THE EFFECT OF YEAST AND YEAST PRODUCTS ON THE EFFICIENCY OF A LIVESTOCK RATION

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INTRODUCTION

From time to time various yeast culture feeds and processes for fermenting or pre-digesting feeds for various classes of livestock have been exploited by clever promoters. Claims have been made that these processes would save one-third to one-half of the feed usually supplied livestock and would result in better production than normal rations.

These processes usually consist in grinding or chopping the feed, treating it with a solution containing the "convertor" and then allowing the mixture to remain in a tank or other container for several hours where it undergoes fermentation.

The "convertor", which usually contains malt, yeast and often other constituents, is suppose, according to claims made by the promoters, to pre-digest the feed, breaking down the crude fiber and reducing the other complex organic compounds to simpler and more digestible compounds, thereby relieving the digestive system of the animal's body from so much strain in the digestive process. In this way more of the energy value of the feed is available for the production of meat, milk, work etc. In one process it was even claimed that the "convertor" would change the carbohydrates into protein.

An example of a very attractive claim made for processing feeds, preparatory to feeding livestock, was made in the Breeder's Gazette for February 1928. Arnold P. Yerkes stated that "by cutting feeds and packing them in presses, adding water and the "convertor", that even coarse or damaged rough-

age would be entirely consumed by livestock and with good results."

Mr. Yerke's statements were rather scathingly refuted by Judge J. E. Foster in the April issue of the same magazine. He pointed out that no authentic experimental data was cited in backing up the statements made by Yerkes.

In a rebutal, printed in the same issue of the Breeder's Gazette, Yerkes cited the Moosehart Farms at Moosehart Illinois as a farm where this processing of feeds had been used successfully for two winters on feeds for their dairy cattle and horses. The following table was given:

Table I.

	Milk Prod.	Av. Test %	Grain Cost $	Roughage cost	Value Milk $	Cost lb. B. F.	Cost 100 lbs. Milk
Untreated Feed	33155	3.45	196.17	286.00	340.00	42¢	1.41
Treated Feed	39149	3.7	196.76	118.00	719.00	20¢	0.73

This table is given here to show what extravagant claims have been made for processed feeds. This table would indicate that the processing of fodder and roughages for dairy cows saves 50% or better of the roughage cost and practically cuts the cost of producing milk and butterfat in half. The data in this table are not official and it will be seen that under experimental conditions in the numerous trials at var-

ious Experiment Stations to determine the value of these convertors and yeast preparations, no such results have ever been duplicated or even approximated.

Yeast has not only been exploited as an efficient fermenting agent which will break down the complex cellulose compounds and crude fiber, thereby changing them into digestible starches and sugars and also partially digesting the complex protein compounds in the same manner, but it is highly advertised as a vitamin carrier and as a highly desirable protein supplement. Considerable work has been carried on to determine the value of yeast in these various capacities.

Within the past few years more has been learned about the nutritional requirements of all animal life than man has ever known before. The discovery of vitamins as dietetic essentials has complicated the proper balancing of rations for the average farmer and he prefers to let others study the food requirements of domestic farm animals and then tell him what kind of feed he should use and how best to prepare this feed to obtain the best results. This situation has enabled unscrupulous feed manufacturers and ingenious equipment builders to put various patented yeast preparations, malted feeds and so-called "convertors" as well as special equipment for processing feeds, on the market. Through 'high pressure' salesmanship, and the publishing of half-facts in the form of magazine articles, these patented, secretely formulated feeds and fermenting equipment have been rather widely distributed.

This review of literature is an attempt to briefly

summarize the results of most of the work which has been done to determine the value of yeast in the various capacities of protein supplement, vitamin carrier and as an agent for pre-digesting feeds.

In an effort to determine the value of yeast and mineralized yeast, when added to a ration of oats for fattening pigs, the experiment reported in this manuscript was planned and carried out.

REVIEW OF LITERATURE

Yeast as a Protein Supplement for Dairy Cattle

Due to the large surplus of brewery yeast run off as waste the possibilities of using yeast as a feed for livestock has been investigated. As far back as 1912 brewery yeast has been utilized as feed for various classes of livestock, especially cattle.

More experiments along this line have been carried on in Europe, due no doubt, to the greater need for utilizing every possible source of feed because of the scarcity of land on which feed can be grown.

Yeast, in these early trials, was generally considered chiefly as a source of protein and the possibilities of fermentation was not considered. Neither was its vitamin content considered, as very little was known concerning vitamins at that time.

