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Effects of Delactosed Whey, Skim Milk, and Sugar on Ration Palatability and Performance of Early Weaned Pigs

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EFFECTS OF DELACTOSED WHEY, SKIM MILK, AND SUGAR ON RATION PALATABILITY AND PERFORMANCE OF EARLY WEANED PIGS

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

There has been much interest in the possibility and feasibility of weaning pigs at an early age with attempts to wean pigs as early as one to two hours post-partum. Most workers, however, have concentrated their studies upon weaning at two to four weeks of age. When pigs are weaned at this early age, it is important to utilize feedstuffs that will result in an economical, highly palatable, starter diet that will provide rapid and efficient pig gains. Therefore, the diet must provide all of the essential nutrients in a readily available form and at a cost which is not prohibitive.

Although acceptable gains have been reported using corn-soybean meal supplemented diets, there is evidence that additional ingredients will improve gains and efficiency. Milk by-products such as dried skim milk and dried whey are well balanced, nutritious ingredients that could be beneficial in diets for early weaned pigs. This would also give milk processors an additional outlet for their by-products, as well as benefiting the swine producer.

Palatability may also be a problem when pigs are weaned at an early age. No matter how good a diet is economically and nutritionally, it is of no practical benefit if sufficient amounts are not consumed. Palatability is more difficult to measure than evaluation of other criteria of feedstuffs. Most palatability trials have been conducted by offering more than one diet at the same time. Using this method, some workers have found that baby pigs prefer a diet containing some

form of sugar or sweetener. However, when these diets are fed as the only feed source, consumption often is no greater than that of a diet that does not contain sugar.

Research conducted by the manufacturers of the delactosed whey product used in this study indicated that the product may be less palatable for young pigs than dried whole whey. This was thought to be due to the increased percentage of salts which occurs when some of the lactose is removed. If this is true, then the amount of salt normally added to the diet must be reduced to compensate for the higher levels of salt in the delactosed whey product.

The reasons for undertaking this study were:

1. To study the effects of feeding milk by-products, with and without sugar, in comparison to a corn-soybean meal diet.
2. To determine the effect of the increased salts in delactosed whey on palatability, feed consumption, and rate of gain.
3. To compare the free-choice selection method with the single-stimulus method of determining palatability of diets containing delactosed whey.

REVIEW OF LITERATURE

An additional ingredient must improve pig gains, feed efficiency, or palatability or lower the cost of the diet without affecting gain, feed efficiency or palatability before its inclusion in the standard corn-soybean meal diet can be justified. Many ingredients have been tested as additions to this standard diet. One of the ingredients that has been tested by many workers is whey in one form or another. The results of these tests have been varied. This is due in part to the various forms of whey which have been used, but there is also considerable variation among results obtained using the same type of whey.

Feeding trials using whey

Krider et al. (1949) fed pigs diets containing 5% sun-cured alfalfa meal; 4% dried whey product; 8% dried whey product; 4% fortified dried whey by-product; and 2% fortified dried whey by-product. The fortified dried whey by-product consisted of dried whey product plus whey fermentation solubles. The lactose content of the dried whey product was at least 55%. The alfalfa meal produced the most rapid gains, but there was no significant difference between this and 8% dried whey product. The diets containing whey produced diarrhea. A second experiment was conducted to study the relationship of lactose content of the diet to the laxativeness of the dried whey product. They concluded that the lactose content was the laxative factor.

In a third experiment, they found that 2% or 4% fortified dried whey by-product gave higher and more efficient gains than the basal corn-soybean meal diet or a diet supplemented with 10% dehydrated alfalfa meal.

Dyer, Krider and Carroll (1949) reported that the addition of 5% meat scraps or 2% whey increased average daily gains, but not significantly. They found, however, that adding both meat scraps and whey resulted in a highly significant increase in average daily gains.

Terrill, Nesheim and Krider (1951) studied the effects of adding 5% dried whey product, whey fermentation solubles, and vitamin B_{12} concentrates to dry lot diets for pigs. The whey increased gains by 15%, but this increase was not statistically significant. They also found that increasing the vitamin B_{12} content of the basal diet to equal that of the whey diet did not give gains equal to those achieved with whey. They therefore concluded that there was an additional growth factor in whey. This was also reported by Vohs et al. (1951). In their work, the addition of 2% dried whey and 15 mcg vitamin B_{12} concentrate significantly increased gains over a diet supplemented with vitamin B_{12} alone.

Many sources of unidentified growth factors were tested by Gard, Becker and Terrill (1955). Five experiments were reported in this paper. They were designed as 2 by 3 factorial experiments. In each experiment a control diet constituted one treatment. Each ingredient was added to the control diet individually and in combination with the others. In experiment one the ingredients tested were grass

juice concentrate, dried whey product with whey fermentation solubles, and dried brewer's yeast. The addition of grass juice concentrate or dried whey increased the average daily gain significantly over the fortified corn-starch, isolated soybean protein control diet. The effects of these ingredients were not additive, however.

In a second experiment the dried brewer's yeast was replaced with menhaden fish solubles. Whey was fed at 5% in this trial, and resulted in slower gains and lower feed consumption than the controls. In a third experiment, comparing the same ingredients to a fortified corn-soybean oil meal diet, whey produced no significant differences.

Becker et al. (1957) fed synthetic diets with casein plus methionine as a protein source to pigs weighing approximately 3.6 kilograms. Levels of 0, 30 and 60% dried whey were studied as a substitute for dextrose. There was no significant difference in rate or efficiency of gain. There also was no evidence of diarrhea. In another trial, whey was fed at levels of 0, 5, 10, 20, 40 and 60% to finishing pigs weighing approximately 45 kilograms. Soybean oil meal plus methionine was used as the protein source and antibiotics were included in some of the diets. There was no interaction between whey and antibiotics. At the 60% level whey depressed rate of gain and feed intake, but not feed efficiency. This level also caused diarrhea. There was some evidence of diarrhea at the 40% level, but performance was satisfactory. They also fed weanling pigs 20 and 30% whey. In this trial whey reduced rate of gain and feed intake. Mild diarrhea resulted from these levels of whey. Roller dried whey produced a higher

rate of gain and feed intake than spray dried whey when fed at the 30% level.

Lloyd and Crampton (1958) substituted a mixture of meat meal and whey powder for skim milk powder in a dry diet for early weaned pigs. This resulted in a decreased rate of gain and feed efficiency due, at least in part, to the lower digestibility of crude protein and total carbohydrates.

Greatest gains and feed efficiency were obtained with a diet containing 30% dried skim milk and 10% dried whey, in work reported by Danielson, Peo and Hudman (1960). They found that gains and feed efficiency decreased when dried whey was fed at levels above 10%. Subsequent gains on the grower diets were higher for those pigs which had received whey in the starter diets.

Buysse (1961) conducted trials lasting from two to eight weeks with pigs that were left with the sows. The basal diet given to twelve litters contained 20% dried skim milk, 60% cereals, plus protein meals, minerals, vitamins and antibiotics. Half of the dried skim milk and some of the cereal was replaced by 10% dried whey for nine litters, 20% for ten litters, and 40% for eight litters. Protein was kept constant by increasing the amount of fish meal. On the diet with 10% whey, growth and feed efficiency were better than on the basal diet. The diet with 20% whey gave results which were almost as good, however, decreased gains and feed efficiency were obtained when the 40% whey diet was fed.

Un-neutralized lactic casein whey was substituted for barley meal in a report by Dunkin (1963). In two trials levels of whey ranging from 10 to 89% were fed to pigs weighing approximately 13 kilograms. The results of these trials indicated that a level of 40% whey was the most beneficial, although there was some evidence of diarrhea at this level.

Sewell and West (1965) studied the effects of lactose on the utilization of protein. The control diet contained isolated soy protein with methionine hydroxy analogue. Dried skim milk, beta-lactose, and dried whole whey containing 68% lactose were each added to the control diet to make four experimental diets. These diets were formulated to contain equal percentages of protein and lactose. Pigs averaging twenty-one days of age were used in this study. Digestion and rate of gain were significantly greater for diets containing lactose. Whey and skim milk resulted in higher gains than for beta-lactose, but the differences were not statistically significant.

Whey was compared against and in combination with soybean meal and fish meal in work reported by Meade et al. (1965). Early weaned pigs were fed diets containing 25.9% soybean oil meal and 3.0% fish meal; 25.0% soybean oil meal and 10% dried whole sweet whey and 17.5% soybean oil meal, 3.0% fish meal and 10% dried whole sweet whey. Average daily gains were lower, but not significantly, for those rations containing whey. Feed efficiency was significantly lower for those pigs receiving the whey.

