed mix, particularly that part comprising the carbohydrate concentrates. An ample supply of protein concentrate still remains as the major roadblock to the compounding of poultry rations from local feedstuffs.

Although tuna meal and meat and bone meal are produced locally, these ingredients are not available in sufficient quantities to meet the needs of this industry. Another possible source of protein is yeast produced by the growth of *Torulopsis utilis* in a substrate of cane final molasses. According to Payne (1960), this yeast was the most efficient converter of molasses to protein among the species he tested. The availability of large quantities of cane final molasses, then, offers an avenue of producing the protein concentrates now needed by the poultry industry in Hawaii. This investigation was undertaken, therefore, to determine the comparative feeding value of molasses yeast fed at graded concentrations as a replacement for soybean oil meal in the rations of growing and laying chickens.

REVIEW OF LITERATURE

In an early report, Bice (1942) found that chicks could be raised on molasses yeast at levels usually used for meat scrap, fish meal, and soybean oil meal. No indication was given, however, as to the comparative growth rates obtained on this feedstuff and the others. Klose and Fevold (1945) reported that Torula yeast grown either on molasses or prune juice was inadequate for optimum growth of chicks. This inadequacy of the protein was corrected by the addition of either methionine or methionine-rich protein to the diet. They cited the studies of Temperton and Dudley, who found that Torula yeast fed at 12 percent of total ration supported egg production as well as 10 percent fish meal in a practical style layer ration.

Torula yeasts from different parts of the world were tested by Goyco and Asenjo (1947). They found that two Torula yeasts, one from England and the other from Puerto Rico, had nearly equal nutritive coefficients. Though the nitrogen content and digestibility of the various samples of yeast were quite similar, there were marked differences in the biological values of the strains that were tested. In another study (1949), they reported that Torula yeast showed approximately the same digestibility and biological values as Brewer's yeast when tested on rats. Torula yeast, however, was inferior in its net protein value and protein efficiency.

Using Torula yeast grown on a substrate of spent liquor from the sulphite process employed in the conversion of wood pulp, Ringrose (1949) found that this yeast was inferior to soybean oil meal when each supplement was added to a basal chick ration on the basis of its crude protein content. At 6 weeks of age, the growth response of chicks fed Torula yeast was 79 percent of that obtained on the soybean oil meal basal ration. In trials with laying chickens, no significant difference in egg production was observed when the Torula yeast and soybean oil meal rations contained meat scrap as a source of protein.

Mojonnier, Hendrick, and Porter (1955) reported that yeasts were relatively poor sources of cystine and methionine. Torula yeast was found to be low in arginine, histidine, methionine, and tryptophan and high in valine, threonine, lysine, leucine, and isoleucine.

CHICK STARTER AND GROWER TRIALS

Trial 1. Wire-Floor Study

Procedure:

Three hundred sixty straight-run day-old New Hampshire chicks were wing-banded and randomized by weight into 18 groups. They were housed in Oakes wire-floor battery brooders for 3 weeks and then transferred into unheated grower batteries to 6 weeks of age. At that time all chicks were vaccinated for fowl pox

TABLE 1. Composition of experimental starter rations, trial 1

INGREDIENTS[1]	EXPERIMENTAL STARTER RATIONS								
	1	2	3	4	5	6	7	8	9
Brewers' yeast	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.5
Molasses yeast	0.0	3.0	6.0	9.0	12.0	15.0	18.0	22.5	0.0
Soybean meal	22.5	19.5	16.5	13.5	10.5	7.5	4.5	0.0	0.0
Ground yellow corn	64.5	Remainder of experimental rations 2 through 9 as shown for ration 1.							
Alfalfa meal	3.0								
Herring meal	7.0								
Defluorinated phosphate[2]	1.5								
Iodized salt	0.5								
Manganese sulfate, gm.	11.0								
Antibiotic supplement, gm.[3]	200.0								
Choline chloride, gm.[4]	200.0								
Vitamin D supplement, gm.[5]	40.0								
Vitamin B_{12}, gm.[6]	20.0								
Vitamin mix, gm.[7]	200.0								
Calculated protein,%	21.39	21.37	21.36	21.34	21.33	21.31	21.30	21.27	21.83