Crowther (3) described dried yeast as a material of powdery to flaky consistency, varying in color from light to medium brown, with an agreeable smell but having a bitter taste. He states that "it is disliked by cows but not objected to by pigs and calves." The composition is given as:

Moisture	4.3%
Protein	48.5%
Fat	0.5%
Soluble Carbohydrates	35.5%
Fiber	0.5%
Ash	10.7%

Feeding trials at Garforth indicate that it is a desirable feed for cows if they can be induced to eat it. It was

not thought to have possessed any medicinal or dietetic virtues other than those to be expected in any highly desirable, digestible protein feed.

Dunlap and Bailey (7) report that in tests comparing dried yeast with decorticated cotton seed meal the milk cows gave slightly more milk of a higher percentage of fat when fed three pounds of dried yeast as a supplement to their basal ration than they did when fed an equal amount of cotton seed meal on the same ration. The cows gained in weight slightly more on the cotton seed meal. They further report that the churnability of the milk and the flavor was equally good for both rations but that the butter made during the feeding of the cotton seed meal was harder and of better color. Taylor and Cranfield (34) in a similar experiment report an increased yield of 41.25 pounds of milk and 3 pounds of butterfat per cow, in favor of the dried yeast during the four weeks of the experiment.

Barton, Ness and Crampton (1) found dried yeast to be equal to linseed meal as a supplement to a ration of grain, silage and hay when fed to dairy cows.

Eckles and Williams (8) did not secure results which showed any advantage in feeding yeast (25 gm. per pound of milk produced) in addition to a normal ration of alfalfa hay, corn silage, dried beet pulp and a grain mixture of ground corn, ground oats, wheat bran and linseed oil meal in the ratio of 2:2:2:1. They report that they could observe no action of the yeast on the condition of the animals or stimulation of their appetites.

In an earlier experiment Eckles, Williams, Wilbur, Palmer and Harsaw (9) found no advantage in the addition of dried yeast to normal rations including whole or skim milk, grain and hay when fed to calves.

Kieferle, Dusch, Merkle, Leicht and Hindemith (20) of the Chem. Div. of the Southern Germany Dairy Res. Inst., report that the results of a detailed investigation on the use of dried yeast as a cattle feed proved that yeast was a suitable domestic substitute for imported protein concentrates and they recommended that avenues be explored to market dried brewer's yeast at a competitive price.

Morrison (25) states that yeast is not only high in protein but that the protein is of good quality. This point is disagreed with by Fairbanks (12) who states that the supplementing ability of yeast protein can be overemphasized as the yeast proteins are of rather low biological value.

Karr (21) in experiments with yeast protein found that the utilization of the yeast nitrogen was about 80%.

Irradiated Yeast for Dairy Cattle

Bilek and Hynek (2) state that the addition of irradiated yeast to winter rations of cows increased the secretion of milk without affecting its fat content. They report further that irradiated foods had no beneficial action on cows receiving ample supplies of fresh green fodder.

Kroon (22) reports that the feeding of irradiated yeast to milk cows three weeks after calving, increased the yield of milk from 25 to 30% but that it had no effect on the fat

content.

Hess and associates (18) secured results which showed that cows fed irradiated yeast containing 60,000 units of vitamin D daily, secreted a highly antirachitic milk adequate for the prevention and cure of rickets in infants. They found that a cow given 100,000 vitamin D units daily secreted 2,362 units in the milk, 27,362 in the feces and none in the urine. Although the yeast was also rich in vitamin E, no change in the amount of this vitamin in the milk was found.

Steenbock, Hart, Hanning and Humphrey (32) in 1930, found that yeast which has been exposed to ultra-violet rays is better than cod-liver oil for increasing the rickets preventing properties of cows milk. They suggest the possibility of feeding a standardized irradiated yeast for the production of a milk of a standard antirachitic potency.

Thomas and McLeod (35) found that by feeding cows irradiated yeast and ergosterol it was possible to increase the vitamin D content of butterfat as much as sixteen times. They state that irradiated yeast was more effective than irradiated ergosterol.

Fermenting Feeds for Dairy Cattle

The preparation of feeds by various fermentation processes probably grew out of the early process of malting various grains. Malting grains is essentially the same process as the addition of yeast cultures to feeds and allowing them to set and ferment. As early as 1845 experiments were carried on at Rothamsted to determine the value of malting barley as a means of preparing feeds for livestock.

