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STUDIES IN IODINE FEEDING
Part I–Potassium Iodide Feeding Beneficial to Young Swine

By John M. Evvard and C. C. Culbertson

AGRICULTURAL EXPERIMENT STATION
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AND MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

AMES, IOWA
SUMMARY

The feeding of iodine in the form of potassium iodide to young growing swine in dry lot and on rape pasture resulted, in three separate experiments, conducted in three different years, in increasing the average daily gain approximately 10 percent, and likewise in decreasing the feed required for one hundred pounds of gain 10 percent.

The pigs receiving potassium iodide made greater dimensional growth in height, in length, and in leg circumference.
STUDIES IN IODINE FEEDING

I. Potassium Iodide Feeding Beneficial to Young Swine

By John M. Evvard and C. C. Culbertson*

When Courtois in 1811 discovered iodine he probably did not dream that within a little more than a century this halogen would be proven essential for mammalian growth. Altho iodine has long since been chemically classed in Group VII, with fluorine, chlorine, manganese and bromine, all constituents of the normal mammalian body, the real significance of iodine in animal nutrition did not find appreciation in scientific circles until the time of Baumann.

A REVIEW OF THE LITERATURE

Iodine is now generally conceded to be one of the essential elements in mammalian nutrition and much effort is being made, particularly in goitrous regions, to insure a supply of it in the foodstuffs or water, or both. McClendon (14) emphasized the use of iodine as a food material and studied its occurrence in the natural waters of all parts of the United States.

Baumann (1) in 1895, almost 30 years ago, announced that iodine was a normal constituent of the thyroid gland. In directing attention to this fact he gave the name iodothyrin to the world, this compound, for a number of years thereafter, being considered as the active principle of this ductless organ or gland. Baumann concentrated some of the material of the thyroid gland down to the point where the residue contained about nine percent of iodine. To this residual mixture of compounds the name "iodothyrin" was given. Later investigations have proved that this so-called iodothyrin of Baumann, the iodine complex or residues, carried other than the active constituents of the gland.

The work of Picke and Pineles (24) in 1909-10 and Kendall (10) in 1919 made clear that iodothyrin is not the active principle it was once supposed to be, Kendall pointing out that it is not to be considered as "even a concentrated form of desiccated thyroid".

Kendall recently made a noted addition to the knowledge concerning the chemical nature of the active material of the thyroid gland. He isolated a substance which he named thyroxin, a crystalline, iodine-containing compound, white, odorless and tasteless, which is a derivative of indol, possessing in a marked man-

*With the collaboration and technical assistance of W. E. Hammond, Q. W. Wallace, F. Key, K. K. Henness, L. C. Brown and G. W. Snedecor. This is the first of a series on the use of iodine in animal feeding.
nder the tautomeric properties of some of the members of this
group of compounds. Kendall submitted formulas to represent
the different forms of thyroxin, and thru biological experiments
he determined that the isolated thyroxin does everything that
desiccated thyroid does in the relief of cretinism and myxedema.
Thyroxin has also been found to influence growth in a manner
similar to desiccated thyroid. The iodine-containing thyroxin
is of profound importance in regulating chemical reactions thr­
ought the body.

In 1911 Marine and Lenhart (16) called attention to the rela­
tionship between so-called thyroid carcinoma of the brook trout
(Salvelinus fontinalis) and endemic goitre. Later Marine (17)
(18) in 1914 showed that fresh seafish as well as iodine were ef­
fective in preventing and curing this malady. The association
of iodine with preventive measures was early noted.

The use of iodine by Marine, Kimball and Rogoff (19), (11),
(12), (20), (13) in the prevention and cure of simple goitre
in school children affords a striking illustration of the need of
this haloid element. The use of iodine in these experiments
showed clearly that it was specific in the prevention of simple
thyroid enlargement. The early experimental work was carried
on at Akron, Ohio, which is in an endemic goitre region.