[1]The unit of measure is pound(s) unless otherwise specified.
[2]34.0% Ca and 17.0% P.
[3]3.6 mg. aureomycin plus appreciable vitamin B_{12} per pound.
[4]217 mg. choline per gm.
[5]3,000 I.C.U. vitamin D_3 per gm.
[6]10 mg. B_{12} per pound.
[7]Contained 2,000 mg. each of niacin, riboflavin, and calcium pantothenate; 10,000 mg. choline chloride; and 60 mg. folic acid per pound.

and moved outdoors into raised wire-floor grower pens. Each lot was provided 20 square feet of floor area to 12 weeks of age. The cockerels were removed at that time and the pullets continued as unculled lots to 18 weeks of age. Individual body weight and group feed consumption data were obtained at 6, 12, and 18 weeks. Variance analyses were based on Snedecor (1951) and differences between means were tested for significance by the use of Duncan's (1955) new multiple range and multiple F test.

The rations shown in table 1 were fed to duplicate lots of chicks to 12 weeks of age, while those shown in table 4 were fed from 12 to 18 weeks. Starter rations 1 to 8 differed only in the graded levels of molasses yeast[1] and soybean oil meal supplied in each. Ration 9 was included to provide a comparison with rations 1 and 8.

The grower rations shown in table 4 also provided graded concentrations of molasses yeast and soybean oil meal. Each ration was fed to duplicate lots in accordance with the corresponding ratio of molasses yeast and soybean oil incorporated in the chick diets.

Results of Trial 1:

The average weights of the male and female chicks at 6 weeks of age are shown in table 2. Body weights tended to decrease as the level of molasses yeast was raised beyond 12 percent, though these differences were not statistically significant up to 18 percent. Only those fed 22.5 percent were significantly lighter. Similarly, efficiency of feed conversion tended to fall as the level of molasses yeast was raised. In this comparison, the lots fed up to 12 percent molasses yeast compared favorably with the controls, while the lots receiving the higher levels (rations 6 through 9) were significantly less efficient.

The data recorded at 12 weeks of age are shown in table 3. The cockerels grew as well as the controls on levels up to 22.5 percent of molasses yeast. The statistical analysis showed no significant difference between the control and the molasses yeast diets. Only those fed 22.5 percent Brewer's yeast (ration 9) were significantly lighter than the controls. Among the pullets, all the experimental lots grew as well as the controls, indicating that these chicks were able to utilize molasses yeast effectively even up to the complete exclusion of all the soybean oil meal in the ration. No significant difference in feed efficiency was observed, although the rations containing the higher levels of molasses yeast tended to be less efficient than the control.

In comparing the results obtained on rations 8 and 9, no real difference in performance was obtained. While the cockerels fed ration 8 were somewhat heavier than those fed ration 9, the reverse observation was noted among the pullets. These differences were not statistically significant.

[1] The Cuban molasses yeast fed in these trials contained 43.5 percent protein and was provided through the courtesy and generosity of the Francisco Sugar Company, 106 Wall St., New York City.

TABLE 2. Performance of chicks to 6 weeks of age, trial 1

RATION	MEAN BODY WEIGHT AT 6 WKS. (GRAMS)		BODY WEIGHT INDEX		FEED EFFICIENCY AT 42 DAYS**	NO. BIRDS DEAD/ NO. BIRDS TESTED TO 42 DAYS OF AGE
	♂♂	♀♀	♂♂	♀♀		
1	802.0	696.0	100.0	100.0	2.02	0/40
2	818.0	695.5	101.9	102.9	2.00	0/40
3	819.0	666.5	102.1	98.6	1.99	0/40
4	815.5	697.5	101.7	103.2	2.00	0/40
5	798.0	689.0	99.5	101.9	2.07	0/40
6	781.5	651.5	97.4	96.4	2.12*	0/40
7	789.0	642.5	98.4	95.0	2.18*	2/40
8	697.5*	623.0	86.9	92.2	2.37*	3/40
9	745.0*	641.5	92.9	94.9	2.17*	0/40

Between rations:
Body weight 42 days ♂♂ F = 2.594 P 0.05 for 8 and 8 d.f.
Body weight 42 days ♀♀ F = 0.007 P 0.05 for 8 and 8 d.f.
Feed efficiency 42 days F = 4.763 P 0.01 for 8 and 8 d.f.