Lawes and Gilbert (23) in 1866, report that none of the trials in which this was practiced resulted in any advantage for the malted feeds over the same feed when fed without being malted, for any class of livestock. They further state however, that "irrespectively of economy, malt is undoubtedly a very good food for stock and that it is beneficial when given to young or weakly animals or in 'finishing' for exhibition when the economy of gains is not considered."

In a study of certain processes for fermenting or enzymating feeds, Perkins and Monroe (26) state that commercial processes claiming to break down crude fiber or cellulose into simpler and more useful forms of carbohydrates are shown to be of little or no value in increasing the digestibility of corn stover, straw or hay when these processed feeds are fed to either rats, horses, or dairy cows. Chemical and feeding tests have failed to indicate any appreciable change in the composition or feeding value, as the fiber of the feed was not broken down and any increase in sugar, even when obtained is offset by a corresponding loss of equally valuable starch. There is no suggestion or indication that any significant improvement occurs in the protein, fat, minerals or vitamins of the feeds treated by the processes.

Hayden and Monroe (16) obtained results which indicated that Dimalt, a proprietary substance, when added to a ration of corn, oats, wheat bran, and linseed meal as the grain mixture together with corn stover and alfalfa hay as the roughage caused sufficient change to make the ration a little more palatable and slightly better utilized. They state,

however, that the advantage obtained was not significant.

In a later experiment Hayden and Monroe (15) used Kultogras as the "convertor" on a ration of alfalfa hay, corn stover and a good grain mixture similar to the one used with the Dimalt "convertor". Their results showed no benefit from the use of this substance so far as increased milk production was concerned. The cows did gain more on the processed ration which would indicate that Kultogras favors body growth. The expense of using the Kultogras was $3.96 more per cow for the 60-day feeding period than it was when the normal ration was used.

Rupel, Roche and Bohstedt (29) made an experimental study of the "Piercy Livestock Food Digestor", as to its value in processing feed for dairy cows. The ration of alfalfa hay, corn fodder and concentrates was processed according to the directions of the manufacturers and treated with their special "convertor", the formula of which was not divulged. From the results obtained there was no saving in the feed where the roughages, corn fodder and alfalfa hay, were pre-digested as compared with corn silage and untreated alfalfa hay. They state that the daily chore of cutting the roughages and pre-digesting them, as well as the expense of the "convertor" and the equipment, consisting of the boiler, digester boxes, and fuel, was largely wasted.

Dried Brewery Yeast as a Protein Supplement for Horses

Voltz, Paechtner and Baudrexel (38) in 1913, stated that dry beer yeast is rich in highly digestible protein. With potato chips it is a very suitable feed for sheep and horses.

Volz (40), in a study of the value of dried yeast as a feed for draught horses reports that it is safe to replace at least one-half of the grain used for feed by a quantity of dried potatoes or yeast of a corresponding nutritive value without having any noticeable influence on the energy of the horses. He further states that this substitution resulted in a considerable saving.

Czadek (6) in 1913 carried on a horse feeding experiment with dried beer yeast. He states, "This product proved to be a palatable, laxative feed and especially adaptable as a supplement to oat feeding."

Fermenting Feeds for Horses

Because of the considerable interest developed by processes advertised as the "Sugar Jack" process and the "Piercy" process of preparing feeds for cattle and horses, Roche, Bohstedt and Fuller (28) made a rather extensive study of the "Piercy" process over a period of 20 weeks with 10 teams of horses. To verify claims for the process and to follow instructions of the company manufacturing the equipment, the horses receiving the fermented feed were fed one-third less of oats and hay than the other horses. This resulted in these horses losing weight steadily for four weeks at which time their feed was increased to within 20% of the normal

ration but they continued to lose weight. Three weeks later the feed allowance was increased to within 12% of the check ration. This resulted in some gains but it was unsatisfactory. At the end of the thirteenth week the ration of the horses receiving the processed feed was increased so that they were getting the same amount as the check teams.

At the end of 20 weeks, when the trial was concluded, the horses which had received the normal ration had gained 318 pounds over their initial weight. At this time the lot which had received the processed feed and which, for seven weeks, had received the same amount of feed as the check teams, weighed within a few pounds of their initial weight. The results of this trial were not favorable to fermenting feed for work horses.