Marine (21), in speaking before the Medical Society of the
State of Pennsylvania in 1922, emphasized a number of points
which are of interest in the consideration of iodine feeding. He
called attention to the fact that the North American Indians and
the inhabitants of Central Africa, as well as the Greeks and
Romans, were strongly convinced that water was a casual fac­
tor in simple goitre. A marked absolute decrease in the iodine
store is noted in the development stage of all goitres in all ani­
mals. If most of the thyroid gland is removed before pregnancy
or during its early stages, iodine meanwhile being excluded, the
new-born will have enlarged thyroids; but on the other hand,
if iodine is available, the young at birth will have normal
thyroids. The ingestion of a milligram of iodine weekly by
dogs prevents thyroid hyperplasia. The thyroid has an extraor­
dinary affinity for iodine, and if the iodine store is above 0.1
percent there are no hyperplastic changes. The Swiss Goiter
Commission has advised the use of iodine for all cantons. The
former manner of iodine administration is of little importance.
The use of iodized salt has been followed with much success and
it is only in the treatment of long-standing goiter that desiccated
thyroid has any advantage over iodine.... Thyroxin has no advan­
tage and many disadvantages over desiccated thyroid in the practical
treatment of goiter.... The nature of iodism is still unknown, but
sodium and potassium salts appear to cause iodism more frequently
than organic preparations.
Smith (28) was the first to point out the value of iodine in the prevention of fetal athyrosis when fed to pregnant swine. His studies on the composition of the feeds in the affected districts, from the iodine standpoint, indicated that the available iodine was lower than of similar samples from unaffected districts. The investigations were carried on in Montana. This significant comment was then made by Smith:

“If more iodine were fed to the pregnant animals in large sections of this continent, especially during the winter months, the young that they produce would be more healthy and more vigorous and the large number of weak and defective young animals that are produced annually would be greatly reduced.”

Smith (29) pointed out in a later paper that pigs which are born in the early spring months of March and April are more frequently affected with fetal athyrosis and hairlessness (the hairless pig malady) than if they are farrowed in May and June. He likewise emphasized that even in badly affected regions the fall litters are usually normal.

That there is a seasonal variation in the iodine content of the thyroid gland was clearly shown by Seidell and Fenger (27). They found that the thyroids as gathered bi-weekly from hogs, sheep and cattle at a Chicago packing house showed the lowest iodine content in the spring and the highest iodine percentages in the fall. This variation appears to correspond quite closely with the green pasturage season, indicating that these animals regain their iodine supply in large measure in the grazing months and lose it to a considerable extent in the pastureless months of winter. Von Fellenberg (30) discovered that the iodine of river water varied seasonally.

Seidell and Fenger also found that swine thyroids showed the least iodine on March 17, the percentage at that time in the dry matter being 0.133; the highest iodine content was noted September 1, when the iodine ran 0.531 percent. The iodine in the thyroid gland of the average slaughtered pig at the “maximum iodine season” would be about 10 milligrams as contrasted with a little over 2 milligrams of iodine in the “minimum iodine season”.

On the basis of the figures given, it appears that the iodine determinations bear out the statement of Smith to the effect that fetal athyrosis is more likely in the early spring than later. Our experience in the corn belt has been that swine litters of the fall farrow are very much less likely to be affected with the hairless pig malady than are the litters of early spring, the ones that come before green, leafy vegetation is available.

That the iodine carried by plant materials varies according to the parts of the plant and a good many plants or plant materials apparently do not carry iodine in measurable quantities is the finding of Cameron (3). This investigator analyzed a good
Fig. 1. Relative distribution of simple goitre in the United States.

The results of the study of Davenport and Love in regard to the geographical distribution of goitre among men examined by draft boards during the World War is here shown in graphical form.

Note the heavy incidence of goitre in the region about the Great Lakes and in the Pacific Northwest. The southern and southwestern states are comparatively free from this malady.

While a similar investigation has not been made with reference to livestock, these studies may be considered fairly representative of iodine deficiency in domestic animals.

many tissues and found none to contain iodine in such large amounts as the thyroid dry tissue. His work emphasized that the iodine content of materials in general was due in large measure to the amount of iodine in the environment. Cameron found from 0.01 to 1.116 percent iodine in the dry thyroid tissue, and less than 0.001 percent in all non-thyroid tissues.

The iodine content of feeds, even when grown under similar, tho not identical, conditions, seems to vary greatly. Forbes and Beegle (5) speak of "... the haphazard nature of its distribution", and also emphasize that "in most cases, at least, it must be strictly an accidental constituent". That there are great variations in the iodine content in the same grain crop grown in adjoining fields has been shown, and on the whole the evidence as gathered by Forbes and associates emphasizes the rarity and accidental nature of iodine as a feed constituent.

Bohn (2) made quantitative determinations of iodine in feeding stuffs at practically the same time that Forbes and Beegle
were carrying on their work and found that the presence of iodine in materials of vegetable origin was apparently accidental. In all of this quantitative work the interesting fact is brought out that feeds, such as potatoes, corn gluten feed, barley and others, may in some cases carry no iodine whatsoever, while other samples show, relatively, considerable of this element.

