Whey-Grown Yeast as a Protein Source for Baby Pigs

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Story in Brief

The nutritive value of whey-grown yeast for baby pigs was examined. In experiment one, 25 pigs were randomly assigned to four diets containing 0.9 percent total lysine with 0, 25, 50 and 75 percent lysine furnished by whey-yeast and the rest from soybean meal, and one ration at 0.8 percent lysine with all supplemental lysine from soybean meal. Including whey-yeast in the diet improved gains a mean of 18 percent. The highest level of yeast fed improved feed efficiency by 35 percent and protein efficiency ratio by 53 percent.

In Trial 2, 25 pigs were allotted on a basis of litter to four diets containing 0.9 percent lysine with 0, 50, 75 and 83 percent lysine furnished by whey-yeast and one ration at 0.8 percent lysine with all supplemental lysine from soybean meal. At 0.9 percent dietary lysine, the corn-whey-yeast diet improved rates of gain, feed utilization and protein efficiency ratio by 28, 23 and 51 percent over the corn-soybean meal diet.

In Trial 3, 24 pigs were assigned to four diets containing 0.9 or 1.0 percent lysine from yeast or soybean meal. At both 0.9 and 1.0 percent levels of dietary lysine, whey-yeast produced higher rates of gain (34 and 24 percent, respectively) and better feed and protein utilization than soybean meal.

It was concluded that whey-grown *Kluyveromyces fragilis* yeast, at levels up to 12 percent of the diet, has no adverse effects on baby pigs and that whey-yeast protein was superior to soybean meal protein for growth rate and feed efficiency of baby pigs by means of 30 and 33 percent.

Introduction

Disposal of whey, a byproduct of the cheese industry, is a major industrial problem. Work to-date at OSU has shown promise in the use of yeast to reduce the total solids and biological oxygen demand of the waste whey. In the process, a 65 percent protein whey-yeast byproduct is produced in large amounts. Studies indicate that yeast proteins are apparently toxicologically safe and economical supplements for swine. However, variations in strains of yeast, the nature of the substrate used in producing yeast and differences in preparation and handling procedures require further research.

In this study, the effect of whey-grown yeast on feed consumption, growth, efficiency of feed and protein utilization in the young pig was investigated.

Materials and Methods

Three feeding experiments were conducted with a total of 74 Yorkshire male baby pigs to evaluate whey-grown *Kluyveromyces fragilis* yeast (Table 1) as a dietary protein source. The three experiments differed in design and treatment combinations but were similar in diet preparation and animal management practices. Corn and the whey-yeast used were ground through 1/8 inch and 1/16 inch screens.

Individual feeding crates equipped with self-feeders and automatic waterers were used to house pigs. Feed and water were supplied free choice. Quantity of feed offered, feed wastage and feed refusal were recorded.

Table 1. Analysis of whey-grown *kluyveromyces fragilis* yeast as compared to soybean meal.

Item	% of as-fed product	
	K. fragilis	*Soybean meal**
Moisture	8.59	11.0
Calcium	.27	.32
Phosphorus	.40	.67
Protein (N x 6.25)	63.07-67.04	45.8
Amino acid (g/100g C.P.)		
Alanine	3.99	-
Arginine	1.89	3.20
Aspartic acid	8.18	-
Cystine	3.33	.67
Glutamic acid	11.21	-
Glycine	1.90	-
Histidine	1.23	1.10
Isoleucine	3.36	2.50
Leucine	8.24	3.40
Lysine	6.92	2.90
Methionine	1.49	.60
Phenyalanine	2.89	2.20
Proline	3.62	-
Serine	3.63	-
Threonine	3.88	1.70
Tryptophan	-	.60
Tryosine	2.53	1.40
Valine	3.53	2.40

*Figures obtained from N.R.C. (1973).
-Value not determined.

In experiment one, 25 pigs averaging 3.5 weeks old and 13.3 lb in initial weight were randomly assigned to five treatments. Treatments comprised five corn-soybean meal diets formulated on the basis of total dietary lysine (Table 2). Whey-yeast furnished 0, 0, 25, 50 and 75 percent of the total lysine in diets 1, 2, 3, 4 and 5, respectively.

In the second experiment, 25 pigs (five from each of five litters) averaging 3.5 weeks old and 13.5 lb in initial body weight were randomly allotted to five diets on the basis of litter. The treatments (Table 3) comprised diets 1 and 2 used in experiment one and diets 3, 4 and 5 in which whey-yeast lysine formed 50, 75 and 83 percent of total lysine. All the soybean meal was replaced by whey-yeast in diet 5.