Dried Yeast for Swine Feeding

Voeltz (37) reports a series of experiments which demonstrates that a combination of the highly digestible, dried yeast, rich in protein, boiled potatoes and small amounts of barley as the only foodstuffs, is very effective in bringing about a quick fattening of hogs. He states that this diet proved to be very profitable.

Voltz (39) in experiments carried on with 9 pigs, in which potatoes formed 2/3 of the feed and with dry yeast making up 70% of the digestible raw protein, together with barley as 5% of the total feeding energy, states that under these conditions dry beer yeast is an excellent feeding stuff, especially for fat production.

Gartner and Gaede (13) report results which showed that irradiated yeast had a beneficial effect on the rate of growth of the pigs in the experiment, and that the yeast had no unfavorable results on the loss of weight at slaughter, the quality of meat or its flavor. They state however, that the yeast fed pigs were leaner than those receiving barley, potatoes and swedes only.

In two experiments comparing the value of fish-meal, irradiated yeast and non-irradiated yeast as supplements to barley, Hofmann (19) reports that the fish-meal and irradiated yeast were equal in feeding value while non-irradiated yeast was 10% less valuable. Fish-meal produced the most economical gains but the quality of the flesh and fat was lower than was the case where irradiated yeast was fed.

Shrewsbury, Vestal and Hauge (31) report that the addition of 3% dried yeast to rations of corn and soybeans did not improve growth sufficiently to pay for its use, although it did cause a slight but consistent improvement in growth.

Fermenting Feeds for Hogs

The use of yeast as a protein supplement and vitamin carrier for hogs has not been investigated nearly so much as has the use of yeast in bringing about fermentation of the feed in the hopes of breaking down the more indigestible portions so that the animal body can more completely digest and assimilate the ration and with less strain on the digestive system than has been the case with natural, unprepared feeds.

Due to the many inquiries and the general interest in the preparation of various grains for feeding swine by adding yeast and allowing the grains to ferment in the hopes of reducing the fiber content and increasing the proportion of useful nutrients, a number of Experiment Stations have carried on investigations to determine the value of such practices. Especially is the interest keen when oats are cheaper than corn, then farmers seek some means of overcoming the disadvantage of the oat hulls for feeding hogs. A number of manufacturers have arisen to the occasion and produced yeast cultures which they claim will actually transform the fibrous oat hull into a palatable and nutritious feed.

In 1924 a large manufacturer of yeast conducted a wide spread propoganda to induce farmers to feed dry yeast to their livestock, claiming great benefits therefrom due to its vitamin content and to its ability to pre-digest the feed. This induced the Wisconsin Experiment Station to investigate the value of such a practice. Russel, Morrison and Ebling (30) report that the addition of yeast to a ration of corn, tankage, linseed oil meal and chopped alfalfa, either immediately before feeding or 24 hours before and allowing fermentation to take place, did not increase the efficiency of the ration. The conclusion was that the addition of yeast was uneconomical.

Thompson (36) in a series of experiments on the preparation of kafir for swine feeding found that fermenting soaked whole kafir corn with yeast increased the feeding value 7% over soaked, whole kafir without yeast but that it was about 3% less efficient than dry, whole kafir corn. However when

ground kafir was fermented with yeast about 5% more kafir was required to produce 100 pounds of gain than when no yeast was used. Later Thompson (36) conducted a somewhat more comprehensive trial on the addition of yeast to kafir for hogs. In this trial he reports even more unfavorable results for the use of yeast. He states that fermenting ground kafir caused a loss of 20% in feeding value of this grain. In another lot however, fermenting whole kafir increased its feeding value about 8% over whole kafir fed dry, but this saving was offset by the cost of the yeast.

Edwards and Brown (11) claim that it could not be observed that the addition of yeast 48 hours in advance of feeding a ration of corn meal and tankage had any effect whatever upon the rate of gains, the appetite of the pigs or the amount of feed consumed per pound of gain, as the yeast fed lot compared very closely with the check lot. They report that the addition of the yeast just before feeding caused womewhat smaller daily gains and required slightly more feed per unit of gain. The difference here was so slight and the number of pigs in the trial was so small that this variation might have been due to the difference in the pigs themselves.

Hackedorn (14) reports that when one percent yeast was added to a ration of rolled barley and millrun the daily gains were somewhat smaller and slightly more feed was required to produce a hundred pounds of gain. The only difference in favor of the yeast fed pigs was that they had a better coat of hair.