Von Fellenberg (30) carried his studies to the point where he differentiated between the foods from a goitrous as compared to a non-goitrous region, noting a lower iodine content on the whole in the food from those sections where goitre is prevalent. Von Fellenberg also found some iodine in the air, but the quantities yielded were very small, not sufficient to be of much significance in the supplying of iodine to mammals.

McClendon and Hathaway (15) proved statistically that both simple and exophthalmic goitre are caused in the United States by iodine starvation. Their maps and charts show remarkable coincidence between goitre occurrence and the low iodine content of the drinking water. In the northern portions of the United States there are from 1 to 22 parts of iodine per hundred

**Fig. 2. Simple goitre in the United States as deduced from data of the draft board.**

The area shown in black furnished soldiers every thousand of whom had from 5 to 111 men with goitres. A goitre in this case was defined as "too large to button a military collar around." Men showing slight goitre were passed and no record taken.

The "Permian Salt Deposits" shown in this figure were formed from the evaporation of sea water, which left extensive salt beds containing some iodine.

Compare figs. 2 and 1, noting the general similarity. The latter shows four degrees of goitre prevalence, the other two, goitrous and non-goitrous.
Exophthalmic goitre is a more serious condition than a simple; it is not very amenable to treatment with iodine. Compare fig. 3 with figs. 1 and 2, noting correspondence. Exophthalmic goitre is apparently less prevalent than the simple.

billion parts of water, whereas in the south the iodine runs as high as 18,470 parts (in Texas), with a good many sections showing over 160 parts. Iowa, which is in a semi-goitrous region, is represented by two water analyses, one from Ames (wells 75 to 100 feet deep), showing 1.2 parts, and one from Iowa City (Iowa river), with 1.5 parts to the hundred billion parts of water. It appears from this study that the water at Ames, Iowa, yields but little of the nutritional iodine. The average human thyroid, according to McClendon and Hathaway, carries approximately 40 milligrams of iodine.

The hairless pig malady has been experimentally observed in association with hyperplasia of the thyroid gland by Hart and Steenbock (6), who found that the malady could be avoided by feeding iodide to the brood sow. The absence of the necessary amount of iodine in the ration of the pregnant sows interfered markedly with the fetal development, but the effects were much more noticeable from the standpoint of the vitality of the offspring than of the sows. Altho the sows that gave birth to the hairless pigs showed thyroids that were enlarged from a normal of 20 to 50 grams up to 125 grams, yet the sows in large measure maintained their apparent well-being. On the other hand, there was heavy mortality among the pigs when they came hairless. One of the sows in these experiments which had been fed
potassium iodide had a thyroid which weighed when fresh 112 grams. It yielded 33 grams of dry matter, containing 0.62 percent iodine, or approximately 205 milligrams of iodine in this sow's thyroid. Hairless pigs were found to possess thyroids weighing from 0.5 to 3.5 grams, containing merely traces or inestimable quantities of iodine. Normal pigs, new-born, were found to have thyroids seldom exceeding 0.3 grams in weight. The thyroids from day old normal pigs weighed up to .8 grams, none of them being under .16. The iodine content of the normal dried thyroid of the latter pigs varied from 0.1 to 0.6 percent. On the basis of these figures a large sized litter of pigs with normal thyroids would show only about two milligrams of iodine in these organs. If the thyroids were of maximum size and also carried the maximum percentage of iodine, then the thyroids of the litter would contain about 7 or 8 milligrams of iodine.

Fig. 4. The iodine content of the drinking water of the United States.

This shows one of the fundamental reasons for goitre. The iodine content of the water of any district is a pretty good index of the amount of iodine which the animals raised thereon receive. Iodine is transported largely thru water, the amount present depends largely upon the character, composition, and amount of soil thru which it passes.

"Hairlessness" in new-born pigs, and associated conditions are regularly highest where the iodine content of water is practically always lowest. Losses of goitrous nature are seldom experienced in the southernmost portion of this country where the water is relatively rich in iodine.

It appears that stockmen of the northern United States should, to insure adequate nutrition, feed iodine regularly.

Compare this figure with figs. 1, 2 and 3. Note that the water of practically the entire northern half of the United States is low in iodine, and that the area so outlined in fig. 4 is closely co-extensive with the territory shown to be goitrous in fig. 1, 2 and 3.
In experiments with iodine feeding as a preventive of hairless pigs, Welch (33) (Montana) was able to increase the iodine content of the fetal gland to a considerable extent by feeding two grains of iodine daily per sow during the period of gestation. The new born pigs of the check group, to which no iodine was allowed, showed .171 percent iodine in the thyroid gland, and the pigs of the iodine fed group, more than twice as much, or .381 percent.