In a North Central Regional co-operative experiment reported by Speer et al. (1967), dehydrated alfalfa meal, corn distiller's dried solubles, and dried whey were compared in growing diets. Five diets were used as follows: (I) 14% corn-soybean meal, basal, (II) basal plus 2.5% dehydrated alfalfa, (III) basal plus 5% dehydrated alfalfa, (IV) basal plus 5% distiller's dried solubles, and (V) basal plus 5% whey. These diets were fed at eight stations, with each station using two to four replications of four to sixteen pigs per pen. There was a total of 22 replications used. There were no significant differences in the basal, distiller's dried solubles, and whey diets. Two stations reported increased gains with whey over basal, but the others found no difference.

Fevrier (1968) reported work in which 0, 30, and 60% dried whey was added to diets containing 11 or 18% crude protein. These diets were fed to pigs weighing 20 kilograms. From 20 kilograms to 35 kilograms animals receiving 18% protein had a higher growth rate than those receiving 11% protein irrespective of the level of whey fed. The 30% whey plus high protein gave the best growth rate and feed conversion. From 35 kilograms to 60 kilograms, at the higher protein level, growth rate decreased as the amount of whey fed increased.

German (1968) conducted an experiment in which 5% dried whey, 7.5% fish solubles, 5% dried whey and 5% fish solubles, and various levels of distiller's dried grains with solubles were compared to a corn-soybean meal diet. The addition of the 5% dried whey or 5% dried whey plus 5% fish solubles did not significantly improve

average daily gains. Gains were slightly improved in one replicate, but not in the other.

Results with liquid whey have generally been negative. Braude et al. (1959) fed unrestricted amounts of fresh whole whey plus two pounds of meal per pig per day. These pigs grew significantly slower and were significantly less efficient than those receiving an all meal diet. They also had significantly lower dressing percentages, but had longer carcasses with less fat. These workers calculated that one gallon of whey replaces approximately .7 gallon of meal.

Dunkin (1959) fed pigs a fixed daily allowance of .22 kilograms barley meal and .22 kilograms meat meal. Whey was given to supply a total dry matter intake equal to 3.5% of body weight. In this trial, fresh whey from three different sources was compared and no significant differences were noted. Daily gains ranging from .39 kilograms to .44 kilograms were obtained.

Whey was included in pig diets to provide 12.6, 17.7, or 22.3% of the total dry matter by O'Grady (1963). The lowest proportion of whey increased feed intake without affecting feed efficiency, and also increased average daily gains. Larger proportions of whey lowered feed intake below that of the controls, but increased feed efficiency. Therefore, the daily gains were greater than or equal to the controls. The effects of whey were more particularly marked in animals up to 45.4 kilograms live weight.

Skim milk, sugar, and palatability trials

In 1954 Crampton and Ness reported an experiment in which pigs were weaned at ten days of age and fed diets containing dried skim milk, molasses, wheat and oats, soybean oil meal, fish meal, brewer's dried yeast, and corn oil. They found that it was feasible to wean pigs at this age and feed dried skim milk.

Jones and Pond (1964) studied the effects of diets containing dried skim milk, whole milk or corn oil with corn-soybean meal diets. The pigs were weaned at three weeks of age. During the first forty-two days, pigs receiving whole milk showed significantly greater gains and those fed skim milk had greater gains than the control, but not significantly greater. From forty-two days to market weight, diets of soybean meal and dried whole milk were found to produce significantly greater gains and feed efficiency than dried skim milk.

White fish meal was compared to dried skim milk in an experiment reported by Barber, Braude and Mitchell (1958). They fed diets containing 10% white fish meal reduced to 7% at 58.95 kilograms live weight, 10% skim milk reduced to 7%, 15% skim milk reduced to 10.5%, and 20% skim milk reduced to 14% to pigs which ranged from nine to eleven weeks of age at the start of the experiment. They found no significant differences between skim milk and fish meal when fed at the same levels. However, there was a difference between the high skim milk and the low skim milk or fish meal diets. These workers stated that no definite conclusions could be drawn since the fish

meal provided an abundance of protein and the skim milk provided an abundance of energy.

Sugar or some other form of sweetener has often been added to diets in an attempt to increase their palatability. In an experiment reported by Lewis et al. (1955), the addition of sugar to meal and pellets was studied. To a basal diet containing 2.5% whey plus corn and soybean meal, they added sugar at levels of 0, 5, 10, 15 and 20%. Sugar was mixed in the pellets in one treatment, in meal in another treatment, and was used to coat the pellets in a third treatment. These workers found that pigs preferred the ration with 20% sugar mixed in the pellets.

In another trial diets containing 0, 10, 20, and 40% oat groats were fed with these five levels of sugar inside the pellet or as a sugar coating on the pellet. In this trial they found that pigs preferred the pellets coated with 20% sugar, the level of oat groats being insignificant. Sugar in either meal or pellets significantly improved feed efficiency, as did pelleting. Sugar within the pellets increased early gains and early starter consumption.

A comparison of refined cane sugar, invert cane molasses, and unrefined cane sugar was made by Diaz et al. (1956). Levels of 0, 5, 10 and 15% refined cane sugar; 0, 5 and 10% invert cane molasses; or combinations of the two giving a total sugar content of 15% or less were compared to a diet containing 15% unrefined cane sugar. They found that gains and feed efficiency were improved by increasing levels of refined and unrefined cane sugar, but were not improved by

increasing levels of invert cane molasses.

Aldinger et al. (1961) studied the effects of saccharin and sucrose on the performance of young pigs. They found a temperature and diet treatment interaction in that the diets containing sugar resulted in optimum performance under conditions of cooler temperature. Storing of diets for six months increased the preference for the diets with sugar. They also found that two-week-old pigs showed a greater response than did four-week-old pigs.

The effect of saccharin on feed consumption was studied by Aldinger et al. (1959). Pigs were weaned at approximately sixteen days of age. They were given a choice of diets containing different levels of saccharin. These workers found that some level of saccharin was generally preferred by the pigs. This was especially true when the diet was in pellet or crumble form rather than in meal form. They also concluded that the best technique for measuring palatability was to provide the pigs with a minimum number of choices and a wide range of differences in the feed.

Beef tallow, lard, molasses, refined cane sugar, and C-grade sugar were tested as to their value in improving palatability of creep diets by Combs and Wallace (1959). In this experiment diets containing each of the above ingredients were fed free choice as a creep feed to suckling pigs on pasture. Several small feeders were placed in one creep location, the positions of the feeders within the creep were switched weekly and feed consumption was recorded. They found that 10% stabilized beef tallow markedly increased

acceptance, 10% molasses had no effect, and 10% refined cane sugar was more effective than beef tallow. They also found that 10% lard was more effective than tallow or sugar.

The most effective addition was 5% lard plus 5% sugar. Pigs preferred C-grade sugar at levels of 30 and 40% to levels of 0, 10, and 20%.

Aldinger and Fitzgerald (1966) described a new method for testing palatability of baby pig diets. This method, which they refer to as the single stimulus method, consists of using two feeders per pen with a time clock mechanism to control alternate feeding from each feeder. They found that the optimum time for alternating feeders was from two to four hours. This method reduced the coefficient of variation of feed consumption from 36.0% to 5.5%. A normal distribution of feed consumption was obtained using the single stimulus method.

Aldinger (1968) listed several problems encountered in conducting palatability trials in swine. These were as follows:

1. The diet previously fed will influence the pigs choice of diet.
2. Individuals may differ from the average.
3. One or two pigs may influence the choice of the other pigs.
4. The pigs may change feeding habits as they get older.
5. The selection of diets may not follow a normal distribution.
6. Variation is extremely high.
7. Preference is not always for the diet which will give optimum performance.

8. There should be a preferential relationship between experimental diets, not merely acceptance or rejection.

Aldinger suggests that many of these problems can be overcome or reduced in significance by using the single stimulus method.

The whey used in the following trials was a partially delactosed dried whey product containing 50% lactose. This study was conducted to determine how this product compared to skim milk and corn-soybean diets, and to compare these results with those obtained using other types of whey. The addition of sugar and two methods of testing palatability were also studied to compare the results with those found in the literature.

PROCEDURES

Three trials were conducted during the course of this study. All pigs used were crossbred pigs from the South Dakota State University swine herd. The pigs in all trials were confined to inside, concrete floored pens which measured approximately 2.44 m in width and 2.74 m in length. The pens were bedded with wood chips during warm weather and with straw during cold weather. Feed and water were provided ad libitum. Water was provided by electrically heated, automatic waterers. In trials I and II and in replicate 4 of trial III feed was provided in round self-feeders holding approximately 45.4 kilograms of feed. In trial III, replicates one, two, and three were provided with rectangular self-feeders which measured 76.8 cm in length, 27.9 cm in width, and 53.3 cm in depth.

Trial I A Comparison of Whey and Skim Milk, With and Without Sugar

One hundred eighty pigs weaned at an average age of three weeks were used in this trial, which consisted of five treatments and four replications. The pigs were placed on trial in two groups in order to start the trial shortly after the pigs were weaned.

