

Salt Tolerance and Salt Poisoning of Swine

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THERE HAS BEEN a good deal of discussion about whether certain cases of poisoning in swine, often fatal, were due to an excess of salt. The author reports the results of a careful investigation to clear up the whole question of how much salt swine can tolerate and what an excessive amount does to them.

COMMON SALT is recognized as one of the chemical substances required in the diet of animals; hence it is good husbandry to include a supply in the rations of livestock. The quantitative requirements vary with the species. Those for swine are regarded as among the lowest. That excessive amounts may be harmful to the extent of being toxic is not at all surprising, since there are recognized limits beyond which various nutritive essentials become a burden, or even toxic, to the animal body. Much of the science of animal nutrition is built around the proper proportioning and balancing of the essential elements of the diet.

"Salt poisoning" is the term frequently used to characterize certain forms of poisoning, often fatal, in swine, which are generally attributed to an excessive intake of sodium chloride. The true cause, particularly the conditions under which severe poisoning may result, remains obscure.

Various reports have listed a number of gross symptoms as characterizing the condition, including extreme nervousness, frothing at the mouth, convulsions, paralysis, diarrhea, vomiting, loss of appetite, extreme thirst, blindness, and finally death. As evidence of the causative agent, case histories have frequently pointed to the consumption of large amounts of salt, especially in the form of brine, by

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hogs that for extended periods had not received salt as a regular part of their ration. Udall (11)² has pointed out that the immediate effect of excessive consumption of salt is inflammation of the mucous membrane of the stomach and marked redness and dryness of that of the mouth. The principal change evident on post mortem examination is gastroenteritis (inflammation of the stomach and intestines).

RESULTS OF STUDIES OF SALT REQUIREMENTS AND SALT TOLERANCE OF SWINE

As a result of feeding investigations on the requirements of swine for salt, the need for small additions to the ration is well recognized. The generally recommended practice is to provide a mineral mixture containing salt in a self-feeder compartment, so that the pigs can satisfy their craving for minerals, or to mix small amounts with the concentrate feeds. The daily requirements are known to be small. Morrison (7) recommends not over $\frac{1}{4}$ pound of salt to 100 pounds of feed mixture. This would allow 5 to 6 grams (less than $\frac{1}{4}$ ounce) a day per 100 pounds of live weight; when this is added to the salt naturally contained in the average ration, the total would probably seldom exceed 10 grams (about $\frac{1}{3}$ ounce).

That salt may be toxic to animals when consumed in large quantities has been recognized as entirely probable for a long time. The lethal, or fatal, dose for poultry has been fairly well established from the work of Mitchell, Card, and Carman (6) and others. Concerning the toxic quantity for swine, the results are conflicting. As will be seen in the present review, the case against salt as the cause of poisoning is not clear-cut in spite of the frequent warnings found in textbooks and popular articles on swine feeding. Undoubtedly, gorging with salt has been at least a contributory if not the main factor in a certain number of deaths among swine. In his discussion of salt poisoning in livestock Udall (11) states that "swine have been poisoned by drinking brine and by eating garbage that had been pickled in brine." He quotes the toxic dose of salt for swine as $\frac{1}{2}$ to 1 pound.

In reviewing his experiences with salt poisoning, Hofferd (3) observes that the most common effects of excessive salt intake over extended periods are inflammation of the kidneys and bladder and hardening of the liver. Acute poisoning was attributed to the consumption of brine. He states that diagnosis is often difficult because of varying symptoms. However, the temperature of affected animals generally remains about normal, and the animals usually show extreme nervousness and evidences of pain as a result of irritation of the kidneys and bladder. Among the instances of poisoning cited was one that occurred on a farm where a commercial mixed cattle feed containing much more salt than the hog feed in use was inadvertently placed in the hog feeders. In another instance a herd of pigs had been vaccinated with both virus and serum, and when a

² Italic numbers in parentheses refer to Literature Cited, p. 808.

number of them sickened and became paralyzed the owner placed blocks of medicated salt in the pens. The pigs were observed to eat considerable amounts of the salt, and thereafter a number of the sick ones died. Removal of the salt blocks coincided with cessation of the deaths.

The consumption of salt in the form of brine is singled out by Hofferd and other writers as the chief factor in causing acute poisoning and sudden death of swine. Buffagni (2) has reported cases of poisoning in pigs due to a mixture of brine with the concentrate feed. A cow was reported as having been poisoned by 1 kilogram (2 $\frac{1}{5}$ pounds) of salt administered as treatment for a condition diagnosed as indigestion.