The use of potassium iodide was found by Welch to be very effective in the prevention of fetal athyrosis in swine. He advocates the feeding of iodine to pregnant domestic animals in those sections of the Northwest where goitre is prevalent. Welch believes that the disturbance of the function of the thyroid gland is not only responsible for hairlessness in pigs, but likewise in lambs and calves, as well as weakness in colts, and that iodine is the essential element required for the proper functioning of the gland in these cases.

The widespread use of iodide in certain sections of the Northwest, as Welch (32) puts it, is "as universal as the use of blackleg vaccine" in cattle raising. Significant comment is made by this investigator concerning the prevalence of goitre in livestock in states other than Montana; in speaking of the loss of livestock from hairless pigs, goitred and hairless lambs, calves and foals, he says: "Correspondence with stockmen here and there in Minnesota and Wisconsin and in other eastern states show that the trouble is by no means confined to the northwest states."

The allowance of one grain a day, which was experimentally administered, was apparently more than actually required, the experiments indicating that the iodine might be fed during a much shorter part of the pregnancy period than formerly, if allowed early and still be effective in preventing trouble. The practical stockmen have not welcomed the idea of feeding less iodide, inasmuch as the expense is relatively small and they are satisfied with the results obtained with the one grain a day dosage.

Even where goitre was not a factor it was found that the addition of a small amount of iodine to the ration of the mother animal tended to increase the iodine content of the thyroid of the young with increased vigor and rate of development.

The minimum field requirement or allowance of iodine during the pregnancy period is difficult to estimate, inasmuch as the natural intake in the feed and water varies so widely, so Welch (33) tells us. In feeding the pregnant sow he has used a minimum dosage of one-half grain potassium iodide per sow daily during the first 60 days of the gestation period with success, and judging from experiments unpublished it is his be-
lief that one-tenth of a grain per day over the same period is ample. On the other hand, numerous cases have been observed in which one grain per sow daily for the last 30 or 40 days of the period of pregnancy has not succeeded in preventing goitre, hence the suggestion that iodine feeding, to secure greatest efficacy, must be done in the early part of the gestation period.

Kalkus (8) gives data to show that the gestation period of animals is sometimes increased because of goitrous conditions. His investigations demonstrated that cows, mares, ewes, sows and does were protected against giving birth to pathological newborn if tincture of iodine, which carries about 10 percent of iodine, was applied at frequent intervals to the skin.

Check experiments with does demonstrated that two grains of potassium iodide given per os daily, or 5 mils (c.e.) of tincture of iodine applied subcutaneously weekly, or 1 mil of tincture of iodine poured on the skin of the back weekly, during gestation, acted as marked preventives of goitre in the new born. In another experiment 1 mil of tincture of iodine poured on the skin, either weekly or every two weeks, resulted in normal offspring, whereas the check does not receiving any applied or ingested iodine showed some goitrous new-born.

Kalkus' (9) work in the state of Washington demonstrated the possibility of absolutely controlling the development of goitre in newborn animals by the administration of iodine to the pregnant mother. He may be quoted in this respect:

"These experiments were so highly successful that they solved our problem entirely in goitrous districts, from a practical standpoint, ..."

Just how large a dosage of iodine is necessary to prevent goitre or hairlessness has, in the opinion of Hart, Steenbock and Morrison (7) not yet been definitely determined. Altho they state that a daily dose of two grains of either potassium or sodium iodine, given throut the gestation period to sows, ewes, cows or mares, will prevent the trouble, yet they say:

"It is entirely possible that a smaller daily dose would be sufficient to prevent the trouble, or else treatment during only the latter part of the gestation period. However, further experiments are necessary to decide the point."

In regard to feeding iodine to swine other than pregnant sows, the opinion of Morrison, Fargo and Martin (23) is of particular interest. They say:

"Wherever there has been trouble from hairless pigs, then iodine should be added to the ration of the pregnant sows to prevent this disease. There is, however, no proof that there is any benefit from adding iodine to the ration of pigs except this prevention of hairlessness. Fortunately, in Wisconsin there is but very little trouble from hairless pigs."

According to Russell and Morrison (26), Hadley observed that sows and ewes which had access to green feed during the last three months of their gestation period seldom, if ever, gave
birth to goitrous offspring, whereas cows and mares may require a longer period on pasture in order to safeguard their progeny.