Ninety pigs were divided into two groups on the basis of weight. Each group was randomly allotted into five lots with nine pigs per lot. Sex was not considered in this allottment because it was felt that at this age sex would have little influence on the results. The heavier pigs which were allotted to replicate one had an average weight

of 7.2 kilograms, while those pigs allotted to replicate two had an average weight of 5.2 kilograms. Ten days later ninety additional pigs were stratified according to weight and litter and randomly allotted to ten lots of nine pigs each. The pigs in replicate three had an average weight of 5.3 kilograms and those allotted to replicate four had an average weight of 5.4 kilograms.

Each of the diets shown in Table 1 constituted a treatment. All the diets contained 10% rolled oats and were supplemented with minerals and vitamins to exceed minimum daily requirements as established by the National Research Council (1968). Diet A, the basal diet, contained ground yellow corn and 48.5% protein soybean oil meal. Diets B through E contained milk by-products and/or sugar in addition to the corn and soybean meal. The percentages of corn and soybean oil meal were adjusted in each diet to obtain isonitrogenous diets containing approximately 18% protein. Diet B contained 10% delactosed whey, the analysis of which is given in Table 1 of the Appendix. Included in diet C, was 10% delactosed whey plus 5% sucrose. Diet D contained 10% dried skim milk and diet E contained 10% dried skim milk plus 5% sucrose.

This trial was conducted over a five week period. The pigs were weighed weekly and feed consumption was recorded at each weigh period. The feeders were weighed at the start of the trial and feed was weighed into the feeders. The feeders were then weighed each time and the amount of feed consumed was calculated.

Table 1. Composition of Diets, Trial I (Percent)

Ingredients	Diet A	B	C	D	E
Ground yellow corn	63.9	57.0	50.5	60.5	54.5
Soybean meal (48.5%)	22.2	20.0	21.5	16.0	17.0
Rolled oats	10.0	10.0	10.0	10.0	10.0
Sugar	----	----	5.0	----	5.0
Delactosed whey	----	10.0	10.0	----	----
Dried skim milk	----	----	----	10.0	10.0
Dicalcium phosphate	1.9	1.5	1.5	1.6	1.7
Ground limestone	0.5	0.3	0.3	0.4	0.3
Trace mineral salts	0.5	0.2	0.2	0.5	0.5
Vitamin-antibiotic premix[a]	1.0	1.0	1.0	1.0	1.0

[a]Provided 4028.5 I.U. vitamin A, 749.7 I.U. vitamin D, 8.8 mg riboflavin, 17.6 mg calcium pantothenate, 39.7 mg niacin, 22.0 mcg vitamin B_{12}, 110.3 mg chlortetracycline, 110.3 mg sulfamethazine and 55.1 mg penicillin per kg of diet.

Trial II The Effect of Different Salt Levels

In this trial, sixty crossbred pigs averaging approximately four weeks of age were stratified according to weight and litter and divided into two replicates on a weight basis. The pigs were randomly allotted within replicates to five groups of six pigs each. Each group was then randomly assigned to one of five treatments. The pigs averaged 8.5 kg and 7.2 kg in replicates one and two, respectively.

The composition of the 18% protein diets used is shown in Table 2. The treatments used in this trial were:

1. Diet A
2. Diet B (10% delactosed whey plus 0.5% salt)
3. Diet C (10% delactosed whey with no added salt)

4. Diets B and C free-choice

5. Diets A, B, and C free-choice

The feeders in pens receiving treatments four and five were rotated daily to prevent pigs from eating out of the same feeder due to habit or the position of the feeder in the pen.

Table 2. Composition of Diets, Trial II (Percent)

Ingredient	Diet A	Diet B	Diet C
Ground yellow corn	63.9	56.7	57.0
Soybean meal (48.5%)	22.2	20.0	20.0
Rolled oats	10.0	10.0	10.0
Delactosed whey	----	10.0	10.0
Dicalcium phosphate	1.9	1.5	1.5
Ground limestone	0.5	0.5	0.3
Trace mineral salt	0.5	0.5	----
Trace mineral mix, gm[a]	----	----	7.1
Zinc oxide, gm	----	----	1.4
Vitamin-antibiotic premix[b]	1.0	1.0	1.0

[a]Calculated to furnish approximately the same trace minerals as provided by the trace mineral salt.

[b]See Table 1.

The pigs in this trial were weighed weekly and feed consumption was recorded on each weigh day. This trial was conducted over a five week period.

Trial III Comparison of Methods for Testing Palatability

One hundred forty-four pigs averaging four weeks of age were used in this trial, which was started on October 7. The pigs in this trial were also placed on test in two groups. Seventy-two pigs were

stratified by weight and litter and randomly allotted into two replicates with six treatments per replicate and six pigs per treatment. The pigs in replicate one were slightly heavier averaging 7.7 kilograms while those in replicate two averaged 6.8 kilograms.

Two weeks later, seventy-two additional pigs were stratified by weight and litter and randomly allotted into replicates three and four. The pigs in replicate three weighed an average of 7.6 kilograms and those in replicate four had an average weight of 7.3 kilograms.

Diets A, B, and C, described in Table 1, were also used in this trial. The experimental treatments were as follows:

Treatment	Diets	Method
1	A and B	Single-stimulus
2	A and B	Free-choice
3	A and C	Single-stimulus
4	A and C	Free-choice
5	B and C	Single-stimulus
6	B and C	Free-choice

The single-stimulus method involved exposing the pigs to one diet at a time at four hour intervals. The free-choice method involved exposing the pigs to both diets at all times, with the feeders being rotated at four hour intervals. The feeders were not changed during the eight hour period from 12:00 PM to 8:00 AM. This was done to prevent the same diet or the same feeder position from being available at the same time every day.

All feeders were weighed daily at 8:00 PM to determine daily feed consumption for each diet. The pigs were weighed weekly. Each replicate was on trial for a period of five weeks.

The daily feed consumption data for each diet were analyzed to determine the amount of deviation from the normal bell shaped curve, which one would expect to occur if the diets were consumed at random. This was done in an effort to determine which method of testing palatability had the least bias.

The average daily gains, feed efficiency, and feed consumption in all trials (except for feed consumption in trial III) were analyzed by the least squares method of analysis. This method was used due to the fact that there were unequal numbers since some of the pigs were lost during the course of this study. Significance was tested using the F-test as described in Steel and Torrie (1960).

RESULTS AND DISCUSSION

Trial I

A summary of the results of trial I is presented in Table 3. Pigs receiving diets containing whey or dried skim milk had average daily gains of 0.33 kilograms when the diets did not contain sugar and 0.34 kilograms when the diets contained 5% sugar compared to average daily gains of 0.30 kilograms for pigs receiving the basal diet. This represented a 10% increase in average daily gains for milk products alone and a 13.3% increase for milk products plus sugar. These differences, while showing a trend, were not significantly different.

The rate of gain of pigs weaned at an early age is generally related to their weaning weight. This effect was demonstrated in this trial in that the first replicate of pigs averaged approximately 1.82 kilograms per pig more in initial weight than the pigs in the other three replicates. At the termination of the trial, there was a difference of approximately 5.45 to 6.35 kilograms in average pig weights. The smaller pigs took a much longer period in adjusting to the diets and gained very little the first two weeks of the trial. However, the treatment differences in rate of gain were similar between the heavy and lightweight pigs.

The pigs receiving the milk by-products, with or without sugar, suffered a rather severe diarrhea for the first two weeks of the trial. This diarrhea, however, did not affect rate of gain or feed efficiency. Pigs on all treatments had feed efficiencies of less than

Table 3. Whey and Dried Skim Milk for Early Weaned Pigs

		Diet				
	Rep	Basal	Whey	Whey and Sugar	Dried Skim Milk	DSM and Sugar
Number of pigs	1	9	9	9	9	9
	2	9	9	9	9	9
	3	9	9	9	9	9
	4	9	9	9	9	8[a]
Average initial weight, kg	1	7.2	7.2	7.2	7.2	7.2
	2	5.1	5.3	5.1	5.2	5.2
	3	5.2	5.3	5.3	5.2	5.3
	4	5.4	5.4	5.4	5.4	5.4
	av.	5.7	5.8	5.8	5.8	5.8
Average final weight, kg	1	21.2	21.9	21.2	22.1	21.6
	2	15.0	17.5	17.4	16.1	17.1
	3	13.7	14.0	15.0	13.5	15.2
	4	15.0	14.6	16.0	16.1	15.6
	av.	16.2	17.0	17.3	16.9	17.4
Average daily gain, kg	1	0.39	0.42	0.39	0.43	0.41
	2	0.28	0.35	0.35	0.31	0.34
	3	0.24	0.25	0.27	0.24	0.28
	4	0.27	0.26	0.30	0.30	0.29
	av.	0.30	0.33	0.34	0.33	0.34
Average daily feed, kg	1	0.72	0.73	0.76	0.89	0.80
	2	0.52	0.61	0.64	0.56	0.61
	3	0.49	0.54	0.52	0.45	0.51
	4	0.48	0.51	0.64	0.57	0.53
	av.	0.55	0.60	0.64	0.63	0.61
Average feed/kg gain, kg	1	1.80	1.74	1.90	2.10	1.95
	2	1.83	1.73	1.83	1.79	1.81
	3	2.00	2.19	1.90	1.92	1.80
	4	1.75	1.96	2.14	1.88	1.80
	av.	1.85	1.91	1.94	1.92	1.84

[a]One pig died, data not included.

two kilograms of feed for each one kilogram of gain. The treatment averages ranged from 1.84 to 1.94 kilograms feed per kilogram gain for feed efficiency. This is in agreement with results obtained by Krider et al. (1949) who also reported diarrhea in pigs receiving whey, although gains were not affected.