*Significant at the 5% level.
**Feed efficiency = pounds of feed per pound of gain.

TABLE 3. Performance of cockerels and pullets to 12 weeks of age, trial 1

RATION	MEAN BODY WEIGHT AT 12 WKS. (GRAMS)		BODY WEIGHT INDEX		FEED EFFICIENCY AT 12 WKS.**	NO. BIRDS DEAD/ NO. BIRDS TESTED TO 12 WKS. OF AGE
	♂♂	♀♀	♂♂	♀♀		
1	2028.5	1498.0	100.0	100.0	2.64	1/40
2	1977.5	1516.5	97.5	101.2	2.69	0/40
3	1984.0	1469.5	97.8	99.1	2.70	2/40
4	2068.0	1528.5	101.9	102.0	2.64	1/40
5	1907.0	1487.5	94.0	99.3	2.80	2/40
6	1917.5	1502.5	94.5	100.3	2.88	1/40
7	1992.5	1474.5	98.2	98.4	2.76	2/40
8	1936.0	1443.0	95.4	93.3	2.80	4/40
9	1892.0*	1507.0	93.3	100.6	2.75	1/40

Between rations:
Body weight ♂♂ F = 2.437 P 0.05 for 8 and 166 d.f.
Body weight ♀♀ F = 0.681 P 0.05 for 8 and 157 d.f.
Feed efficiency F = 0.256 P 0.05 for 8 and 8 d.f.

*Significant at the 5% level.
**Feed efficiency = pounds of feed per pound of gain.

TABLE 4. Composition of experimental grower rations, trial 1

INGREDIENTS[1]	EXPERIMENTAL GROWER RATIONS								
	10	11	12	13	14	15	16	17	18
Molasses yeast	0.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	12.0
Soybean meal	17.5	15.0	12.5	10.0	7.5	5.0	2.5	0.0	5.5
Ground yellow corn	71.94	Remainder of experimental rations 11 through 18 as shown for ration 10							
Alfalfa meal	4.0								
Herring meal	4.0								
Defluorinated phosphate[2]	1.56								
Iodized salt	0.5								
Manganese sulfate, gm.	10.0								
Antibiotic supplement, gm.[3]	50.0								
Choline chloride, gm.[4]	150.0								
Vitamin D_3 supplement, gm.[5]	14.0								
Vitamin mix[6]	20.0								
Calculated protein,%	17.65	17.64	17.63	17.61	17.60	17.59	17.58	17.56	17.59

[1]The unit of measure is pound(s) unless otherwise specified.
[2]34.0% Ca and 17.0% P.
[3]3.6 mg. aureomycin plus appreciable vitamin B_{12} per pound.
[4]217 mg. choline per gm.
[5]3,000 I.C.U. vitamin D_3 per gm.
[6]Contained 2,000 mg. each of niacin, riboflavin, and calcium pantothenate; 10,000 mg. choline chloride; and 60 mg. folic acid per pound.

The average weights of the pullets obtained at 18 weeks of age are shown in table 5. Upon analysis, it was found that the differences in growth rate among the experimental groups were not statistically significant. The rate of growth in this study tended to decrease as the level of molasses yeast was increased beyond 15 percent. This trend may have been influenced in part, however, by the relationship that existed at 12 weeks of age, particularly for the two lots of pullets fed ration 17.

TABLE 5. Performance of pullets to 18 weeks of age, trial 1

RATION*	MEAN BODY WEIGHT AT 18 WKS. (GM.)	BODY WEIGHT INDEX	FEED EFFICIENCY FROM 12–18 WKS.
10	2044.5	100.0	7.21
11	2082	100.8	6.81
12	1989.5	97.3	6.91
13	2053.0	100.4	7.13
14	2020.0	97.2	6.73
15	2024.5	98.8	7.28
16	2020.0	98.8	6.83
17	1965.5	96.1	7.30
18	2016.5	105.8	6.46

Between rations:
Body weight $F = 0.714$ $P > 0.05$ for 8 and 8 d.f.: no significant difference
Feed efficiency $F = 0.289$ $P > 0.05$ for 8 and 8 d.f.: no significant difference

*Two replicate groups fed each diet.