Mitchell (22), in speaking of the mineral requirements of farm animals, emphasizes that there is no evidence that farm rations are ever deficient in any other minerals excepting calcium, phosphorus, sodium, chlorine and iodine. In respect to iodine he says that this element “seems to be restricted to certain localities and to pregnant females, or young growing animals”. He tells us that iodine may be provided as potassium or sodium iodide, but in speaking of the manner of supplying it he says that “its general use in mineral mixtures is neither necessary nor advisable”. We shall have more to say in regard to this last statement later.

Rice and Mitchell (25) while admitting that the element iodine occurs in meager traces in most feeds and may at times, in certain restricted localities, be deficient in otherwise well-balanced rations, insist that although the administration of small amounts of iodine to breeding animals in localities where goitre is prevalent seems to prevent this condition, this offers no excuse for the general administration of iodides to farm stock.

**INVESTIGATIONS COVERING THE FEEDING OF POTASSIUM IODIDE TO YOUNG GROWING AND FATTENING SWINE.**

Inasmuch as practically the whole northern half of the United States is a goitrous region, it would appear that the shortage of iodine is not necessarily restricted to certain localized areas. Furthermore, it would appear that even tho goitre is not manifest, nor recognized as such, there still may be a deficiency of iodine in the rations of the various farm animals.

It is the purpose of this paper to present some evidence that in one locality of this widespread goitrous area of the United States, namely, Ames, Iowa, the addition of iodine to the ration of young growing swine is good practice,—this in spite of the fact that in the 14 years of the senior author’s experimental experience at the Iowa station no recognizable goitre symptoms developed in any of the swine of the station, nor did any hairless “full-time” new-born pigs appear. In these years, 1910-1924, the station never had less than 300 new-born pigs in the spring, and oftentimes the number ran up to approximately 800; in the fall the number of pigs farrowed ran from 150 to over 300. With such large numbers of pigs under observation it would appear that if there were a sufficient shortage of iodine to produce a goitrous condition in our swine we would have had the hairlessness and other correlated conditions exhibited many times.
Ewes, on the other hand, drinking of the same water as the swine and partaking of feeds from the same fields, in four years out of fifteen presented some lambs with goitre. In the other 11 years we saw no evidence whatsoever of gross goitrous pathology. The ewes themselves did not exhibit goitres sufficiently large to be noticeable on palpation.

Inasmuch as goitre represents fairly advanced stages of the disease it is easy to see that there may be a shortage of iodine in the ration sufficient to prevent adequate nutrition and yet not so great a deficiency as to develop goitrous pathology. Inasmuch as the presence of goitre was noted in our sheep flock and not in our swine herd, it would appear that perhaps sheep had a greater quantitative need for iodine than swine in order to prevent the appearance of goitre. If it is true that feeds of low fat content tend to conserve the iodine supply, and that leafy vegetables or roughages as well as the coarser milled products of seeds carry more iodine than concentrated feeds, then one might logically assume that the breeding flock, under Ames conditions, actually secured a larger supply of iodine suitable for their nutrition, proportionately, in their feeds than did swine. The actual quantitative requirements of sheep and swine for iodine remain for future determination.

FIRST EXPERIMENT IN FEEDING POTASSIUM IODIDE TO YOUNG SWINE

In the summer of 1920 we fed in Experiment 208 three lots of five pigs each from July 29 until the pigs reached an average weight of 225 pounds. When the experiment started these pigs ranged from two and one-half to three months in age, and weighed on the average practically 50 pounds per head.

The allotment and rations fed were as follows:

LOT I—Grazed on rape pasture. (Commercial or standard ration). Shelled corn grain, mixed color, yellow and white, self-fed; plus Swift’s Digester tankage or meat meal, 60 percent protein grade, self-fed; plus pressed block salt of unusually good grade, self-fed.

LOT IX—Grazed on rape pasture. (Iodide check). Shelled corn grain, mixed color, yellow and white, self-fed; plus supplemental protein, vitamin, and mineral feed mixture (meat meal tankage, 30; corn gluten meal, 15; corn oil cake meal, 20; linseed oil meal, 10; prime cottonseed meal, 20; bone meal, 3, and flake salt, 2 pounds; total 100 pounds), self-fed; plus pressed block salt of unusually good grade, self-fed.

LOT X—Grazed on rape pasture. (Iodide fed). Fed exactly like Lot IX with the exception that one-tenth (0.1) pound of potassium iodide was thoroughly mixed with one thousand (1,000) pounds of the supplemental protein, vitamin and mineral feed mixture.