The statistical analysis is shown in Table 4. The data were analyzed for average daily gain and feed efficiency. There were no significant differences shown for any of the treatments.

Table 4. Least Squares Analysis for Average Daily Gain and Feed Efficiency

Source of variation	d.f.	Mean squares: Average daily gain	Mean squares: Feed efficiency
Total	19		
Replicate	3	.0743**	.0209
Treatment	4	.0031	.0016
R X T	12	.0062	.0090

Although there were no significant differences among treatments, there was a highly significant difference among replicates for average daily gain. This is probably due to the difference in starting weights of the pigs and the increased gains of the heavier pigs in replicate one as described above.

Trial II

The results of this trial are summarized in Table 5. The pigs in the first replicate were approximately 1.36 kilograms heavier at the

start of the experiment than the pigs in replicate two. However, only in treatment 4 and 5 where the pigs received two and three diets, respectively, on a free-choice basis, did the heavier pigs gain faster than the lighter pigs.

Table 5. Whey in Early Weaned Pig Diets

		Treatment				
		1	2	3	4	5
	Rep	Basal	Whey and Salt	Whey	Diets B and C Free-choice	Diets A, B and C Free-choice
Number of pigs	1	6	6	6	6	6
	2	6	6	6	5[a]	6
Average initial weight, kg	1	8.5	8.5	8.5	8.5	8.4
	2	7.2	7.2	7.2	7.2	7.2
	av.	7.9	7.9	7.9	7.9	7.8
Average final weight, kg	1	17.6	19.3	19.1	20.7	22.8
	2	16.9	17.7	17.9	17.1	17.8
	av.	17.3	18.5	18.6	18.9	20.3
Average daily gain, kg	1	0.26	0.31	0.31	0.35	0.42
	2	0.28	0.30	0.31	0.29	0.31
	av.	0.27	0.31	0.31	0.32	0.36
Average daily feed, kg	1	0.69	0.62	0.88	0.87	0.96
	2	0.66	0.62	0.60	0.60	0.74
	av.	0.68	0.62	0.74	0.73	0.85
Average feed/ kg gain, kg	1	2.65	1.98	2.87	2.47	2.32
	2	2.34	2.03	1.94	2.11	2.43
	av.	2.50	2.01	2.41	2.29	2.38

[a]One pig was removed, data not included.

The production data for this trial are in close agreement with that of trial I. The pigs receiving whey in the diet had average

daily gains of 0.31 kilograms compared to an average daily gain of 0.27 kilograms for the pigs on the basal diet. This represented a 14.8% increase in average daily gains for those pigs receiving whey. However, average daily gains for the first four treatments of this trial were slightly lower than those obtained in trial I. The pigs in this trial also required more feed per kilogram of gain than did those in trial I. This may have been partially due to the fact that the second trial was conducted during the summer months and high temperatures caused some stress on the pigs. There were no significant differences in rate of gain or feed efficiency in any of the treatments. The pigs fed a choice of diets gained more rapidly in replicate one, but there was no difference in replicate two. The increased performance in replicate one was probably due to chance and the fact that the pigs on treatment 4 and 5, fed a choice of diets, gained at more uniform rates. The statistical analysis for average daily gain and feed efficiency for this trial is given in Table 6.

Table 6. Least Squares Analysis for Average Daily Gain and Feed Efficiency

Source of variation	d.f.	Mean squares	
		Average daily gain	Feed efficiency
Total	9		
Replicate	1	.0507	.0432
Treatment	4	.0166	.0144
R X T	4	.0074	.0175

There was no consistent preference shown for any of the diets. The pigs in replicate one of treatment 4 that received the whey and whey plus salt diets, consumed an average of 0.60 kilograms of the whey diet per day compared to an average daily consumption of only 0.26 kilogram of the whey plus salt diet. In replicate two, however, the pigs consumed about equal quantities of both diets. Average daily feed consumption for the whey diet was 0.30 kilogram and for the whey plus salt diet was 0.29 kilogram. The larger difference in replicate one may have been partially due to feed wastage of the basal diet. When the two replicates were averaged, the pigs consumed 0.46 kilograms of the whey diet compared to 0.28 kilogram of the whey plus salt diet per day. This is shown graphically in figure 1.

In treatment 5, the pigs in replicate one consumed about equal quantities of the basal and whey plus salt diets, 0.41 kg/day and 0.40 kg/day respectively. They only consumed 0.15 kg/day of the whey diet. In replicate two, the pigs consumed far more of the basal diet that did not contain whey than either of the other two diets which contained whey, with or without added salt. The average daily feed consumption for the basal diet was 0.51 kg as compared to 0.21 kg for the whey diet and 0.01 kg for the whey plus salt diet. When the two replicates were averaged, the pigs consumed 0.46 kg/day of the basal diet, 0.18 kg/day of the whey diet and 0.21 kg/day of the whey plus salt diet. This is shown graphically in figure 2.

It is difficult to explain the apparent difference in diet preference noted in the two replicates. The consumption pattern of

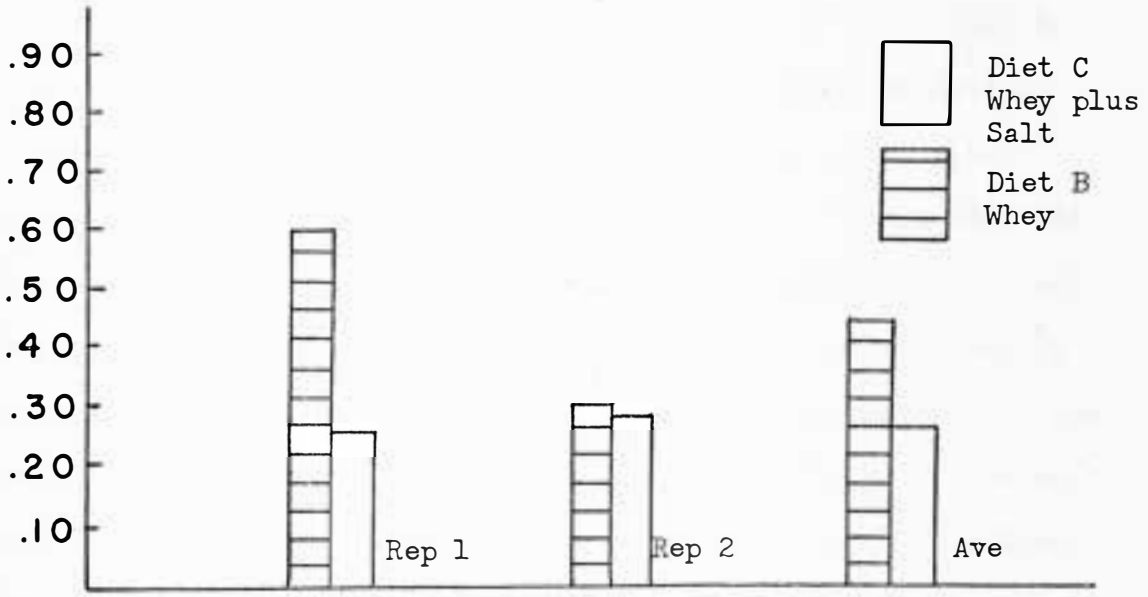


Figure 1. Average daily feed consumption of pigs fed Diet B, whey, and Diet C, whey plus salt, (treatment 4, trial 2).