Wautie (13), describing experimental work on salt and brine poisoning, tells that three pigs fed a brine solution that gave them 60 to 80 grams (2 to 3 ounces) of salt daily were severely affected by the tenth day. The symptoms consisted of stiffness of the legs, absence of reflex response, blindness, and constipation. An injection of calcium gluconate gave relief. Dry salt up to 250 grams (a little over half a pound) a day did not produce the extreme symptoms observed in the pigs given brine. He concluded that salt poisoning depends on the form in which the salt is taken (liquid or solid), the availability of water, the tolerance of the animal, and the type of food it is receiving. The poisoning from brine was thought to be due partly to the presence and action of nitrates, propylamine, and trimethylamine.

In recent years a number of workers have studied the salt tolerance of pigs in relation to their appetite for salt and to optimum and toxic levels. Amounts up to 80 grams (nearly 3 ounces) per animal per day increased the live-weight gains, and an intake of a gram per kilogram of live weight was not toxic, according to Vil'ner et al. (12). The ingestion of 100 grams (3 $\frac{1}{2}$ ounces) a day over a 7-day period had no appreciable effect on the level of chloride in the blood in experiments reported by Marcq and Devuyt (4). Another conclusion that appears to be of special significance was that poisoning was difficult to cause experimentally except where secondary disorders were present. Tocher (10) concluded that pigs will not consume rations high in salt unless the salt is added gradually. He gave the optimum amount of salt with rations of mixed cereal, as approximately $\frac{1}{2}$ ounce daily per 100 pounds of live weight.

In a study of the effect on swine of fish meals containing large amounts of salt, Rasenack (8) observed that pigs weighing 30 to 40 pounds showed signs of injury after consuming 15 grams (over $\frac{1}{2}$ ounce) of salt daily. Serious injury and death did not result, however, until the level reached 75 or 100 grams daily (2 $\frac{1}{2}$ to 3 $\frac{1}{2}$ ounces). Another study on fish meal, by Mayrhofer (5), indicated that meals with as much as 9 percent of salt can be used without ill effects.

In view of the varying levels of sodium chloride naturally contained in swine rations and the disagreement in the recommendations on the optimum level, Sinclair (9) undertook some studies in which the salt additions were varied from none to 3 percent. The cal-

culated daily total sodium chloride intake ranged from less than 0.1 gram in the basal grain ration to approximately 75 grams (2.7 ounces) in the ration with 3 percent of salt added. He estimated the daily sodium chloride requirement for a pig increasing in weight at the rate of 1 pound a day as 1.33 grams (about one-twentieth of an ounce). Apparently the sodium chloride contributed by tankage was sufficient to supply the needs of the pigs fed the grain-tankage diets used by Sinclair (9), since additions of salt to the diet did not increase the growth rates or efficiency of feed utilization of the pigs. From the standpoint of salt poisoning, no significant changes due to high salt intake were observed other than increase in water consumption and excessive urination. No changes were observed in the size or appearance of the kidneys, the water content of the muscle tissue, or the dressing percentage.

Interest in the often-repeated warning against salt poisoning led the Rowett Research Institute in Scotland to make a study of salt feeding (1). Pigs of 60 to 190 pounds live weight were fed a ration of cereal feeds, skim milk, cod-liver oil, and ground limestone, with different levels of sodium chloride. The pigs refused to eat a ration containing 4.7 percent of salt, and on a 3.3-percent salt level no apparent symptoms of ill health were noted. Further experiences, with pigs starved for 24 and 48 hours, led to the conclusion that pigs are unlikely to succumb to salt poisoning, because they refuse to eat salty feeds. The data on the optimum salt content of the ration for fattening pigs indicated a figure between 0.25 and 0.50 percent, which is in agreement with other published data.

EXPERIMENTS AT THE BELTSVILLE RESEARCH CENTER

A somewhat different picture of the palatability of salt-containing rations, but with no change in the inability to produce toxic effects with any consistency, has been obtained in experiments with fattening pigs (results heretofore unpublished) at the Department of Agriculture Beltsville Research Center, Beltsville, Md. In the first experiment, to a series of six diets, 0, 1, 2, 4, 8, and 12 percent, respectively, of salt was added. Two pigs were fed each diet. The average daily gains of the two pigs on the diet containing 2 percent of salt exceeded those of the other pigs. Increasing levels of salt resulted in decreased feed intake and retardation of gains. Nevertheless, the two pigs on the highest salt level ate sufficient feed to give them an intake of approximately half a pound of salt a day. One of the animals that received the diet with 8 percent of salt showed evidence of salt poisoning on the eighty-sixth day of the experiment. This pig, which had refused its feed for 2 days, when forced to move out of the shelter walked with a hesitant, nervous motion, frothed at the mouth, and champed its teeth. Two hours later, when it was driven with much difficulty to the scale house, the animal was quite evidently blind. Its weight was 160 pounds whereas 3 days previously it had weighed 187 pounds. A total of 1,770 cc. ($1\frac{3}{4}$ quarts) of water was administered by mouth. Five days later when the animal was slaughtered it had fully recovered except for the blindness and

weighed 197 pounds. It should be noted that while the development of blindness was attributed to the effects of the salt, the evidence is purely circumstantial. Microscopic examinations on the 12 hogs did not reveal any unusual changes attributable to salt ingestion.