Lot I is included inasmuch as it represents a very good commercial ration which is widely used in practice, a ration which
TABLE I. FIRST IODINE FEEDING EXPERIMENT—FEEDING AND GAINS RECORD
(Experiment 208)

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>No. of days required to reach 225 lbs</th>
<th>Av. daily gain per pig lbs</th>
<th>Av. daily feed eaten per pig lbs</th>
<th>Feeds used</th>
<th>Total</th>
<th>Feed required for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>All groups fed entire time on rape pasture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (standard commercial check)</td>
<td>125</td>
<td>1.42</td>
<td>Corn* Tankage</td>
<td>5.05</td>
<td>.41</td>
<td>5.46</td>
</tr>
<tr>
<td>IX (iodide check)</td>
<td>145</td>
<td>1.23</td>
<td>Corn* Suppem't Salt</td>
<td>4.56</td>
<td>.82</td>
<td>5.38</td>
</tr>
<tr>
<td>X (iodide fed)</td>
<td>133</td>
<td>1.33</td>
<td>Corn* Suppem't Salt</td>
<td>4.16</td>
<td>.35</td>
<td>5.11</td>
</tr>
</tbody>
</table>

14% moisture basis

on rape pasture gives consistently good results. Inasmuch as the meat meal tankage used in this Lot I is made of animal by-products in a packing house it is presumed that it carries some iodine. The direct experimental comparison, insofar as iodine feeding is concerned, however, is to be noted in the study of Lots IX and X only.

Table I gives in brief form some pertinent facts in regard to the average daily gain, average daily feeds and the feeds required for the hundred pounds of gain.

It is plainly evident that the iodide fed lot, X, outgained Lot IX, which received no added iodide. It is also evident that the feed requirement was considerably lessened by iodide feeding.

Chart I shows the progressive gains per pig in pounds, this being based on the average of the groups by months (30-day periods) throughout the experiment. It is noted that Lot IX early assumed the lead, but this was soon overcome by the iodide fed Lot X, so that at the close of the experiment the iodide fed pigs were ahead in daily gains.

The statistical study of the average daily gains, from the standpoint of the probable error of the mean and the coefficient of variability, indicates that the feeding of iodide was instrumental in decreasing the probable error and also in lessening the variability. The mean daily gain and the corresponding probable error by lots was: Lot I, 1.422 ± .069; Lot IX, 1.226 ± .08; and Lot X, 1.329 ± .044. The median daily gains by lots were: I, 1.488; IX, 1.430, and X, 1.431.
The mean difference between the daily gains in Lots IX and X, together with its probable error, was: 0.103 ± 0.091. The mean difference is therefore 1.14 times the probable error. This would lead us to expect that future experiments, similarly planned and conducted, would result in approximately 78 percent of the cases showing that the addition of the iodide would result in an increased average gain.

The coefficients of variability for the three lots were: I, 16.07 percent; IX, 21.74 percent, and X, 10.87 percent. These coefficients, expressed on the percentage basis, show clearly a greater uniformity in the gains of the iodide fed lot. The gains in this group show a greater consistency of increase among the various individuals, if one compares them with the no iodide Lot IX, or even the reliable general check Lot I.

Chart 2 presents the total pounds of average daily feed consumed per pig by ten-day periods throughout the experiment; it also covers the average of the entire period. The general or commercial Check Lot I shows the largest consumption for the whole period. The iodide fed Lot X shows a somewhat more consistent appetite than Lot IX, not fed iodide, but the feed
TABLE II. TOTAL AVERAGE DAILY FEED CONSUMED PER PIG BY PERIODS

Based on 14 Percent Moisture Corn, Minerals Included
(Experiment 208)