Trial 2. Litter vs. Wire-Floor Study, Involving Cane Final Molasses and Molasses Yeast

Procedure:

Inasmuch as 12 percent molasses yeast was found to be the optimum upper limit as a pound-for-pound substitute for soybean oil meal in rations fed to 12 weeks of age, this level was selected in trial 2 to be incorporated into experimental chick rations containing 0, 8, 16, and 24 percent cane final molasses. These rations are shown in table 6. Thus, ration 22 contained 24 percent cane molasses plus 12 percent molasses yeast, a total of 36 percent sugar cane by-products in the total ration.

Because the use of litter has been adopted for broiler production in Hawaii during recent years, in contrast to the use of wire floors, both systems of management were compared in this trial. Rosenberg and Palafox (1956) had shown that the incorporation of cane final molasses beyond 10 percent tended to produce moist

TABLE 6. Composition of experimental starter rations, trial 2

INGREDIENTS[1]	EXPERIMENTAL STARTER RATIONS			
	19	20	21	22
Hawaiian cane final molasses	0.00	8.00	16.00	24.00
Soybean oil meal	10.10	11.50	12.75	14.10
Ground yellow corn	65.52	56.24	47.13	37.91
Ground oyster shell	0.60	0.45	0.24	0.04
Defluorinated phosphate[2]	1.28	1.31	1.38	1.45
Molasses yeast	12.00	Remainder of experimental rations 20 through 22 as shown for 19.		
Herring meal	7.00			
Alfalfa meal	3.00			
Iodized salt	0.50			
Manganese sulfate, gm.	11.00			
Antibiotic supplement, gm.[3]	200.00			
Choline chloride, gm.[4]	200.00			
Vitamin D supplement, gm.[5]	20.00			
Niacin, mg.	900.00			
Calcium pantothenate, mg.	500.00			
Riboflavin, mg.	160.00			
Calculated protein, %	21.01	21.03	21.01	21.00

[1]The unit of measure is pound(s) unless otherwise specified.
[2]34.0% Ca and 17.0% P.
[3]3.6 mg. aureomycin plus appreciable vitamin B_{12} per pound.
[4]217 mg. choline per gm.
[5]3,000 I.C.U. vitamin D_3 per gm.

droppings. Also, other trials had shown that coccidiosis was a problem when litter-reared chicks were fed high levels of cane final molasses. Thus, an interaction was involved in these studies by adding two types of coccidiostatic drugs, as described below.

This study, then, was conducted with 12 groups of chicks, involving three systems of management. In treatment A four groups, each containing 30 chicks, were reared in Oakes battery brooders to 21 days of age, in unheated wire-floor grower batteries to 42 days of age, and in outdoor raised wire-floor grower pens to 70 days. In treatment B four lots, each containing 104 chicks, were reared in 6′ × 10′ pens on litter under heat ray lamps to 28 days of age. They were then transferred to 9′ × 10′ raised wire-floor grower pens to 70 days. The chicks in this treatment received 0.003 percent glycamide throughout the 70-day study. In treatment C the chicks were reared on litter throughout the trial and received 0.0125 percent aquanoxaline in the test rations. In treatment D, the chicks were treated as in C but received 0.003 percent glycamide instead of aquanoxaline during the 70-day study. In treatments C and D there were 52 chicks randomized into each of the respective subgroups. All chicks were vaccinated for fowl pox at 6 weeks of age.

Each of the four rations shown in table 6 was fed, respectively, to four lots of chicks. The results of this trial are shown in table 7.

TABLE 7. Summary of data obtained from litter vs. wire-floor pens at 10 weeks of age, trial 2

	TREATMENTS*			
	A	B	C	D
Average body weight, gm.:				
cockerels	1522	1460	1431	1494
pullets	1165	1137	1122	1166
No. birds dead/total birds tested	3/120	21/416	6/208	0/208
Pounds of feed per pound of gain	2.71	2.76	2.86	2.84

*No significant difference was observed between treatments in the economic characters studied.