In experiment three, 24 pigs averaging 3.5 weeks of age and 13.0 lb in initial body weight were randomly allotted to four dietary treatments (Table 4) with two sources (soybean meal and whey-yeast) and two levels of protein.

Results and Discussion

Problems encountered with early weaning of baby pigs include digestive disorders associated with diarrhea and/or depressed appetite and slow adaptation to dry feed. These problems are more common with some diets than others. The data obtained at the end of the first week of experiments one and two were analyzed to determine the effect, if any, of whey-yeast on the ability of pigs to adapt to the feed regime.

During the first week of experiment one, no significantly different response of pigs to the treatments were observed with respect to average daily gain, average daily feed

Table 2. Calculated composition of diets used in experiment 1.

Ingredients	% Composition (as-fed) Diet No. 1	2	3	4	5
Corn	73.61	70.10	74.45	78.79	83.10
Soybean meal	23.12	26.69	18.66	10.62	2.62
Whey-grown yeast	-	-	3.67	7.34	11.01
DL-methionine (98% pure)	0.22	0.20	0.15	0.10	0.05
Dicalcium phosphate	0.27	0.23	0.31	0.40	0.49
Calcium carbonate	1.68	1.68	1.66	1.65	1.63
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05	0.05
Calculated analysis					
Crude protein (N x 6.25)	16.65	17.91	17.08	16.23	15.41
Calcium	0.80	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59	0.59
Lysine, total	0.80	0.90	0.90	0.90	0.90
Methionine + cystine	0.74	0.74	0.76	0.76	0.76
Tryptophan*	0.20	0.22	0.18*	0.13*	0.09*
Yeast lysine (% of total)	-	-	25.00	50.00	75.00

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan was expected to come from whey-yeast.

Table 3. Calculated composition of diets used in experiment 2.

Ingredients	% Composition (as-fed) Diet No. 1	2	3	4	5
Corn	73.61	70.10	78.79	83.10	84.55
Soybean meal	23.12	26.69	10.62	2.62	-
Whey-grown yeast	-	-	7.34	11.01	12.20
DL-methionine (98% pure)	0.22	0.20	0.10	0.05	-
Dicalcium phosphate	0.27	0.23	0.40	0.49	0.52
Calcium carbonate	1.68	1.68	1.65	1.63	1.63
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05	0.05
Calculated analysis					
Crude protein (N x 6.25)	16.65	17.91	16.23	15.41	15.13
Calcium	0.80	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59	0.59
Lysine, total	0.80	0.90	0.90	0.90	0.90
Methionine + cystine	0.74	0.74	0.76	0.76	0.68
Tryptophan	0.20	0.22	0.13*	0.09*	0.08*
Yeast lysine (% of total)	-	-	50.00	75.00	83.00

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan expected from whey-yeast.

Table 4. Calculated composition of diets used in experiment 3.

	% Composition (as-fed)			
	Diet No.			
Ingredients	1	2	3	4
Corn	70.04	85.80	69.90	85.66
Soybean meal	26.69	-	26.70	-
Whey-grown yeast	-	10.85	-	10.86
DL-methionine (98% pure)	0.27	0.10	0.27	0.10
Lysine hydroxychloride (78.5% lysine)	-	-	0.13	0.13
Dicalcium phosphate	0.23	0.51	0.23	0.51
Calcium carbonate	1.67	1.64	1.67	1.64
Vitamin T.M. premix[a]	0.75	0.75	0.75	0.75
Salt, iodized	0.30	0.30	0.30	0.30
Aureomycin	0.05	0.05	0.05	0.05
Calculated analysis				
Crude protein (N x 6.25)	17.91	14.39	17.90	14.39
Calcium	0.80	0.80	0.80	0.80
Phosphorus	0.59	0.59	0.59	0.59
Lysine, total	0.90	0.90	1.00	1.00
Methionine + cystine	0.73	0.73	0.73	0.73
Tryptophan	0.22	0.08*	0.22	0.08*

[a]Vitamin T.M. premix supplied 300,000 IU Vitamin A; 22,500 IU Vitamin D; 300 mg Riboflavin; 1500 mg Pantothenic acid; 2250 mg Niacin; 60,000 mg Choline; 1.13 mg Vitamin B_{12}; 750 IU Vitamin E; 150 mg Menadione sodium bisulfite; 15 mg iodine; 6.75 gm iron; 1.50 gm Manganese; 0.75 gm Copper; 6.75 gm Zinc and 7.50 mg Selenium per 100 pounds of feed.

