for commercial production of magnesium ammonium phosphate, the preferred procedure would probably be ammoniation of the solid acidulates of mixtures of the two minerals. An advantageous adaptation might be their introduction with the chosen acid into the "cone mixer" developed by Bridger, Wilson, and Burt (*1*) and used by Yates and Williams (*17*) and by Young and Heil (*18*) for subsequent ammoniation of the resultant superphosphate. With olivine as a chosen variant for magnesium content, the resultant acidulate could be ammoniated directly—i.e., without filtration.

Although pointed to continuous acidulation of the jointly delivered minerals, the process could be adapted to batch acidulations, with or without ammoniation of leachates therefrom. One certainty and one uncertainty arise from such operations. The unfiltered acidulated mixtures become diluted by the silica (SiO_2) liberated from the olivine, but this need not become a problem where the olivine inclusions would be a small fraction of the total. The uncertainty is whether the variations in ammoniation technique would result in an anhydride or hexahydrate precipitate.

The results from the closely controlled acidulations of 50-gram charges of the mixtures of olivine and rock phosphate and ammoniations of the resultant slurries were in close accord with the values indicated by the equations, and it is believed that rigorous pilot plant trials would demonstrate the ease and economy of the proposed procedure and production.

Important also is the fact that olivine has proved efficacious both as conditioner and for input of magnesium. Obviously, in case direct additions of the silicate to superphosphates are not to be followed by ammoniation, the mixtures should be sufficiently moist to offset the drying resultant from hydration of the two engendered diphosphates (*5*).

The magnesium silicate minerals occur in multiple locations in the United States. The North Carolina Conservation Commission has described and pictured the extensive and relatively accessible formations in western North Carolina and north Georgia (*14*), fairly close to sources of both sulfuric acid and rock phosphate, so that operation of the "wet method" upon olivine, alone and jointly with rock phosphate, and successive ammoniations of the resultant slurries might bring economic production of magnesium fertilizers of known value.

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ENZYME RESPONSE TO DIETARY SUGAR

Effect of Various Levels of Dietary Sugar on the Succinoxidase of the Liver of Swine and Cattle

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THE SEARCH for new feeds is of great importance in the animal industry. Each new possibility demands tests such as rate of gain, carcass characteristics, and chemical evaluations. "Crude" sugar becomes available at times and may have special properties as an animal feed. It is partially refined sugar, fairly economical, and should be equivalent to other dietary carbohydrates. A typical analysis gives approximately the following percentages of various substances: sucrose, 88; invert sugar, 5; protein, 0.7; ash, 1.4; and water, 4.7. Wilcox *et al.* (*7*) fed sucrose to 95 beef cattle and 12 swine from 14 days to 6 hours before slaughter and observed that the livers of the animals fed the sucrose were larger and contained more sugars than the controls. Heck (*3*) found that crude sugar reduced shrinkage in swine during shipment to market, decreased shrinkage of hams during curing, and improved flavor, texture, and tenderness. Shipley, Meyer, Copenhaver, and McShan (*5*) reported that the diabetic lactating rat has twice as much succinoxidase in the liver as normal lactating rats. They believed that such a response to excess sugar was an example of enzyme adaptation (*5*). Bargoni (*2*) found that rats fed 87% sugar diets for 25 days had approximately 20% more succinic dehydrogenase in their livers than corresponding rats that were fed casein instead of sugar. The present study was made in the light of the above reports, to determine how succinoxidase activity in the liver would be affected by sugar fed in growing-fattening diets of swine and cattle.

Procedure

Forty-seven purebred Duroc, purebred Spotted Poland China, and Spotted Poland China X Hampshire crossbred swine were divided into four dietary groups according to breed, sex, and weight and fed the rations shown in Table I from 9 weeks of age until they weighed 220 ± 8 pounds. All were fasted 24 hours before slaughter. As breed and sex had no effect on the data, no values are presented for these factors.