Results of Trial 2:

The analysis of variance of 10-week body weights showed no significant difference either between rations, regardless of system of management, or between systems of management, regardless of rations. This study showed that with proper precautions against coccidiosis it was possible to rear chicks on litter to 10 weeks of age, feeding as much as 24 percent cane final molasses plus 12 percent molasses yeast, with results comparable to chicks raised on wire and fed comparable diets. Feed efficiency ranged from 2.71 to 2.86 (table 7). Birds raised on wire were the most efficient. Those raised on litter and then transferred to wire were next, whereas those raised on litter throughout were the least efficient. These data corroborate previous results obtained at this station. Also, feed efficiency of chickens became poorer with increased concentrations of molasses in the diet.

LAYER TRIALS

Trial 1. Molasses Yeast Rations Containing Herring Meal

Procedure:

Three hundred forty-two 24-week-old New Hampshire pullets were randomized into 18 lots according to weight and apparent sexual maturity. Each group was housed in a raised wire-floor, wire-wall pen, 9′ × 10′ in size. All lots received the control ration for 2 weeks in order to establish reliability of randomization. The test rations shown in table 10 were gradually introduced during a 2-week period and then fed during the test interval of 20 weeks. Each ration was fed to three subgroups selected at random. As in the chick trials, the test rations differed in the concentrations of molasses yeast and the soybean oil meal they replaced. As shown in table 8, ration 1 contained 14.2 percent soybean oil meal and no molasses yeast, while ration 6 contained 14.2 percent molasses yeast and no soybean oil meal. All the rations contained 4.0 percent herring meal.

TABLE 8. Composition of experimental layer rations, trials 1 and 2

INGREDIENTS[1]	TRIAL 1						TRIAL 2					
	23	24	25	26	27	28	29	30	31	32	33	34
Molasses yeast	0.0	3.0	6.0	9.0	12.0	14.2	0.0	4.0	8.0	12.0	16.0	21.0
Soybean oil meal	14.2	11.2	8.2	5.2	2.2	0.0	21.0	17.0	13.0	9.0	5.0	0.0
Herring meal	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
Ground yellow corn	75.7	75.7	75.7	75.7	75.7	75.7	69.5	69.5	69.5	69.5	69.5	69.5
Defluorinated phosphate[2]	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.4
Alfalfa meal	3.0	Remainder of rations 24 through 34 as shown in ration 23										
Iodized salt	0.5											
Manganese sulfate, gm.	6.0											
Choline chloride, gm.[3]	100.0											
Vitamin D supplement	30.0											
Niacin, mg.	400.0											
Riboflavin, mg.	50.0											
Thiamine HCl, mg.	60.0											
Calculated protein	16.4	16.4	16.3	16.3	16.3	16.4	16.0	16.0	16.0	15.9	15.9	15.9

[1]The unit of measure is pound(s) unless otherwise specified.
[2]34.0% Ca and 17.0% P.
[3]217 mg. choline per gm.
[4]3,000 I.C.U. vitamin D_3 per gm.

Results of Trial 1:

Egg Production

The egg production record of the 18 lots of pullets is shown in table 9. Following 20 weeks on the experimental diets, no significant difference in egg production was found between treatments. Indeed, the three control subgroups averaged 68.4 percent hen-day egg production, while the lots receiving the highest level of molasses yeast averaged 70.3 percent. No real effect of rations on egg size, frequency of meat and blood spots, and soft shell and broken eggs was detected (table 9).

TABLE 9. Summary of data obtained in trial 1[1]

	EXPERIMENTAL LAYER RATIONS[2]					
	23	24	25	26	27	28
Average hen-day egg production,%	68.4	66.7	69.6	67.5	70.8	70.3
Average egg weight, gm.[3]	55.1	53.6	54.8	55.9	54.9	54.9
Frequency of meat and blood spots,%[4]	6.2	7.5	6.9	6.5	6.5	7.1
Average soft shell and broken eggs,%	9.6	8.1	8.2	8.5	12.2	8.4
Average gains of survivors, gm.	245.9	193.2	262.6	265.4	245.2	212.0
Average mortality,%	17.5	22.8	15.8	14.0	19.3	8.8
Pounds of feed per dozen eggs[3]	4.19	4.18	4.16	4.09	4.06	4.07
Cost of feed per dozen saleable eggs	$0.283	$0.281	$0.280	$0.276	$0.274	$0.274

[1]No significant difference between rations was noted in the economic characters studied.
[2]Each ration was fed to three replicate groups from 28–48 weeks of age.
[3]Only eggs delivered to egg room included in analysis.
[4]Detected by candling all eggs delivered to egg room.