*Additional tryptophan comes from whey-yeast.

consumption and average gain: feed (feed efficiency) ratio (Table 5). Although the level of protein in the diet decreased as graded levels of whey-yeast lysine were substituted for 25, 50 and 75 percent of total lysine (Table 5), average daily protein intake values were not affected. Since carryover effects of previous nutritional management and change of housing environment were common to all pigs, these results indicate that whey-yeast has no adverse or positive effects on adaptation of baby pigs to the diet.

Over the entire five-week period of the experiment one (Table 6), the inclusion of up to 11 percent whey-yeast in the diet did not reduce feed consumption. Average daily gain tended to be improved (23, 4 and 30 percent when 25, 50 and 75 percent of the 0.9 percent dietary lysine was supplied by whey-yeast). Feed efficiency and protein efficiency ratios were higher when whey-yeast was added to the diet at any level.

At the highest level of whey-yeast fed, improvements of 35 and 53 percent in feed efficiency and protein efficiency ratio were obtained. Advantage of whey-yeast over soybean meal as a source of protein when fed to baby pigs with corn as an energy source was implicated in this experiment.

During the first week of experiment two, no treatment differences existed with respect to rate of gain, feed consumption, efficiency of feed utilization, protein intake or protein efficiency ratio (Table 7). Over the entire five-week period of experiment two (Table 8), the inclusion of whey-yeast in the diet improved rate of gain, feed efficiency and protein efficiency ratio when 0.9 percent lysine was fed.

Best performance was obtained when all the soybean meal lysine was replaced with whey-yeast lysine. The corn-whey yeast diet (diet 5) produced 28, 23 and 51 percent greater rates of gain, feed efficiency and protein efficiency ratio, respectively, than the corn-soybean meal diet. The results of this experiment corroborate those of experiment one. Overall pig performance improved with increasing dietary levels of whey-yeast lysine.

Table 5. Performance of pigs during the first week of experiment 1.

Variable	Diet Number 1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	25	50	75
No. of pigs	5	5	5	5	5
Avg initial wt, lb	13.9	14.0	12.5	13.4	12.8
Avg daily feed, lb*	0.42	0.61	0.53	0.64	0.58
Avg daily gain, lb	0.09	0.06	0.19	0.11	0.21
Avg feed efficiency gain/feed	−0.04	−0.04	0.32	0.08	0.32
Avg daily protein, lb	0.08	0.13	0.11	0.12	0.11
Avg protein efficiency, gain/protein	−0.23	−0.19	1.60	0.41	1.69

*Average daily feed dry matter intake.

Table 6. Performance of pigs over the entire 5-week period of experiment 1.

Variable	Diet Number 1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	25	50	75
No. of pigs	5	5	5	5	4
Avg initial wt, lb	13.9	14.0	12.5	13.4	12.8
Avg daily feed, lb*	1.47	1.53	1.59	1.43	1.49
Avg daily gain, lb	0.47[a]	0.64[ab]	0.79[b]	0.67[ab]	0.84[b]
Avg gain/feed	0.31[a]	0.41[ab]	0.50[bc]	0.46[bc]	0.56[c]
Avg daily protein, lb	0.28	0.33	0.32	0.28	0.28
Avg gain/protein	1.64[a]	1.93[ab]	2.48[bc]	2.40[bc]	2.96[c]

*Average daily feed dry matter intake.
[abc]Means in a row with different superscripts differ significantly ($P<.05$).

Table 7. Performance of pigs during the first week of experiment 2.

Variable	Diet number 1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	50	75	83
No. of pigs	5	5	5	5	5
Avg initial wt, lb	11.4	13.7	12.6	15.2	15.2
Avg daily feed, lb*	0.83	0.89	0.99	1.01	0.96
Avg daily gain, lb	0.00	1.11	0.10	0.07	0.11
Avg gain/feed	−0.04	0.09	0.11	0.06	0.12
Avg daily protein, lb	0.16	0.19	0.20	0.19	0.17
Avg gain/protein	−0.22	0.42	0.58	0.32	0.65

*Average daily feed dry matter intake.

Table 8. Performance of pigs over the entire 5-week period of experiment 2.

Variable	Diet number 1	2	3	4	5
Total lysine, %	0.80	0.90	0.90	0.90	0.90
Whey-yeast lysine, % of total	-	-	50	75	83
No. of pigs	5	5	5	5	5
Avg initial wt, lb	11.4	13.7	12.6	15.2	15.2
Avg daily feed, lb*	1.24	1.29	1.36	1.34	1.34
Avg daily gain, lb	0.41[a]	0.51[ab]	0.62[bc]	0.60[bc]	0.65[c]
Avg gain/feed	0.33[a]	0.39[ab]	0.46[bc]	0.45[bc]	0.49[c]
Avg daily protein, lb	0.23	0.28	0.27	0.25	0.24
Avg gain/protein	1.74[a]	1.83[a]	2.32[b]	2.35[b]	2.75[b]

*Average daily feed dry matter intake.
[abc]Means in a row with different superscripts differ significantly (P<.05).