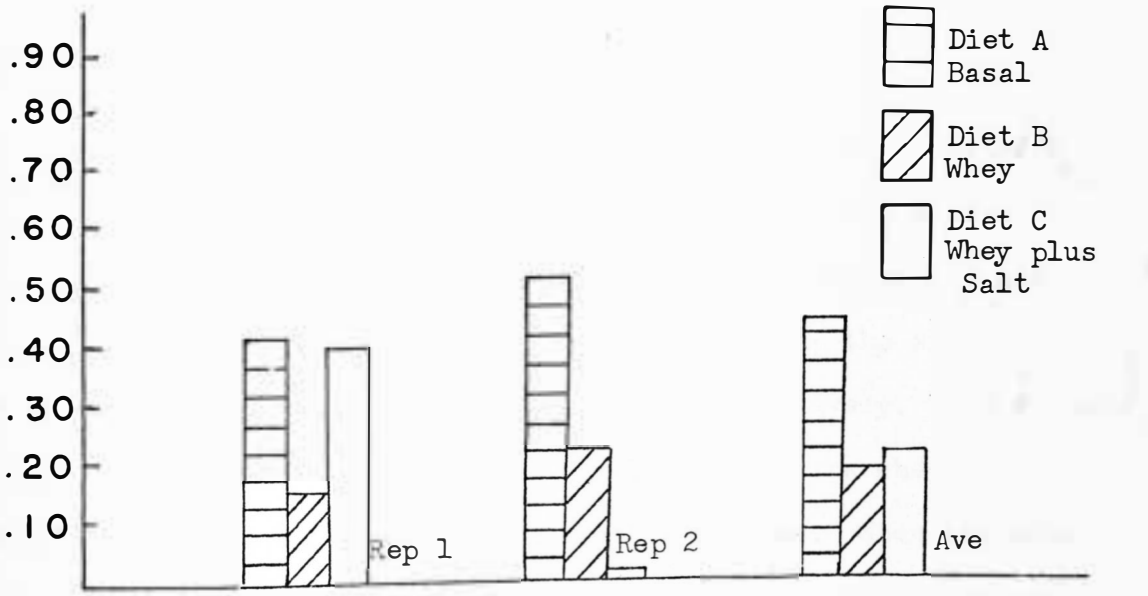


Figure 2. Average daily feed consumption of pigs fed Diet A, basal, Diet B, whey, and Diet C, whey plus salt, (treatment 5, trial 2).

replicate two would suggest that the whey diet plus added salt was unpalatable while the results of replicate one would refute this assumption. Consumption patterns were similar for pigs in both replicates the first week. The consumption of the basal, whey and whey plus salt diets was 5.2, 11.3 and 10.2 kilograms respectively in replicate one and 4.5, 12.0 and 11.3 kilograms respectively in replicate two. During the second week all the pigs refused the whey diet with added salt. After this consumption of the whey plus salt diet increased again. This may possibly be explained by the fact that the pigs consumed too much salt during the first week and compensated for this during the second week. Consumption of the whey diets increased as the pigs got older. Weekly feed consumption data for treatments 4 and 5 are shown in Appendix Table 2.

Trial III

The results of this trial are presented in Table 7. Average daily gains were higher for pigs on this trial than for those on trials I and II. Average daily gains for pigs receiving the basal diet and the whey diet were 0.41 kg and 0.40 kg for the single-stimulus and free-choice selection methods respectively. The average daily gains for pigs receiving the basal diet and the whey plus sugar diet were 0.40 kg for both selection methods. When the pigs were given a choice of the whey or whey plus sugar diets, average daily gains were 0.43 kg for the single-stimulus method and 0.41 kg

for the free-choice selection method. These differences in average daily gains were not statistically significant.

Feed efficiencies for pigs on this trial were better than those for pigs on trial II, but not as good as those for pigs on trial I. Feed efficiency was nearly the same for all treatments.

Four pigs died during the course of this trial. The deaths could not be attributed to any specific treatment. Three of the deaths were attributed to inflammation and hemorrhage of the stomach and intestines. The fourth death was caused by a ruptured kidney.

The least squares analysis for average daily gain, feed efficiency and total feed consumption is shown in Table 8. There were no significant differences among treatments for any of the parameters analyzed. There were, however, highly significant differences among replicates for average daily gain and total feed consumption, but not for feed efficiency. This significant difference in replicates can probably be explained by the fact that one replicate had a lighter average weight at the start of the trial. Although the pigs in replicate two only averaged 0.5 to 1.0 kilograms less in initial weight than those in the other replicates, these lighter pigs took longer to adjust to the dry rations. These results, as well as those of trials I and II, indicate the effect of weaning weight on post weaning gains when pigs are weaned at three or four weeks.

Palatability was tested using the single-stimulus method in treatments one, three and five. Treatments two, four and six included the same rations but palatability was tested using the free-choice

Table 7. A Comparison of Basal (Diet A), Whey (Diet B) and Whey Plus Sugar (Diet C) Fed by Free-Choice Selection or Single-Stimulus Methods

		Treatment					
		1	2	3	4	5	6
	Diets:	A & B	A & B	A & C	A & C	B & C	B & C
Method	Rep	SS[a]	FC[b]	SS	FC	SS	FC
Number of pigs	1	5[c]	6	6	5[c]	6	6
	2	6	6	6	6	6	6
	3	5	6	6	6	6	6
	4	6	6	6	6	6	6
Average Init. wt., kg	1	7.7	7.7	7.7	7.8	7.7	7.7
	2	6.9	6.8	6.9	6.8	6.9	6.8
	3	7.6	7.6	7.6	7.5	7.5	7.5
	4	7.3	7.3	7.3	7.3	7.3	7.3
	av.	7.4	7.4	7.4	7.4	7.4	7.4
Average final wt., kg	1	25.2	21.9	23.9	23.6	25.0	25.4
	2	22.5	20.2	21.4	22.5	21.2	21.2
	3	28.1	28.7	28.5	25.7	29.3	27.5
	4	22.3	24.9	22.9	23.6	26.1	24.9
	av.	24.5	23.9	24.2	23.8	25.4	24.8
Average daily gain, kg	1	0.41	0.34	0.39	0.38	0.41	0.42
	2	0.37	0.32	0.34	0.37	0.34	0.34
	3	0.49	0.50	0.50	0.44	0.52	0.47
	4	0.36	0.42	0.37	0.39	0.45	0.42
	av.	0.41	0.40	0.40	0.40	0.43	0.41
Average daily feed, kg	1	0.79	0.69	0.78	0.73	0.83	0.82
	2	0.72	0.58	0.71	0.73	0.67	0.68
	3	1.10	1.01	0.83	0.92	1.04	0.93
	4	0.90	0.89	0.73	0.76	0.90	0.81
	av.	0.88	0.79	0.76	0.79	0.86	0.81
Average feed/kg gain, kg	1	1.91	2.07	2.03	1.93	2.02	1.94
	2	1.93	1.81	2.05	1.96	1.96	1.98
	3	2.26	2.01	2.00	2.12	2.00	1.95
	4	2.53	2.13	1.96	1.97	2.01	1.94
	av.	2.16	2.01	2.01	2.00	2.00	1.95

[a] Single-stimulus selection method.

[b] Free-choice selection method.

[c] One pig died, data not included.

selection method. Those pigs on the single-stimulus method showed a more consistent preference than did those on the free-choice selection method. Only one replicate in each treatment on the single-stimulus method failed to show a preference or showed a preference opposite that of the other replicates. When all the replicates in each treatment are averaged, a consistent preference is shown for the same diet, irregardless of the method of palatability testing used. This is true despite the fact that there was much variation in preference shown by each replicate on the free-choice selection method. The weekly feed consumption for pigs on this trial is shown in Appendix Table 3.

Table 8. Least Squares Analysis for Average Daily Gain, Feed Efficiency and Total Feed Consumption

Source of variation	d.f.	Mean squares		
		Average Daily gain	Feed efficiency	Feed consumption
Total	23			
Treatment	5	.00175	.00452	.00679
Replicate	3	.02029**	.00460	.09706**
Error	15	.00171	.00426	.00373

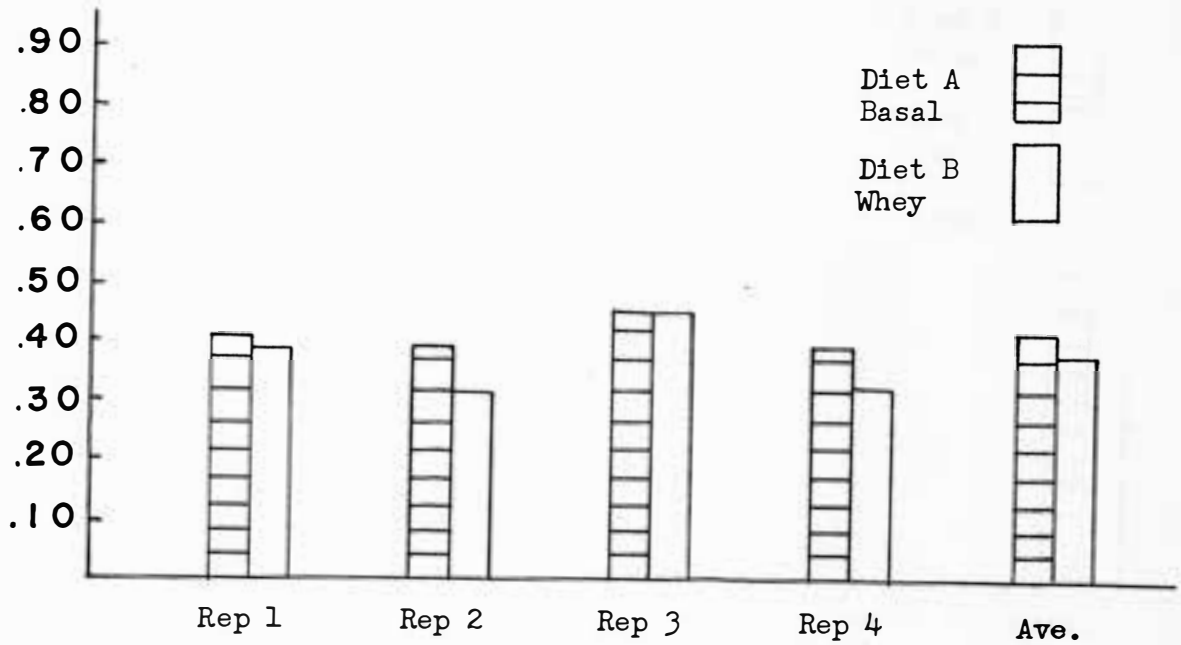
In treatments one and two the pigs were given a choice of the basal diet, which did not contain whey, or a diet containing 10% whey. The daily feed consumption for pigs on these treatments is shown graphically in figure 3. The average daily feed consumption for all replicates in treatment one was 0.49 kg of the basal diet and 0.39 kg of the whey diet. The pigs in treatment two consumed an average of