Body weight

The data recorded for average gains of survivors by lots are shown also in table 9. Upon analysis, these data showed no real difference either due to experimental rations or among replicates fed the same ration.

Mortality

Livability was not adversely affected by the concentrations of molasses yeast fed in this study. These data are shown in table 9. As may be seen therein, the three subgroups fed ration 6 suffered approximately one-half the mortality shown by the controls. The lower levels of mortality at the higher concentrations of molasses yeast indicated these differences could be attributed to chance alone.

Efficiency of feed conversion

When the data of the three replicate lots fed each ration were averaged, as shown in table 9, it was found that all the experimental rations containing molasses yeast were more efficient than the control. The analysis of variance, however, showed no real difference either between treatments or replicates within treatments.

Cost of feed per dozen eggs

The cost analysis of the experimental rations was based on the price of ingredients charged the University of Hawaii. Because no cost factor was available for the molasses yeast, the same price was assigned as for the soybean oil meal. The data shown in table 9 revealed no significant difference among the experimental rations in cost to produce a dozen saleable eggs.

Trial 2. Molasses Yeast Rations Without Animal Protein

Procedure:

The same procedure of randomization was employed in layer trial 2 with the following differences: At the time of randomization the pullets were 31 weeks old; the test period was shortened to 12 weeks; and 18 pullets were available for each of the three replicates fed each ration. Rations 7 through 12, as shown in table 8, were fed during the test period.

No herring meal was fed in the second experiment. Thus, ration 7 contained 21 percent soybean oil meal and no molasses yeast, while ration 12 contained 21 percent molasses yeast and no soybean oil meal. This was done to test more rigorously the nutritive value of molasses yeast when not protected by a source of animal protein, in this instance herring meal.

Results of Trial 2:

Egg production

Following 12 weeks on the experimental rations, no significant difference in hen-day egg production was found. As may be seen in table 10, however, all the lots fed molasses yeast tended to lay somewhat less than the control. Egg weight, frequency of meat and blood spot eggs, and percentage of soft shell and broken eggs proved not to be adversely affected by the exchange of molasses yeast for soybean oil meal, even to the complete replacement of soybean oil meal.

Body weight

The data collected on body weight are shown in table 10. The lots fed rations 30, 31, and 32 gained more, while those fed rations 33 and 34 gained less than the control. These differences, however, were not statistically significant.

Mortality

Livability was also not adversely affected by the experimental treatments. As may be seen in table 10, mortality among the lots fed graded levels of molasses yeast ranged above and below the control, but these values proved to be nonsignificant either between treatment or among replicates within treatments.

TABLE 10. Summary of data obtained in trial 2[1]

	EXPERIMENTAL LAYER RATIONS[2]					
	29	30	31	32	33	34
Average hen-day egg production,%	73.80	68.50	72.13	69.76	67.93	69.90
Average egg weight, gm.[3]	55.16	55.37	55.82	55.57	56.05	54.59
Frequency of meat and blood spots,%[4]	5.61	5.08	4.26	5.31	5.18	6.09
Average soft shell and broken eggs,%	6.03	4.62	4.99	7.18	5.69	6.82
Average gains of survivors, gm.	167.8	217.5	237.4	208.1	126.4	121.6
Average mortality,%	7.4	7.4	7.4	11.1	1.9	5.6
Pounds of feed per dozen eggs[3]	4.39	4.64	4.79	4.84	4.53	4.60
Cost of feed per dozen saleable eggs	$0.253	$0.263	$0.272	$0.257	$0.257	$0.261

[1]No significant difference between rations was noted in the economic characters studied.
[2]Each ration was fed to three replicate groups from 31–43 weeks of age.
[3]Only eggs delivered to egg room included in analysis.
[4]Detected by candling all eggs delivered to egg room.

Efficiency of feed conversion

All of the lots fed graded levels of molasses yeast were less efficient than the controls in converting feed into saleable eggs. As shown in table 10, the controls required 4.39 pounds of feed per dozen eggs, while those lots fed rations 8 through 12 required 4.64, 4.79, 4.84, 4.53, and 4.60, respectively. Nevertheless, upon analysis of these data, there was no significant difference between treatments.