Robison (27) reports that fermenting a ration of corn, tankage, salt and limestone resulted in more rapid growth and in slightly greater gains from a given amount of feed but that the saving was not sufficient to cover the extra cost when commercial yeast was used. He states that practically the same results were secured with self propagated or home grown yeast but that, despite the fact that this method involved practically no expense, it is doubtful whether the benefit derived will ordinarily pay for the extra labor involved.

Weaver (41) added 2% yeast in one instance and 4% yeast in a second instance to a basal ration of ground corn, wheat shorts and tankage and allowed the mixture to ferment for 24 hours before feeding. No beneficial results due to the yeast were detectable in the figures on gains. In fact, the largest gains were made in the lot receiving the yeast-free ration. He states that this difference was slight and probably not significant but the data justifies the conclusion that the yeast did not produce any benefits, that the fermentation was apparently without value and the yeast did not have any so-called tonic effect.

In a trial to determine the best preparation of rye for fattening hogs Edwards and Brown (10) obtained slightly more favorable gains when the ration of rye, oats, tankage and mineral mixture was fermented with 1/4 pound of yeast for each 100 pounds of the mixture. This advantage did not cover the cost of the yeast nor of the added labor required in preparing and feeding the fermented feed.

Williams (42) reports that "apparently, by making it more palatable and thereby increasing the consumption, fermenting feed with yeast resulted in the production of more rapid gains." He states further however, that these gains were more expensive when the cost of the yeast was taken into consideration.

Culbertson and Hammond (4) carried on a very exhaustive study of a number of yeast culture feeds in 1932, which were manufactured and highly advertised as "Scientific Blends of Digestive Cultures." These cultures were advertised to carry yeast, lactic acid and most, if not all, of the known vitamins and were suppose to convert feeds into pork at a minimum cost. They found that, in no case was the addition of a yeast culture feed to either a ration of corn, supplemented with the "Big Ten" protein and mineral supplement, a ration of oats and the "Big Ten" or a ration of corn and oats with the "Big Ten".

The "Big Ten" consisted of the following ingredients:

Meat meal tankage	40	lbs.
Linseed oil meal	15	"
Cottonseed meal	20	"
Peanut oil meal	9	"
Alfalfa meal	12.8	"
Salt	1	"
Limestone	1.5	"
Iron Oxide	0.198	"
Wood Ashes	0.5	"
Potassium Iodide	0.002	"
Total	100	"

Culbertson and Hammond (5) in 1937, had further inquiries as to the best method of preparing oats as a substitute for high priced corn for feeding hogs. The popular opinion was that the mineralized yeast feeds, obtainable on the market,

when added to oats would break down the fibrous hull and increase the feeding value, so they made a similar study on oats as they had done some five years before. The results of the first experiment were verified in this recent trial, as the use of yeast to ferment ground oats increased, slightly, the amount of feed required per pound of gain and increased the cost of feed per 100 pounds of gain from $3.68 to $4.20.

Loeffel (24) in the summer of 1937, undertook a test in order to answer the many requests for information on the feeding value of yeast preparations. The following table gives the results of his experiment.

Table II. Summary of the data compiled from an 85-day feeding trial to determine the value of yeast feeds for fattening pigs in dry lot.

Ration	Av. daily gain	Feed req. for 100 lb. gain: Grain	Tankage
	Pounds	Pounds	Pounds
1. Corn & Tankage--------	1.78	326	40
2. Ground oats----------	1.39	438	--
3. Ground oats & tankage-	1.47	413	17
4. Ground oats & yeast---	1.39	439	2
5. Ground oats & yeast-O-Lac----------	1.42	425	4
6. Ground oats & Nu-Lac--	1.43	430	4
7. Ground corn, 85; cane molasses 15; & tankage	1.55	C.336 M. 59	26

The results of the above experiment indicate that oats and yeast were no better than oats alone. Loeffel states that "The differences of gains between the various lots were so slight that they are insignificant and within the limits of experimental error. The addition of yeast and yeast preparations in this test did not prove economical."

Fairbanks, Burroughs, Mitchell and Hamilton (12) initiated an experiment to determine the effect on the digestibility of the ration and the rate and economy of gains made by hogs when fed a soaked oats ration supplemented with three per cent yeast. In one case the yeast was inactivated with heat while in the other lot the yeast was alive and allowed to cause fermentation. Hamilton summarizes the outcome in the following statement; "These results indicate no benefits from fermenting a poor ration (oats) or a good ration with yeast for growing pigs. There were no significant differences in rates of gain; neither were there any differences in the digestibility of the fermented and unfermented rations."