Fourteen Aberdeen Angus heifers, 15 months old, and weighing 709 ± 57 pounds each, that had been on a full feed of ground snapped corn, cottonseed meal, and alfalfa hay for 4 months, were given the dietary sugar treatments shown in Table I. The heifers were fasted 16 hours before slaughter.

Samples of liver were obtained from the swine and heifers 45 ± 5 minutes after they were sacrified by bleeding. The samples were immediately frozen solid at −8° C. and analyzed during the following week for succinoxidase activity

Three groups of swine were self-fed 0, 40, and 72% of crude sugar diets from weaning until they weighed 220 ± 8 pounds. A similar group was fed the basal ration until the 40% sugar diet was fed 72 to 24 hours before slaughter. The average succinoxidase activity values obtained for the liver, expressed as microliters of oxygen uptake per milligram of nitrogen per hour, for the four dietary groups were 18, 25, 24, and 56, respectively ($P < 0.01$). Aberdeen Angus heifers that weighed 709 ± 57 pounds and were fed 0 and 3 pounds of crude sugar per day for 28 days just prior to being slaughtered had 63 ± 15 and 83 ± 10 μl. of oxygen uptake per mg. of nitrogen per hour due to succinoxidase activity in the liver, respectively ($P < 0.01$). Lactic dehydrogenase activity was not influenced in the liver of the heifers by the dietary sugar. Succinoxidase activity was not affected in the heart of the swine or cattle by the dietary treatments.

Table I. Composition of Crude Sugar Diets

		Swine		
Diet No.	1[a]	2[a]	3	4[a]
Sugar, %	0	40	72	Diet 1, then No. 2 during 72 to 24 hours before sacrifice
Corn, %	84	36	as determined by free choice with protein supplement[b]	
Soybean oil meal, %	7	11		
Meat and bone scrap, %	7	11		
Protein, %	14.0	14.2	13.7	14.2
No. of animals	12	11	13	10
		Cattle		
Diet No.	1	2	3	
Ground snapped corn, lb./day	14	14	11	
Cottonseed meal, lb./day	3	3	3	
Alfalfa hay, lb./day	5	5	5	
Sugar, lb./day	0	4 (in saturated drench 1 day before slaughter)	3 (for 28 days before slaughter)	
No. of animals	3	3	8	

[a] Also vitamin A and D mix, 1% (supplied 2380 I. U. of vitamin A and 396 I. U. of vitamin D per lb. of feed); iodized salt, 0.5%; Aurofac-10, 0.2%; trace elements 0.1%, and Fortafeed 2-49C, 0.2%; Aurofac-10 contains 10 grams of chlortetracycline per pound, and Fortafeed 2-49C contains the following vitamins in mg. per pound: riboflavin, 200; pantothenic acid, 4000; niacin, 9000; and folic acid, 60.

[b] High protein supplement contained 47% soybean oil meal, 47% meat and bone scraps, 1.5% iodized salt, 3% vitamin A and D mix, 0.6% Aurofac-10, 0.3% trace minerals (supplying following elements in p.p.m.: Mn, 54; ferrous Fe, 67; Cu, 5; Co, 1.5; I, 23; K, 7).

by the manometric method of Schneider and Potter (*4*) at 38° C. Succinoxidase activity was found not to change in these samples over a 28-day period of storage. Nitrogen was determined in the homogenates of the tissues by the Kjeldahl method and the enzyme activity was calculated as microliters of oxygen uptake per hour per milligram of nitrogen and per gram of wet weight. Statistical analyses of the variance of the data were made according to Snedecor (*6*).

Results and Discussion

Table II shows data obtained for daily gain and weight of the liver as percentage of body weight. The swine fed the 72% sugar (free choice) ration had a slower ($P < 0.01$) rate of gain per day, and a larger ($P < 0.01$) liver expressed as percentage of body weight. The sugar rations fed the heifers did not significantly affect weight gains, dressing percentages, or carcass characteristics.