Cost of feed per dozen eggs

No statistically significant difference among the experimental rations was found in the cost of feed per dozen saleable eggs. However, the control ration proved to be the most economical, though the differences were small. As may be seen in table 10, rations 30 through 34 were 1.0, 1.9, 0.4, and 0.8 cent more costly than the control for each dozen saleable eggs produced.

DISCUSSION AND CONCLUSIONS

Starter and Grower Rations

Trial 1

The body weight data recorded at 12 weeks of age showed that male chicks tolerated molasses yeast rather well, although growth rates comparable to the controls were obtained on levels not exceeding 9 percent of total ration. Female chicks, in contrast, grew as well as their controls on levels of molasses yeast ranging up to 18 percent of total ration. Even at the complete substitution of soybean oil meal, 22.5 percent of total ration, the growth of the test pullets was 96.8 percent that of the controls. When the female chicks were continued to 18 weeks of age on comparable levels of molasses yeast, though the rations were modified in accordance with the nutritive requirements for growing pullets, the pullets fed rations 11 through 15 grew as well as the controls. Even those fed ration 16, containing 15.0 percent molasses yeast, grew 98.9 percent as well as the control. If growth rate, *per se*, were evaluated in the light of well-grown pullets raised for egg production, then ration 17, wherein all the soybean oil meal was replaced by molasses yeast, also proved to be a good ration.

The data on efficiency of feed consumption for male chicks to 12 weeks of age and female chicks at 12 and 18 weeks of age showed that substitution of molasses yeast for soybean oil meal, on a pound-for-pound basis, did not adversely affect the results.

The results of this study revealed that molasses yeast, protected by herring meal (7.0 percent in chick rations and 4.0 percent in grower rations), could successfully replace 40 percent of the soybean oil meal in cockerel rations to 12 weeks of age and 100 percent of the soybean oil meal in pullet rations to 18 weeks of age. These observations indicate that male and female chicks, when raised separately, may be advantageously fed different levels of molasses yeast. Were a price differential available, the alternate use of one for the other could be used to advantage. Even at the same price, this study showed that molasses yeast could replace soybean oil meal quite effectively, as indicated above, when chicks are raised exclusively on wire. The data also indicated that the substitution of molasses yeast for soybean oil meal beyond 40.0 percent resulted in a retarded growth rate among male chicks, although the differences were not statistically significant.

Trial 2

This investigation revealed that it was possible to incorporate as much as 24 percent cane final molasses and 12 percent molasses yeast in rations fed to chicks that were reared on litter throughout to 10 weeks of age with results comparable to lots reared on raised wire floors. Although the moist droppings from chicks fed rations 21 and 22 tended to compact the litter and create a somewhat undesirable appearance, no adverse effects on livability and growth were noted. Apparently, the inclusion of coccidiostatic drugs in the feed from 1 day of age, particularly glycamide, proved adequate to prevent coccidiosis. Thus, it may be assumed that as much as 36 percent of starter rations can be composed of sugar cane by-products to the exclusion of a like amount of ground yellow corn and soybean oil meal.

Layer Rations

From the results obtained in the layer trials, it may be concluded that molasses yeast, supplemented by 4 percent herring meal, may be used successfully as a partial or complete substitute for soybean oil meal. By all the standards of comparison used in this study, the rations containing graded levels of molasses yeast compared well with the control. No real differences were found in egg production, body weight gain, livability, efficiency of feed utilization, and cost of feed per dozen saleable eggs produced.

Apparently, herring meal provides certain essential amino acids lacking in molasses yeast. As previously indicated, Mojonnier, *et al.* (1955) reported that Torula yeast was found to be low in arginine, histidine, methionine, and tryptophan. This observation is given further support by the results obtained in trial 2 on egg production and efficiency of feed conversion into eggs. For these traits, molasses yeast not supplemented with herring meal tended to be less satisfactory than soybean oil meal. Although not statistically significant, it was nonetheless uniformly observed that egg production, with the exception of ration 9, ranged 3.9 to 5.9 percent below the control, and the cost of feed per dozen eggs for all the molasses yeast rations ranged from 0.4 to 1.9 cents higher. No real effect or uniform trend was observed for such traits as egg size, meat and blood spot eggs, percentage of soft shell and broken eggs, and body weight increase.