EXPERIMENTAL

In order to obtain more recent experimental data on the use of yeast in fermenting oats for swine and attempt to verify the claims made by the manufacturer of a certain mineralized yeast feed, an experiment was conducted at the Oklahoma Experiment Station.

Forty-five spring pigs were divided into five lots of nine pigs each and used in a feeding trial to determine the value of fermenting a ration of oats with mineralized yeast and ordinary yeast as compared to oats and tankage for fattening pigs. The trial began August 10, 1937 and continued until October 23, 1937, a period of seventy-four days.

There were five different breeds of pigs used in this trial: Duroc Jersey, Chester White, Poland China, Hampshire and Berkshire; whose initial weight ranged from 44 pounds to 131 pounds. They were divided in such a way that each pen contained the same number of each breed and the average initial weight of each pen was approximately the same.

All lots were hand fed twice each day on concrete floors so that they received only such feed as was fed to them. They were given only as much feed as they would clean up readily. The amount of feed given varied according to the appetites of the pigs. Each daily allotment was weighed and recorded, and the total feed consumed during the trial was calculated by adding up the daily amounts recorded.

The lots were fed as follows:

Lot No. 1 -- Oats, 24 parts, plus tankage, 1 part. Fed moist.

Lot No. 2 -- Oats, 24 parts, plus tankage, 1 part. soaked 12 hours.

Lot No. 3 -- Oats, 400 parts, plus yeast, 1 part. Allowed to ferment for 12 hours.

Lot No. 4 -- Oats plus mineralized yeast (1 lb. to 96 lbs. of oats, according to instructions given by the company). Allowed to ferment for 12 hours.

Lot No. 5 -- Oats only, soaked 12 hours.

In each lot, the oats were finely ground before being fed. Each lot, except No. 4, had access, at all times, to a mineral mixture consisting of ground limestone, bone meal and salt in the ratio of 1:1:1. Lot No. 4 was dependent on the mineralized yeast for its supply of minerals.

The pigs were weighed four times during the trial in addition to the initial weighing and the final weighing. The general condition was observed and recorded at the time these weights were taken.

RESULTS

All of the pigs in this trial remained on feed throughout the entire feeding period. The general condition of the pigs in lot 1, which was fed the check ration of oats and tankage was slightly better than that of the other lots during the trial. Lot 3, which received the oats and yeast seemed to be next best in general condition, with lot no. 2 in third place. Lot 5, receiving the oats alone, was fourth in condition while lot 4, which received the oats and mineralized yeast with no mineral supplement, maintained the poorest general condition throughout the trial.

Table III is a compilation of data secured during the 74-day feeding trial designed to determine the value of yeast and mineralized yeast as supplements for oats as compared to tankage.

In this trial no very rapid gains were made but considering the fibrous nature of the ration fed they were satisfactory.

Lot No. 1, which was fed the basal ration of oats and tankage moistened, made both the most rapid and the most economical gains, with a daily average gain of 1.11 pounds and having required 428.93 pounds of oats and tankage to produce 100 pounds of gain in live weight.

Lot No. 2 was second in economy of gains, having required 447.64 pounds of oats and tankage to produce 100 pounds of gain, which was 18.71 pounds more than was required by lot 1. The ration fed lots 1 and 2 was the same except

Table III. A Summary of the Results of a 74-day Feeding Trial to determine the Value of Fermenting a Ration of Oats with Mineralized Yeast and Ordinary Yeast as Compared to Oats and Tankage for Fattening Pigs.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Av. Initial Wt.	84	87.6	85.44	83.22	87.77
Std. Dev. of Initial Wt.	21.53	17.24	24.95	26.46	31.54
Av. Final Wt.	165.33	165.22	164.33	144.11	163.11
Av. Daily Feed Consumed per Hd.	4.7	4.69	4.84	4.12	4.8
Total Feed Consumed per Lot.	3135.5	3124.5	3230.0	2746.5	3198.5
Av. Gain per Head per Lot.	81.2	77.5	78.8	60.8	75.3
Av. Daily gain per Head.	1.11	1.06	1.08	0.83	1.03
Feed Req. per 100 lbs. gain	428.93	447.64	454.93	501.19	471.76

that the ration of lot 1 was only moistened while the ration of lot 2 was soaked for 12 hours before feeding. The daily rate of gain was practically the same for lots 1 and 2, although it was slightly in favor of lot 1.