In the second experiment, hogs were fed a ration containing only 0.1 percent of sodium chloride for 3- and 6-week periods and then given access to salt under various conditions, including free access to loose salt, salt mixed in different percentages in the dry feed, and free access to different brine concentrations. In no case were there any unusual effects that could be attributed in any way to salt poisoning. When the salt content of the diet was adjusted to 10 percent, the daily salt intake approximated 150 grams (5½ ounces) per 100 pounds of live weight. At a 15-percent level the feed intake was still not greatly depressed. The salt intake, however, increased in one case to approximately 180 grams (6.3 ounces) and in another to 225 grams (7.9 ounces) per 100 pounds live weight. Thus one animal weighing 218 pounds, after being fed 26 days on the high salt ration, was consistently consuming an average of 8.4 pounds of total ration and 495 grams (1.1 pounds) of salt a day. A daily water consumption of 2.35 gallons at a period when water intake is normally low (December) was apparently sufficient to permit elimination of the salt without ill effects.

When brine solutions of 5- and 10-percent salt concentration were placed before two pigs that had received no added salt in the ration during a preliminary 3-week period, and no other water was furnished, relatively small amounts of the brine were consumed. One pig drank only 6 quarts of the 5-percent brine in 10 days, while the other consumed 5 quarts of 10-percent brine. Thus the daily salt intake was only a small fraction of that when salt was added to the ration. When two more pigs, after a preparatory period of 6 weeks without added salt, were given access to the usual water supply in addition to the brine solutions, the brine consumption was of the same order as that of the pigs limited to brine only, namely, 4 to 5 quarts per 10-day period. The daily intake of salt in brine was thus only 40 to 60 grams (1.4 to 2.1 ounces) daily.

Two pigs were permitted free choice of dry salt without a preliminary salt-starvation period and four others (two in each group) after a 3-week and a 6-week salt-starvation period, respectively. In the first case (no salt-starvation period) the average daily salt intake amounted to only 5.5 grams. After a 3-week preliminary period the salt consumption averaged 12.7 grams a day, and after the 6-week period, 27 grams.

Two other animals were fed basal diets in which the salt content was increased at 7-day intervals by 4 percent each time. By the fifth week, the salt content was 20 percent, and it was maintained at this level for 4 weeks. The pigs grew normally for the first 4 weeks and maintained their weights with small fluctuations for the remaining 4 weeks. The water intake ranged between 6 and 8 gallons per pig per day during this time.

The 12 pigs used in these experiments were apparently in good health at the conclusion of the salt feeding. Several were changed

back to the basal diet without salt additions for short periods previous to slaughter. When the pigs were slaughtered and examined, no unusual conditions were observed. Sodium chloride analyses of samples of lean tissue from the hams of the pigs that had received up to 20 percent of salt in their diets showed no significant difference from samples taken from hogs on ordinary diets.

PRACTICAL CONCLUSIONS

Considerable difficulty seems to attend the experimental production of salt poisoning by the direct use of salt. It is unfortunate that critical studies have not been made on the brine solutions that have reportedly caused toxic effects. Such studies might have disclosed the presence of other substances more definitely toxic than sodium chloride. Other secondary factors involving ailments difficult to diagnose are suggested in some of the reports.

Such practices as mixing salt with the mixed feeds in the slop barrel, dumping into the feeding troughs vats of old brine left over from the curing of meats, or adding to the feed batches of salt contaminated with unknown substances should be avoided in the feeding of swine. As already indicated, the salt requirements are so low and salt is so inexpensive that there is little justification for the use of waste products that might in one way or another be the cause of such cases of so-called salt poisoning as do occur.

The available evidence shows that there is considerable latitude in the tolerance of growing and fattening pigs for salt. In certain of the experiments cited, the pigs were induced to consume diets containing large amounts of salt, while in others the animals refused diets with even moderately high levels of salt. Undoubtedly the components of the diet and the previous feeding history play an important part. The low salt requirement of pigs was also emphasized in a number of instances. It would appear that the use of the animal-protein supplements and simple mineral mixtures containing moderate levels of salt such as are generally used by swine feeders in this country will seldom lead to salt hunger, much less to the setting up of conditions favorable to the intake of salt in unfavorable or toxic amounts.

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