In Figure 1 data are graphed that were obtained for the succinoxidase activity of the liver of the swine and cattle. There was no significant difference in the enzyme activity of the liver of the swine fed the 0, 40, and 72% sugar rations. The group that was fed the 40% sugar rations from 72 to 24 hours before slaughter had greater ($P < 0.01$) activity than the other dietary groups on both the wet weight and per milligram of nitrogen basis. This greater activity occurring in the liver soon after sugar feeding was started may be related to the greater amount of sugar present in the liver at this time. Wilcox *et al.* (*7*) found 2.0% of dextrose in the liver of swine fed 2 pounds of sucrose per day for 3 days, compared to 1.49% in those fed for 14 days. Their control swine had 0.86% of dextrose in the liver. The present observation is similar to that of Baccari and Auricchio (*1*) who reported that in a glucose-tolerance test, rats had a marked increase in phosphatase activity in the liver 1 hour after injection of 2 grams of glucose per kg. of body weight. Bargoni (*2*) found that rats fed high sugar diets had more succinic dehydrogenase in their livers than corresponding rats that were fed casein in place of sugar. These observations suggest enzymatic mechanisms through which animals are able to make a quick response to dietary sugar, and may give a lead to explain the favorable action on the meat of animals as observed by Heck (*3*) when the sugar is fed just before slaughter.

Table II. Effect of Sugar Diets Fed to Swine on Daily Gain, and Weight of Liver as Percentage of Body Weight

Sugar, %	0	40	72[a]	40[b]
Gain, lb./day[c]	1.98	2.03	1.64	2.04
Liver, %[c]	1.56	1.64	1.92	1.88
No. of swine	12	12	13	10

[a] Free choice of sugar *vs.* high protein supplement (see Table I).

[b] Basal diet, then 40% sugar diet from 72 to 24 hours before slaughtering (see Table I).

[c] Highly significant, $P < 0.01$.

Succinoxidase activity was also determined in the heart of the swine. The dietary groups that were fed 0, 40, and 72% of crude sugar from weaning until slaughtered and 40% of sugar 72 to 24 hours before being slaughtered, had 900 ± 108, 990 ± 116, 868 ± 44, and 1018 ± 142 μl. of oxygen uptake per hour per mg. of nitrogen in their hearts, respectively. Statistically, these differences were not significant.

The data for succinoxidase in the livers of the heifers are graphed in Figure 1. The heifers did not demonstrate any increase in succinoxidase activity one day after the sugar was administered. However, more ($P < 0.01$) succinoxidase activity occurred after the 28th day of feeding 3 pounds of sugar per day. Wilcox and coworkers (*7*) found a small increase in dextrose in the liver 30 hours after giving sugar to cattle by stomach tube, but the highest concentration was observed 3 days after continuous feeding of sugar. These observations help ex-

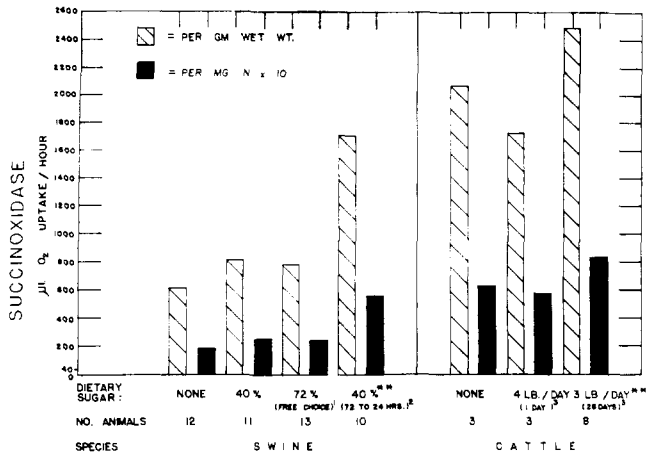

Figure 1. Effect of various sugar diets on the succinoxidase of the liver of swine and cattle