Lot No. 3 was third in economy of gains, having required 454.93 pounds of oats to produce 100 pounds of gain. The rate of gain for lot 3 was only very slightly less than it was for lot no. 1 and it was practically the same as for lot 2.

Lot No. 5 was fourth in economy of gains. This lot consumed 471.76 pounds of oats alone to produce each 100 pounds of gain in live weight. The daily rate of gain was practically the same as it was for all other lots except lot no. 4.

Lot No. 4, which received the mineralized yeast made the slowest gains and required more feed per 100 pounds of gain than any of the other lots, the daily gain being 0.83 pounds and requiring 501.19 pounds of feed to produce 100 pounds of gain in live weight.

The lot receiving the mineralized yeast consumed less feed per day while the lot receiving yeast consumed slightly more feed per day than any of the other lots, thus indicating that the mineralized yeast was unpalatable while the addition of yeast enhanced the palatability of the oat ration.

It will be noted that the lot receiving oats alone, ground and soaked, ate more each day than any other lot except the lot receiving yeast, indicating that it was

slightly more palatable than oats and tankage either moistened or soaked. The differences in this daily consumption of feed are so slight that they cannot be relied on to indicate conclusively which ration was the most palatable however.

It was observed that very few of the pigs in any of the lots were really finished at the close of the trial. They tended to grow more than to fatten. This was not unexpected however, as it has been known for many years that the feeding of oats tends to produce growth rather than fat. When it is considered (25) that oats contain 9% more fiber, 11% less nitrogen-free extract and slightly less fat than corn it is obvious why these pigs, fed oats as the chief source of carbohydrates, did not put on such a good finish but tended to grow instead.

An analysis of variance was run on the gains made by the five lots in this experiment in order to determine whether the variation between the lots was enough greater than the variation within the lots, to be significant.

Refering to Table XXXV in Snedecor (33) it is found that the F value (ratio of the larger mean square to the smaller) must equal 2.64 to be significant or 3.91 to be highly significant. The value of F was found to be 2.704, therefore it was assumed that there was a significant difference between the gains made by some of the lots. Further calculation revealed the fact that there was not a significant difference between lots 1, 2, 3 and 5, but that lot 4, which received the mineralized yeast preparation made gains which were significantly inferior to any other lot.

Lot 3, which received the oats and yeast made significantly greater gains than the lot which received the mineralized yeast but the difference in gains made between lot 3 and lots 1, 2 and 5 were so small as to be insignificant and therefore neither favorable for or against the addition of pure yeast to a ration of oats.

Lot 5, which received the ration consisting of oats alone, soaked for 12 hours, compared favorably with the oats and tankage ration of lot 1, which was the check ration and was slightly superior to all other rations. This was unexpected as it was thought that oats alone was not sufficiently balanced nor of sufficient variety to make gains comparable to a ration containing tankage. The superior results from this lot may have been due to superior feeders in the lot fed oats alone, or it may have been due to the fact that oats are relatively high in protein and that supplementing 24 parts of oats with 1 part of tankage did not change the ratio of protein to carbohydrates sufficiently to make significantly superior gains.

It was further found in the analysis of variance that the pigs having a large initial weight made better gains than those pigs with the smaller initial weight. The division of weights was made at 80 pounds. All pigs having an initial weight of 80 pounds or less were placed in the small weight class and all pigs having an initial weight of over 80 pounds were placed in the large weight class. This variation due to the difference of initial weights was calculated and taken

out so that it was not attributed to the difference in the rations.

DISCUSSION

There are certain fundamental and scientific factors that should be considered in arriving at any conclusion concerning the possible effects of yeast upon the digestion and upon the digestibility of feeds. Hamilton (17) of the Division of Animal Nutrition at the University of Illinois has stated; "All healthy, normal animals produce all the enzymes necessary to digest, very completely, the proteins, fats, sugars and starches of their food. As far as is known, no animal produces an enzyme which digests crude fiber. Some of the crude fiber of feeds is digested, or at least disappears, during its passage through the digestive tract of some of our farm animals. The process of digestion of crude fiber is accomplished, not by digestive enzymes, but through the action of certain micro-organisms which live in the digestive tracts of most of our animals. Two things must be kept in mind when considering the digestive action of these micro-organisms: 1. The end-products are various acids, alcohols and gases. 2. These organisms also attack starches and sugars as well. In fact, they prefer them to such an extent that considerable amounts of the starches and sugars, which are of value as such to the animal, are rendered valueless to the animal because of the action of these organisms."