These findings support the conclusion that molasses yeast, if properly priced in comparison with soybean oil meal, can become a valuable source of plant protein in chick, grower, broiler, and layer rations, provided adequate supplementation of certain essential amino acids is provided. Herring meal, at 7 percent in chick rations and 4 percent in grower and layer rations, provided adequate supplementation to permit the complete substitution of molasses yeast for soybean oil meal with optimum results. From this it follows that molasses yeast, readily produced on a substrate of cane final molasses, could be produced for use in poultry rations wherever sugar cane is grown. This finding has wide applicability and importance, moreover, because protein, *per se*, tends to be limited among the natural products and by-products produced agriculturally in the tropical nations. If economically feasible, this finding may contribute toward greater self-sufficiency and, thus, greater economic stability among communities, such as Hawaii, where plant protein is nearly lacking and therefore must be imported.

SUMMARY

Graded levels of molasses yeast substituted for soybean oil meal on a pound-for-pound basis were fed to replicated groups of straight-run New Hampshire chicks. Supplemented with 7 percent herring meal, the test rations, containing up to 22.5 percent molasses yeast, supported growth well to 12 weeks of age. Among male chicks, however, the upper level of substitution that provided growth rates equal to the controls appeared to be 9 percent of total ration or 40 percent of the amount of soybean oil meal included in the control ration. Among the female chicks, the test rations were essentially equal to the controls even at 100 percent substitution. Pullet chicks continued from 12 to 18 weeks of age on comparable levels of substitution, supplemented with 4 percent herring meal, grew 98.9 percent as fast as the controls when 85.6 percent of the soybean oil meal was replaced by molasses yeast. Even at complete replacement, the pullets weighed 96.3 percent as much as the controls. Pullets fed 22.5 percent Brewer's yeast were heavier than those

fed molasses yeast, though the difference was not statistically significant. No significant difference in feed efficiency was noted among the treatments at either 12 or 18 weeks.

Chicks reared to 10 weeks of age either on wire floors, on litter to 4 weeks and then transferred to wire floors, or on litter floors only showed no real differences in growth rate and efficiency of feed utilization when fed rations containing graded levels of cane final molasses up to 24 percent of total diet plus 12 percent molasses yeast. The inclusion of 0.003 percent glycamide as a coccidiostatic drug appeared to support somewhat superior growth rates than 0.0125 percent aquanoxaline when these compounds were included in the test diets throughout the 10-week study.

In a layer experiment lasting 20 weeks it was found that molasses yeast supplemented with 4 percent herring meal successfully replaced all the soybean oil meal included in the control ration. No statistically significant difference attributable to experimental rations was observed for such characters as hen-day egg production, egg weight, meat and blood spots, soft shell and broken eggs, increase in body weight, and mortality. Efficiency of feed conversion into saleable eggs was also not adversely affected. When the cost of feed per dozen saleable eggs was compared, molasses yeast rations 24 through 28 produced a dozen eggs on the average 0.2, 0.3, 0.7, 0.9, and 0.9 cent cheaper, respectively, than the control.

In a second layer trial lasting 12 weeks, no herring meal was included in the test rations. All the lots fed graded concentrations of molasses yeast tended to lay less well than the controls, although the differences were not statistically significant. Egg weight, meat and blood spots, and soft shell and broken eggs proved not to be adversely affected by the exchange of molasses yeast for soybean oil meal, even to the complete exchange of soybean oil meal. No real trend was noted in livability and body weight increase of survivors. All the lots fed the molasses yeast rations were less efficient than the soybean oil meal control, although the differences were also not statistically significant. Most important, rations 30 through 34 were found to be 1.0, 1.9, 0.4, 0.4, and 0.8 cent more costly than control ration 29 for each dozen of saleable eggs produced.

These data support the conclusion that molasses yeast may be used quite effectively as a substitute for soybean oil meal, as described in these studies, when protected by the inclusion of herring meal at 7 percent of total diet in chick and broiler rations and 4 percent in grower and layer rations.

These findings may find greatest usefulness in tropical regions where cane final molasses is produced and plant proteins are deficient.

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