** $P < 0.01$

1. Sugar and protein supplement free choice (see Table I). 2. Basal diet, then 40% sugar diet from 72 to 24 hours before slaughter. 3. Sugar, 4 pounds per day, given as saturated aqueous drench. 3 pounds per day fed in dry diet (see Table I) during 28-day period

plain the lack of response of the succinoxidase to the sugar after 24 hours, but not the increase observed at the 28-day period. It may be that continuous stimulation of the enzyme over the 28-day period by the sugar results in a more active enzyme in the liver of cattle. The increase in size of the liver observed in animals fed sucrose may be related to increased metabolic activity in the liver in general, of which succinoxidase activity is only a part. It may be that the liver has the capacity to keep the dextrose at a near normal level by means of greater enzyme activity. The present observations demonstrate that cattle and swine have a succinoxidase system in the liver that is sensitive to dietary sugar in a manner similar to that observed in rats by Shipley *et al.* (*5*) and Bargoni (*2*).

Succinoxidase was also determined in the heart of the heifers, but was not affected by the dietary treatments. All values ranged from 900 to 1000 μl. of oxygen uptake per mg. of nitrogen per hour in the left ventricle. Lactic dehydrogenase was determined in both the liver and heart of the heifers, but did not vary among the dietary groups. The heart had approximately 9 times as much lactic dehydrogenase activity as the liver—i.e., approximately 180 as compared to 20 μl. of oxygen uptake per mg. of nitrogen per hour.

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GRAIN WAX COMPONENTS

Fractionation of Sorghum Grain Wax

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Considerable study has been given to the problem of finding a wax to replace carnauba wax in some of its many uses. Sorghum grain wax is somewhat similar, but there are some differences in their physical properties (*2*). If the compounds present in sorghum grain wax could be determined, perhaps means could be devised to alter their proportions to produce a material with more of the characteristics of carnauba wax. Column chromatography was used to study the isolation and identification of sorghum grain wax components.

Experimental

Extraction of Wax. Sorghum grain (Midland variety) was extracted, with Skellysolve B, in 1200-gram batches in a large Soxhlet extractor. The extract was evaporated to 100 ml. and 500 ml. of hot acetone were added. Upon cooling to 4° C. a white, flocculent precipitate was obtained. The precipitate was collected on a Büchner funnel and washed with small portions of cold acetone. Two grams of crude wax (melting point 80–4° C.) were obtained from each batch of grain.

Attempts to obtain a reaction between the crude wax and 2,4-dinitrophenylhydrazine were unsuccessful, and it was concluded that the wax did not contain a ketone. Absence of unsaturation was shown by failure of the wax to decolorize a bromine–carbon tetrachloride solution.

Chromatography of Known Compounds. The physical constants of certain components of saponified sorghum wax (*2*) were similar to those of some of the components of alfalfa wax (*1*), indicating that the components of the two waxes may be similar. Therefore, a preliminary study was made of the chromatographic behavior of purified alfalfa wax components to establish conditions that might be used to separate the components of sorghum grain wax.

Samples of pure paraffin, ester, and alcohol from alfalfa wax were available from the work of Blair and others (*1*). Adsorbents selected for the study were: tricalcium phosphate, Supercel, 1 to 1 by weight; magnesia (Westvaco 2641), Supercel, 1 to 1 by weight; and silicic acid (Mallinckrodt AR, 100 mesh), Supercel, 1 to 1 by weight. Adsorption tubes (1 × 18 inches) were attached to suction flasks. The adsorbent was added, under vacuum, to the tubes in small portions and was tamped firmly with a cork mounted on a glass rod. The final length of the adsorbent column was 15 inches. One-tenth gram of a single wax component was dissolved in 50 ml. of warm