He further states that, "The only enzymes of any importance in yeast are those capable of fermenting certain

sugars. The result of the fermentation of these sugars is the production of gases, acids and alcohol--all of decidedly less value to the animal than the original sugars. Yeast contains no enzyme capable of changing, in any way, the crude fiber of oats or of any other rations. It therefore seems impossible to increase the nutritive value of a ration by fermentation with yeast. On theoretical grounds at least, the actual reverse might be predicted."

No instance in literature was found in which the fermenting of either oats or any other grain, before being fed to swine, resulted in a significant increase in the feeding value of these feeds. In a few cases the yeast fermented ration has been very slightly more efficient, and in some cases the hogs had a better coat of hair than the hogs receiving normal rations, thus indicating a slightly more thrifty condition, but never has this advantage been sufficient to pay for the yeast required nor the labor involved.

In the experiment, the results of which are recorded in Table III, the above conclusion is confirmed and the statements made by Hamilton are obviously correct, as the fermentation of the oat ration with mineralized yeast resulted in a considerable loss of the nutrient value of the oats. This loss of nutriment is indicated by the fact that the lot receiving the mineralized yeast required 16.6% more feed per unit of gain than was required by the lot receiving oats and tankage.

On the other hand, investigations indicate that yeast is

a highly desirable protein supplement and when available in sufficient quantities and at sufficiently low prices, as is the case near breweries, it may be successfully and efficiently utilized as a supplement to balance carbonaceous feeds for practically all classes of livestock. It is generally accepted that yeast is rather high in vitamins B and G and under certain circumstances where the rations, being fed, have been highly refined, thereby removing vitamin B, or in the case of rations of some of the cereal grains, which are low in vitamin G, without any green pastures or animal protein supplement, both of which are good sources of vitamin G, then it would seem likely that the use of yeast would improve such deficient rations, when added in sufficient quantities.

The above circumstances are rather unusual and for the average farmer feeder the use of yeast to alleviate the disadvantages of such rations would not be necessary.

The use of irradiated yeast in the ration of dairy cows, for the production of antirachitic milk, seem to have possibilities and this use of yeast promises to acquire considerable importance.

In view of the results found in the review of literature, together with very similar results obtained in this trial, it can safely be said that the use of yeast in the rations of swine can benefit only as it contributes protein and vitamins to the ration, but it is of no value as a convertor of fibrous feed into digestible carbohydrates and proteins.

SUMMARY

1. This experiment was conducted with 45 pigs of five different breeds, whose initial weights were quite variable. The average initial weight in each lot was approximately the same.

2. An analysis of variance was run on the gains made in order to take out the variation due to the difference in the initial size and to determine whether the variation between lots was significant.

3. Lots 1, 2, 3 and 5 made significantly greater gains than did lot 4, which received the ration of oats and mineralized yeast.

4. There was not a significant difference between the gains made by lots 1, 2, 3 and 5, although lot 1, which received the oats and tankage moistened, made slightly greater gains and required somewhat less feed for each 100 pounds of gain than did lots 2, 3 or 5.

5. The pigs in lot 4 made an average of 20 pounds or 25% less gain, and required 72 pounds or 17% more feed for each 100 pounds of gain than did the check lot.

6. There was no advantage in soaking the ration of oats and tankage for 12 hours before feeding.

7. Lot 3, which received the oats and yeast, consumed somewhat more feed each day than any other lot, indicating that this was the most palatable ration.

8. Lot 4, which received the oats and mineralized yeast

consumed less feed per day than any other lot, indicating that this was the least palatable ration.

9. Lot 5, which received oats alone soaked 12 hours consumed slightly more feed each day than the lots receiving either oats and tankage moistened or the one receiving oats and tankage soaked for 12 hours, indicating that oats alone was the more palatable.

10. The results of this trial indicate that the addition of yeast to a ration of oats, and allowing fermentation to take place was of somewhat less value than supplementing oats with tankage, although the difference in gains did not significantly indicate any advantage for either ration.

11. The results obtained did indicate, however, that the addition of mineralized yeast to a ration of oats without the addition of any other mineral was significantly inferior to either oats and tankage moistened, or soaked; or to a ration of oats alone with minerals, or a ration of oats and yeast with minerals.

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