0.48 kg of the basal diet and 0.32 kg of the whey diet daily. However, the pigs in replicates one and three of treatment two showed a definite preference for the basal diet, while those in replicates two and four showed a preference for the whey diet.

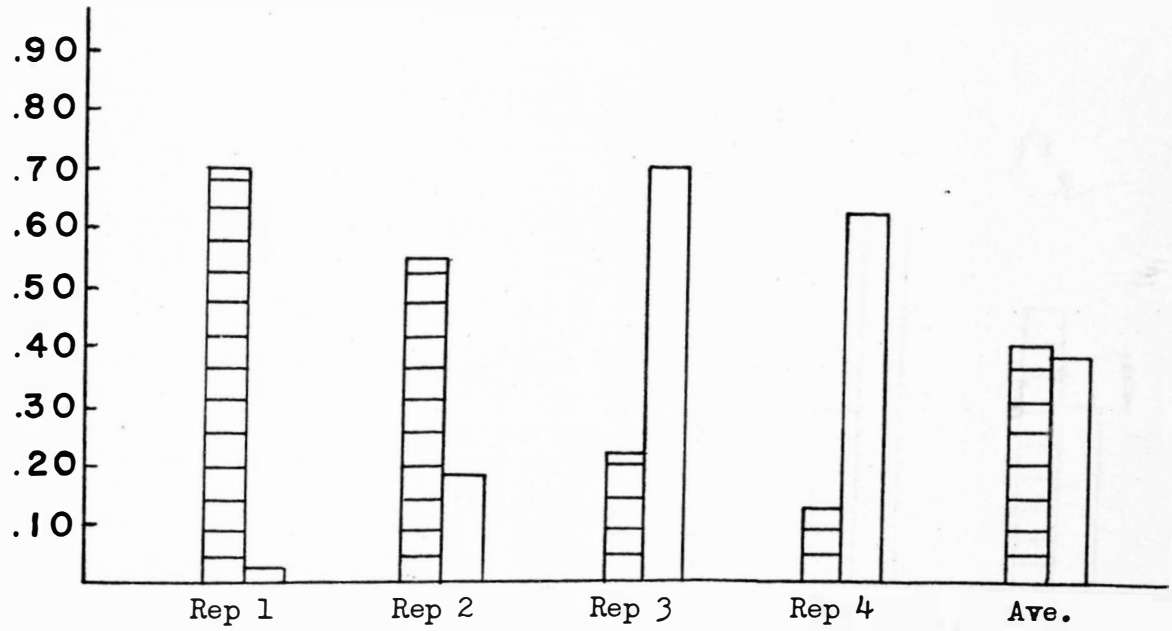
Figure 4 shows the average daily feed consumption for those pigs in treatments three and four. In these treatments, the pigs were given a choice of the basal diet or one containing 10% whey plus 5% sugar. The averages of all the replicates in each treatment were again similar, with the pigs in treatment three consuming 0.41 kg of the basal diet and 0.37 of the whey plus sugar diet daily, while those in treatment four consumed 0.40 kg of the basal diet and 0.38 kg of the whey plus sugar diet daily. Again there was variation among the replicates on the free-choice selection method. Replicates one and two showed a definite preference for the basal diet, while replicates three and four showed a definite preference for the whey plus sugar diet.

These data suggest that the corn-soybean meal-rolled oats type diet is quite satisfactory for pigs weaned at three to four weeks of age and is not improved by including 10 percent whey or 10 percent whey and 5 percent sugar. Seerley (1966) reported that pigs weaned at three weeks of age grew at similar rates when fed a corn-soybean meal diet, a complex diet containing corn, soybean meal, rolled oats, dried skim milk and sugar or both diets free-choice.

The average daily feed consumption for the pigs in treatments five and six is shown in figure 5. Here the averages for all the replicates in each treatment show a preference for the whey plus