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot I (standard check) pounds</th>
<th>Lot IX (iodide check) pounds</th>
<th>Lot X (iodide fed) pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>1.983</td>
<td>2.480</td>
<td>2.867</td>
</tr>
<tr>
<td>11-20</td>
<td>2.941</td>
<td>2.960</td>
<td>2.518</td>
</tr>
<tr>
<td>21-30</td>
<td>3.081</td>
<td>4.057</td>
<td>2.982</td>
</tr>
<tr>
<td>31-40</td>
<td>3.540</td>
<td>3.314</td>
<td>3.210</td>
</tr>
<tr>
<td>41-50</td>
<td>5.254</td>
<td>3.966</td>
<td>4.712</td>
</tr>
<tr>
<td>51-60</td>
<td>5.050</td>
<td>6.712</td>
<td>5.318</td>
</tr>
<tr>
<td>61-70</td>
<td>5.965</td>
<td>5.558</td>
<td>6.093</td>
</tr>
<tr>
<td>71-80</td>
<td>6.434</td>
<td>5.861</td>
<td>5.697</td>
</tr>
<tr>
<td>81-90</td>
<td>7.416</td>
<td>5.666</td>
<td>6.025</td>
</tr>
<tr>
<td>91-100</td>
<td>7.716</td>
<td>6.303</td>
<td>6.173</td>
</tr>
<tr>
<td>101-110</td>
<td>7.762</td>
<td>8.172</td>
<td>8.271</td>
</tr>
<tr>
<td>111-120</td>
<td>7.360</td>
<td>5.074</td>
<td>5.313</td>
</tr>
<tr>
<td>121-130</td>
<td>7.397</td>
<td>6.854</td>
<td>5.136</td>
</tr>
<tr>
<td>131-140</td>
<td>7.690</td>
<td>7.690</td>
<td>7.690</td>
</tr>
<tr>
<td>141-150</td>
<td>7.164</td>
<td>7.164</td>
<td>7.164</td>
</tr>
<tr>
<td>Average to 225 lbs.</td>
<td>5.459</td>
<td>5.381</td>
<td>5.118</td>
</tr>
</tbody>
</table>

Lots reached 225 pound weight as follows:
1, 125; IX, 145 and X, 133 days.

consumed on the average for the whole period is somewhat in favor of Lot IX.

**CHART 2**

![Chart showing feed consumption over days for different lots.](image-url)
Fig. 5. This pig received a standard commercial ration, composed of corn grain, meat meal tankage, and flake salt, on rape pasture.

This pig of lot I, experiment 208, (taken Dec. 8) made rapid and economical gains, but the feed requirement for the hundred pounds of gain was only 1 pound less than in lot X which received an inferior ration but which had potassium iodide added.

Fig. 6. This representative pig of lot X, experiment 208, received potassium iodide in his supplemental feed.

Weight, 299 pounds, 243 days old on Jan. 12. His group showed beneficial results from iodide feeding.

Fig. 7. This representative pig of lot IX, experiment 208, received no iodide in his supplemental feed.

Weight, 211 pounds, 254 days old on Jan. 12. His group made a good showing but were excelled by a similar group, lot X, experiment 208, fed experimentally the same except potassium iodide was added to their supplemental feed. The addition of iodide increased the gain 8.4 percent and lessened the feed requirement 12.5 percent. The pigs in this group did not exhibit any gross signs of pathology such as might be expected from an inadequate iodine ration.
TABLE III. SUPPLEMENTAL FEED AND IODIDE CONSUMPTION
Daily Average Per Pig in Pounds
Lot X

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Days in period</th>
<th>Average daily feed consumed per pig</th>
<th>Iodine added daily per pig grains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Supplement pounds</td>
<td>Potassium iodide grains*</td>
</tr>
<tr>
<td>1-30</td>
<td>30</td>
<td>.850</td>
<td>.60</td>
</tr>
<tr>
<td>31-60</td>
<td>30</td>
<td>1.437</td>
<td>1.01</td>
</tr>
<tr>
<td>61-90</td>
<td>30</td>
<td>1.176</td>
<td>.82</td>
</tr>
<tr>
<td>91-120</td>
<td>30</td>
<td>.471</td>
<td>.33</td>
</tr>
<tr>
<td>121-140</td>
<td>20</td>
<td>.945</td>
<td>.66</td>
</tr>
<tr>
<td>1-140</td>
<td>140</td>
<td>.804</td>
<td>.67</td>
</tr>
<tr>
<td>1-133</td>
<td>133</td>
<td>.68</td>
<td>.55</td>
</tr>
</tbody>
</table>

*1 grain equals 64.8 milligrams.

Table II gives the total average daily feed consumed per pig during the entire experiment.

Table III gives the average daily supplemental feed consumed by periods per pig in Lot X during the entire experiment; it also presents the average daily potassium iodide and its equivalent in iodine by periods.

The potassium iodide intake per pig for the 133 days of feeding averaged 0.67 grain daily, this being equivalent to 0.51 grain of iodine added; at this rate of potassium iodide feeding the milligram ingestion was approximately 33.

The feed required for 100 pounds of gain is presented in Table IV.

Lot IX took 440 pounds of feed for the hundred pounds of gain as contrasted with 385 pounds in Lot X, iodide fed. Here is an added feed requirement of 55 pounds, due to the lack of iodide feeding. On a percentage basis this amounts to better than 14 percent more feed being required for the unit of gain where extra iodide was omitted from the ration.