Table 9. Performance of pigs over the 5-week period of experiment 3.

Variable	Diet number 1	2	3	4
Diet composition*	CSBM	CWY	CSBM	CWY
Total lysine, %	0.90	0.90	1.00	1.00
No. of pigs	6	5	5	5
Avg daily feed, lb**	1.41	1.36	1.30	1.43
Avg daily gain, lb	0.53	0.71	0.62	0.77
Avg gain/feed	0.37[a]	0.52[b]	0.47[ab]	0.64[c]
Avg daily protein	0.28[a]	0.22[b]	0.26[a]	0.21[b]
Avg gain/protein	1.92[a]	3.15[b]	2.35[a]	3.72[b]

*CSBM-corn/soybean meal diet.
**CWY-corn/whey-yeast diet.
[abc]Means in a row with different superscripts differ significantly (P<.05).

The results of experiment three are presented in Table 9. At both .90 and 1.00 percent dietary lysine, the source of protein did not affect feed consumption. Corn-whey-yeast diets produced faster growth rates at both levels of dietary lysine than did corn-soybean meal diets. Within each level of dietary lysine, corn-whey-yeast diets produced greater feed efficiency (P<.05) and protein efficiency ratio (P<.05) than corn-soybean meal diets.

The level of dietary lysine had no effect on pig performance (P<.05) when pigs were fed corn-soybean meal diets but when fed corn-whey-yeast diets, pigs showed greater feed efficiency and protein efficiency ratio at 1.00 percent than at 0.9 percent dietary lysine.

If lysine and protein were the limiting factors of performance, then the pigs fed 1.0 percent lysine in the corn-soybean meal diet at 17.9 percent protein should have performed better than those fed .90 percent lysine in the corn-whey-yeast diet at 14.39 percent protein. Since pigs fed the higher level of lysine and protein did not perform as well, this suggests that protein was not a limiting factor and that lysine and/or other dietary indispensible amino acids may have been more readily available from whey-yeast than from soybean meal.

As long as the baby pig's requirement for dietary lysine is met, the level of protein in the diet is a function of the source of protein and can be as low as 14 percent for whey-yeast based cereal diets without depressing gain.

In this experiment, pigs fed corn-whey-yeast at 14.4 percent protein and .9 percent dietary lysine had 35, 40 and 65 percent greater rate of gain, gain: feed ratio and gain: protein ratio, respectively, than those pigs fed the corn-soybean meal diet at 0.9 percent lysine and 17.9 percent crude protein. At 1.0 percent lysine (14.3 percent protein), the corn-whey-yeast diet produced 25, 35 and 59 percent greater average daily gain, feed efficiency and protein efficiency ratio over the 17.9 percent protein corn-soybean meal diet.

The results of this study indicate that whey-yeast protein is consistently superior to soybean meal protein for baby pigs. The reasons for this are unclear; however, whey-yeast protein contains higher levels of most indispensible amino acids than soybean meal protein. The possibility of whey-yeast lysine being more readily available to the pig than soybean meal lysine is suggested in this study.

Literature Cited

N.R.C. 1973. Nutrient Requirements of Domestic Animals, No. 2. Nutrient requirements of swine. National Academy of Science - National Research Council, Washington, DC.

Influence of Protein Intake, Energy Intake and Stage of Gestation on Protein Status of the Gestating Gilt

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Story in Brief

Thirty-six crossbred gilts were fed three levels of protein (8, 14 and 20 percent protein diets) and two levels of energy (approximately 6200 kcal DE/day and 6200 kcal DE/day + 20 percent) throughout gestation. Five-day nitrogen balance studies were conducted at early (0-30 days), mid (30-60 days) and late (60-90 days) gestation. At slaughter (90 days gestation), reproductive tracts were evaluated for reproduction performance and samples of the reproductive tract and semimembranosus muscle were analyzed for crude protein.

The results of this experiment suggest that an 8 percent protein ration during gestation is just as effective as the higher levels of crude protein intake for litter size or storage of protein in the reproductive tissue. However, storage of protein in muscle tissue increased as protein level was increased to levels from 14 to 20 percent crude protein. No advantage for the higher energy diets for these traits was noted.

Introduction

Several recent studies have been unable to establish a relationship between protein or energy intake on subsequent litter size or pig weight at birth. This suggests that the gestating gilt or sow is able to utilize tissue stores for the normal development of