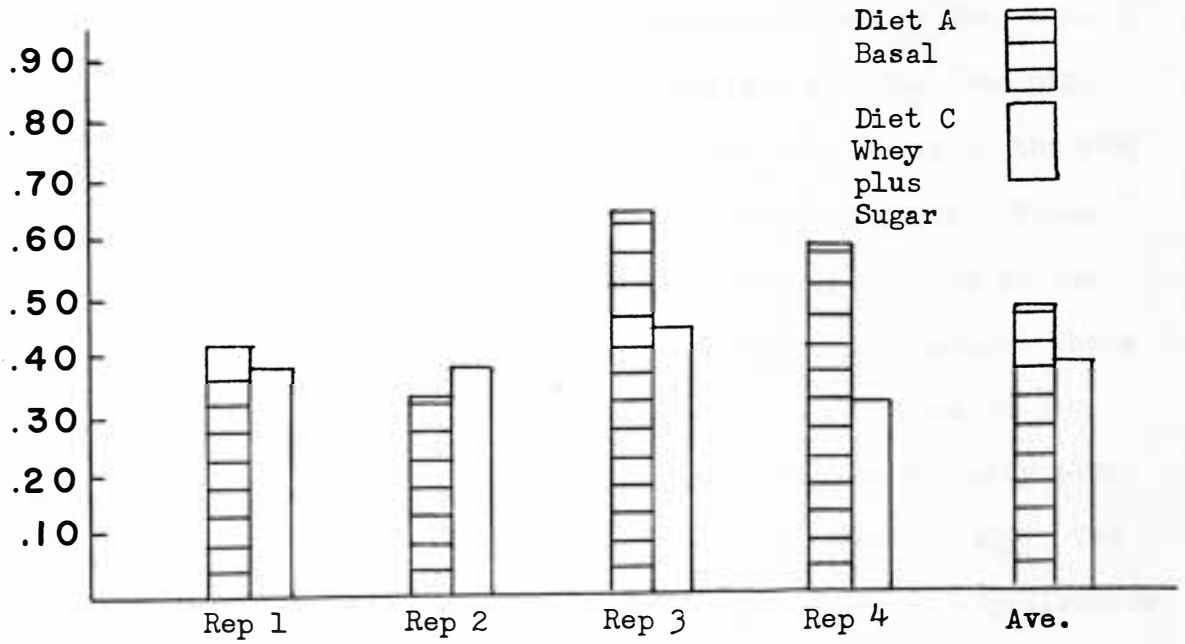


Treatment 1. Single-stimulus selection

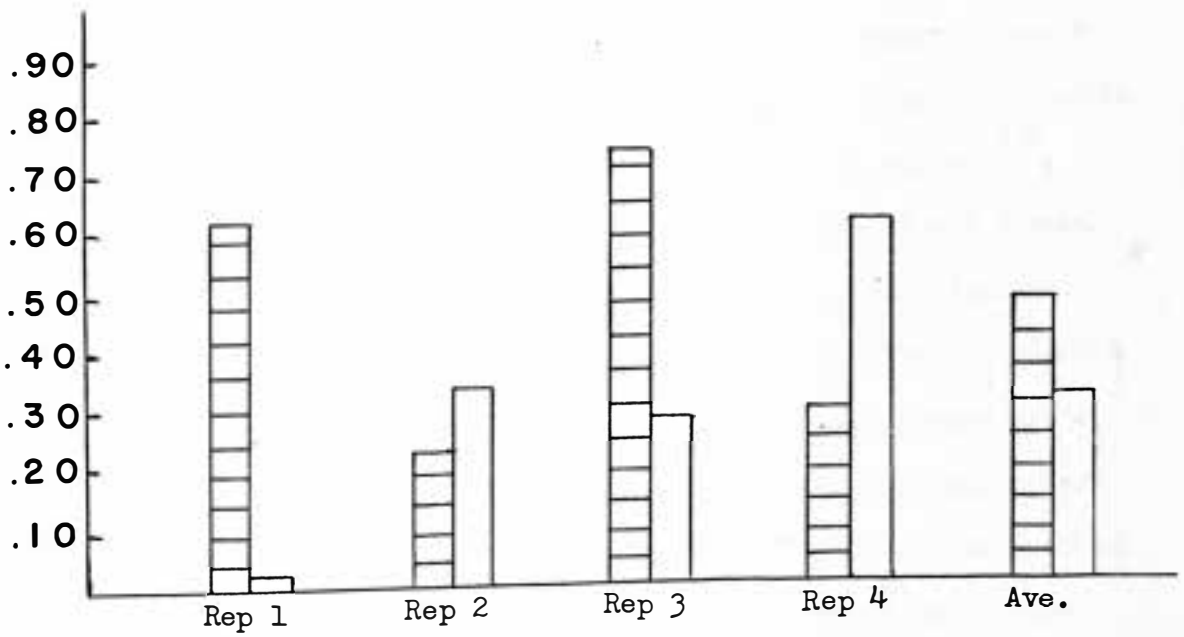


Treatment 2. Free-choice selection

Figure 3. Average daily feed consumption of pigs fed Diet A, basal, and Diet B, whey, (trial 3).



Treatment 3. Single-stimulus selection

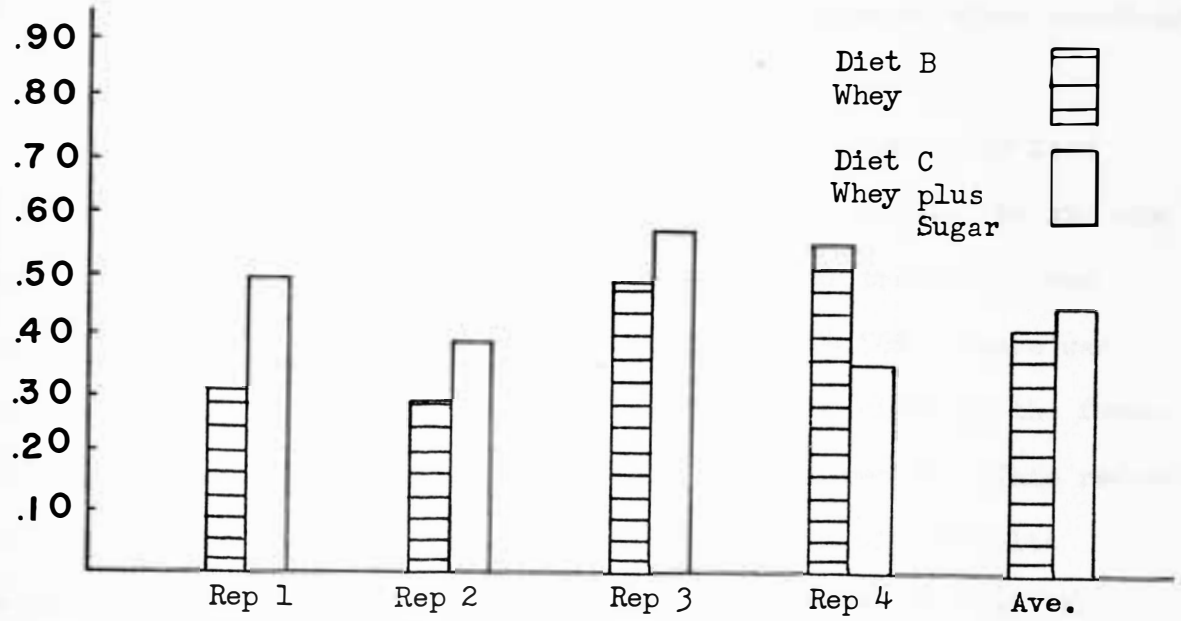


Treatment 4. Free-choice selection

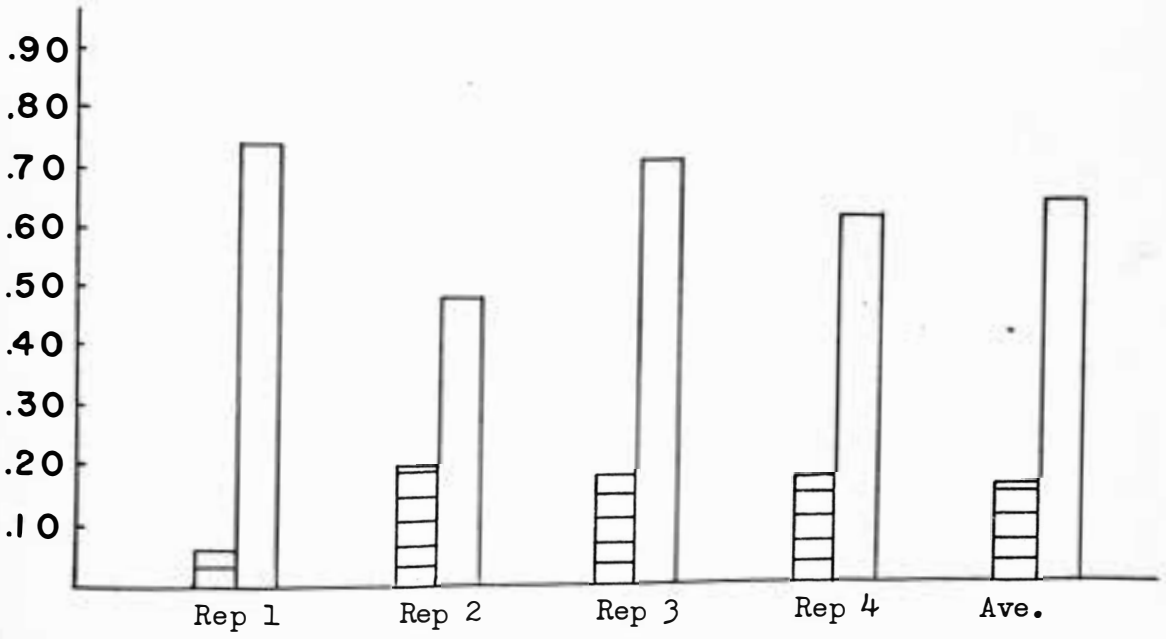
Figure 4. Average daily feed consumption of pigs fed Diet A, basal, and Diet C, whey plus sugar, (trial 3).

sugar diet over the whey diet, but this preference is shown much more definitely by the pigs on the free-choice selection method. The pigs on the single-stimulus method consumed an average of 0.42 kg of the whey diet as compared to 0.45 kg of the whey plus sugar diet daily. Those pigs on the free-choice selection method consumed only 0.16 kg of the whey diet compared to 0.65 kg of the whey plus sugar diet daily. There was no variation in preference shown in any of the replicates on the free-choice selection method as all replicates preferred the whey plus sugar diet by ratios of 9.2, 2.8, 3.8 and 3.5 to 1, respectively. The pigs in replicate four of the single-stimulus method showed a preference for the whey diet over the whey plus sugar diet, however, pigs in the other three replicates all consumed larger amounts of the whey plus sugar diet.

The preference for the diet containing whey plus sugar shown by the pigs on each method of palatability testing would seem to indicate that young pigs will consume more of a diet containing sugar in preference to one which does not if both are available at all times. However, if only one diet is available at a time, the addition of sugar does not greatly increase consumption. Seerley (1966) reported similar consumption of two diets when each was fed separately but a definite preference for the diet containing milk products and sugar when both were fed free-choice. The preference for a diet containing sugar when the pigs were allowed access to either ration on a free-choice basis is also in agreement with results reported by Lewis et al. (1955), Diaz et al. (1956) and Aldinger et al. (1959) who all



Treatment 5. Single-stimulus selection



Treatment 6. Free-choice selection

Figure 5. Average daily feed consumption of pigs fed Diet B, whey, and Diet C, whey plus sugar, (trial 3).

reported that young pigs preferred some level of sugar or other sweetener in the diet.

The coefficient of variation was determined for the daily feed consumption for each diet in each treatment and replicate. The average coefficient of variation for all the single-stimulus treatments was 51.94%, while that for the free-choice method was 94.86%. There was also a wider range of variation among replicates and diets in the free-choice selection method than in the single-stimulus method. This reduction in the coefficient of variation is in agreement with results reported by Aldinger and Fitzgerald (1966). They reported that the coefficient of variation was reduced from 36.0% to 5.5% by the use of the single-stimulus method.

SUMMARY AND CONCLUSIONS

A total of three hundred eighty-four crossbred pigs were used in three trials to study the effects of adding milk by-products and sugar to a basal diet of corn, soybean meal and rolled oats for early weaned pigs. In trial I, one hundred eighty pigs were used in making a comparison of the basal diet and diets containing the following additions: ten percent whey, ten percent whey plus five percent sugar, ten percent dried skim milk, and ten percent dried skim milk plus five percent sugar. There were no significant differences in average daily gain or feed efficiency. The pigs receiving the milk products in the diet had average daily gains of 0.33 kilogram when the diets did not contain sugar and 0.34 kilogram when the diets contained sugar, compared to 0.30 kilogram for those pigs on the basal diet. This represented a 10.0% increase in rate of gain for pigs fed milk products alone and a 13.3% increase for those fed milk products plus sugar. Feed efficiency for the pigs on this trial ranged from 1.84 to 1.94 kilograms of feed per kilogram of gain.

Sixty pigs were used in trial II to study the effects of the increased salt content of delactosed whey on palatability, rate of gain and feed efficiency. Five treatments were used in this trial. Pigs on treatment one received the basal diet, those on treatment two received the whey diet, those on treatment three received the whey plus salt diet, those on treatment four received the whey and whey plus salt diets on a free-choice selection basis. There were

no significant differences in average daily gain or feed efficiency between treatments. The pigs receiving the whey diets had slightly better average daily gains as was true in the first trial. Average daily gains for those pigs receiving whey were 0.31 kilogram compared to 0.27 kilogram for the pigs on the basal diet. Feed efficiency ranged from 2.01 to 2.50 kilograms of feed per kilogram of gain.

There was no consistent marked preference shown for any of the diets when the pigs were fed two or three diets on a free-choice selection basis, although the pigs did consume more of the basal diet than the whey diets. The higher salt content of delactosed whey apparently has little effect on the palatability of the whey diet. However, when the pigs were given a choice of three diets they consumed about equal quantities of both whey diets the first week, but did not consume any of the whey plus salt diet the second week. After this period they again began to consume the whey plus salt diet and total consumption of the two whey diets was about equal during the trial.

In trial III one hundred forty-four pigs were used to compare the free-choice selection method and the single-stimulus method of palatability testing. Three diets were used in this trial. They were the basal diet, the whey diet and the whey plus sugar diet. The pigs in each treatment were given a choice of two diets. Each diet containing whey was compared to the basal diet and the two whey diets were also compared. Each combination of diets was tested using both methods of

palatability testing. There were no significant differences among treatments in average daily gain or feed efficiency.

The pigs on the single-stimulus method showed less variation in diet preference and there was less difference in the amounts of each diet consumed. The pigs on the free-choice selection method showed much variation in preference with the pigs in some replicates within the treatment showing a definite preference for one diet while those in other replicates showed a definite preference for the other diet. When all the replicates were averaged, however, the pigs on both methods showed a preference for the same diet in each comparison.

Pigs showed a greater preference for the basal diet than either of the whey diets, however, there was little difference in consumption when the choice was the basal or whey plus sugar diets. The pigs on the free-choice selection method showed a very definite preference for the whey diet containing sugar compared to the whey diet, however, this preference was much less definite for the pigs on the single-stimulus method indicating that the addition of sugar does not greatly increase the consumption of the diet.

The single-stimulus method of testing palatability appears to be a better method than the free-choice selection method especially if a small number of pigs and replicates is used. With the single-stimulus method the pigs show a more consistent pattern of preference. The coefficient of variation was reduced from 94.86% for the free-choice method to 51.94% for the single-stimulus method.

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APPENDIX

Table 1. Analysis of Delactosed Whey

Nutrient	Content
Lactose, %	50.00
Protein (N x 6.25), %	18.00
Minerals, %	14.10
Fat, %	1.00
Moisture, %	4.00
Fiber, %	None
Calcium, %	1.50
Phosphorus, %	1.00
Potassium Chloride, %	1.20
Sodium Chloride, %	3.80
Riboflavin, mg/kg	52.92
Niacin, mg/kg	17.64
Pantothenic Acid, mg/kg	74.97
Choline, mg/kg	4,189.50
Vitamin B_{12}, mmg/kg	133.08
Pyridoxine, mg/kg	5.29
Thiamine, mg/kg	4.85
Folic Acid, mmg/kg	253.58
Biotin, mmg/kg	595.35
Arginine, %	0.59
Glycine, %	1.04
Histidine, %	0.33
Isoleucine, %	1.07
Leucine, %	1.73
Lysine, %	1.49
Methionine, %	0.57
Cystine, %	0.57
Phenylaline, %	0.72
Tyrosine, %	0.76
Tryptophane, %	0.36
Valine, %	0.94
Threonine, %	0.86
Aspartic Acid, %	1.57
Glutamic Acid	2.58

Table 2. Weekly Feed Consumption in Kilograms for Pigs Receiving Diet A, Basal, Diet B, Whey and Diet C, Whey Plus Salt in Treatments 4 and 5 of Trial II

Treatment 4			
Replicate 1		Replicate 2	
Diet B	Diet C	Diet B	Diet C
6.1	11.6	11.3	7.3
22.4	0.2	5.2	10.4
30.2	12.9	7.5	18.1
31.5	16.6	18.1	14.3
42.6	25.4	29.3	12.2

Treatment 5					
Replicate 1			Replicate 2		
Diet A	Diet B	Diet C	Diet A	Diet B	Diet C
5.2	11.3	10.2	4.5	12.0	11.3
8.4	13.6	0.0	15.2	2.3	0.0
34.2	1.6	6.6	25.9	10.7	0.9
14.1	0.2	32.0	29.0	7.7	0.5
23.1	16.1	39.7	28.1	23.6	1.4

Table 3. Weekly Feed Consumption in Kilograms for Pigs Receiving Diet A, Basal, Diet B, Whey and Diet C, Whey Plus Sugar in Trial III

Treatment 1			
Replicate 1		Replicate 2	
Diet A	Diet B	Diet A	Diet B
3.6	3.4	5.9	4.3
8.8	12.7	9.8	11.3
19.3	14.3	17.2	20.6
21.3	24.7	18.6	32.0
32.2	24.3	33.8	26.8
Replicate 3		Replicate 4	
17.0	14.1	9.1	6.3
23.6	20.0	16.3	15.0
23.8	22.9	28.3	17.5
32.0	16.6	35.8	20.9
40.8	19.3	51.5	25.9

Treatment 2			
Replicate 1		Replicate 2	
Diet A	Diet B	Diet A	Diet B
8.6	0.5	8.2	0.7
20.9	0.0	18.8	0.0
40.1	0.0	25.9	4.3
46.7	0.9	2.5	36.7
48.5	9.3	8.2	43.5
Replicate 3		Replicate 4	
24.0	1.8	6.8	10.7
27.0	12.2	4.3	26.8
36.7	16.1	10.7	37.0
54.2	9.5	11.3	46.0
58.5	28.3	36.3	35.8

Table 3. (Continued)

Treatment 3			
Replicate 1		Replicate 2	
Diet A	Diet C	Diet A	Diet C
10.2	5.0	5.7	6.3
13.6	9.3	11.8	12.5
20.6	17.0	20.6	16.1
24.0	30.2	23.8	21.8
33.1	34.2	37.9	22.2
Replicate 3		Replicate 4	
12.9	15.2	9.1	7.0
16.8	21.3	12.9	13.4
27.0	22.9	17.9	17.5
27.2	34.9	24.7	20.2
29.9	38.1	34.5	25.6

Treatment 4			
Replicate 1		Replicate 2	
Diet A	Diet C	Diet A	Diet C
9.3	1.6	9.1	7.0
18.6	0.9	12.9	13.4
27.9	1.1	17.9	17.5
39.7	0.7	24.7	20.2
51.7	1.8	34.5	25.6
Replicate 3		Replicate 4	
8.4	24.0	2.3	15.4
11.6	28.1	7.0	23.8
10.2	37.0	7.5	32.0
14.3	40.1	1.8	44.4
10.7	47.2	14.3	43.8

Table 3. (Continued)

Treatment 5			
Replicate 1		Replicate 2	
Diet B	Diet C	Diet B	Diet C
5.2	8.8	4.8	5.0
9.5	17.5	7.5	13.8
20.0	22.4	15.0	22.7
23.6	32.9	20.4	24.5
29.9	40.1	26.8	28.8
Replicate 3		Replicate 4	
12.7	17.7	10.9	8.6
22.2	21.5	17.9	13.2
25.2	25.9	27.4	20.6
28.1	36.7	32.4	24.9
32.2	39.7	46.7	24.5

Treatment 6			
Replicate 1		Replicate 2	
Diet B	Diet C	Diet B	Diet C
0.7	10.7	0.9	8.4
0.0	25.2	0.7	21.5
1.8	42.2	6.8	31.1
1.4	56.0	23.6	23.1
16.3	52.2	18.6	35.8
Replicate 3		Replicate 4	
1.4	29.3	4.3	14.3
1.6	37.6	4.8	27.7
8.6	33.6	17.0	24.3
11.8	44.2	5.0	46.7
17.2	47.8	14.7	46.0