TABLE IV. TOTAL FEED REQUIRED FOR 100 POUNDS GAIN BY PERIODS UP TO 225 POUNDS WEIGHT
Based on 14 Percent Moisture Corn, Minerals Included (Experiment 208)

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot I (standard check) pounds</th>
<th>Lot IX (iodide check) pounds</th>
<th>Lot X (iodide fed) pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-30</td>
<td>334</td>
<td>389</td>
<td>401</td>
</tr>
<tr>
<td>31-60</td>
<td>366</td>
<td>370</td>
<td>288</td>
</tr>
<tr>
<td>61-90</td>
<td>366</td>
<td>410</td>
<td>384</td>
</tr>
<tr>
<td>91-120</td>
<td>434</td>
<td>479</td>
<td>424</td>
</tr>
<tr>
<td>121-Last Weight taken (1)</td>
<td>*414</td>
<td>*503</td>
<td>*507</td>
</tr>
<tr>
<td>Average to 225 lbs.</td>
<td>384</td>
<td>410</td>
<td>385</td>
</tr>
</tbody>
</table>

*Lots reached 225 pounds weight as follows:
I, 125; IX, 145, and X, 133 days.

(1) Last weight taken:
1, 130; IX, 150; X, 140 days.
Chart 3 shows the feed requirement for the hundred pounds of gain made by 30 day periods in the various lots; it also gives the average feed requirement during the period up to 225 pounds. Lot X, receiving iodide, was consistently a better producing lot from the standpoint of amount of feed required to produce a unit of increase, clearly excelling Lot IX throughout the entire period.

Summarizing, it appears that the young growing swine fed in this experiment (208) on rape pasture showed beneficial results from iodide feeding. The average daily gain was greater by 8.4 percent because of the iodide addition, and the feed requirement was lessened by 12.5 percent. Commercially, such results as these, when capitalized in practice, are of much significance.

SECOND EXPERIMENT IN FEEDING POTASSIUM IOIDE TO YOUNG PIGS

In the summer of 1921, we fed in Experiment 220, three lots of seven pigs each from August 4 until the pigs reached an approximate average weight of 225 pounds. When the experiment
started these pigs were approximately three months old and weighed on the average practically 50 pounds per head.

The allotment and rations fed were as follows:

LOT I—Dry lot. (Basal ration without mineral mixture). Shelled corn grain, mixed color, yellow and white, self-fed; plus supplemental protein feed mixture (prime cottonseed meal, 80; and Armour's dried blood meal, 20 pounds; total 100 pounds), self-fed.

LOT II—Dry lot. (Iodide check). Same as Lot I with the exception that 10 pounds of Mineral Mixture A were mixed with each 100 pounds of the supplemental protein feed mixture. Mineral Mixture A consisted of high calcium limestone, finely ground, 33.33+; flake salt, 33.33+, and bone meal, 33.33+ pounds; total 100 pounds.

LOT III—Dry lot. (Iodide fed). Same as Lot II with the exception that potassium iodide was introduced into the mineral mixture, giving this new Mineral Mixture B the following composition high calcium limestone, finely ground, 33.3; flake salt, 33.3; bone meal, 33.3, and potassium iodide, .1 pound; total 100 pounds.

Table V, presented, gives in brief form some pertinent facts in regard to the average daily gain, average daily feed, and the feeds required for the hundred pounds of gain.

Here again we note that the addition of potassium iodide to a ration fed young swine resulted in a greater average daily gain and a lessened feed requirement. It may also be noted that Mineral Mixture A was considerably improved by adding potassium iodide.

Chart 4 shows the progressive gains per pig in pounds, based on the average of the groups by months (30-day periods) throughout the experiment. It is to be noted that the iodide fed Lot III took the lead right at the outset and gradually widened its margin of superiority as the feeding period progressed, easily excelling both Lots I and II.

**TABLE V. SECOND IODINE FEEDING EXPERIMENT—FEEDING AND GAINS RECORD**

*(All groups in Dry Lot)*

<table>
<thead>
<tr>
<th>Group no.</th>
<th>No. of days required to reach 225 lbs.</th>
<th>Av. daily gain per pig lbs.</th>
<th>Feeds used</th>
<th>Av. Daily feed eaten per pig</th>
<th>Feed required for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Basal ration)</td>
<td>113.5</td>
<td>1.49</td>
<td>Corn*, Suppl.em't</td>
<td>5.05</td>
<td>6.05</td>
</tr>
<tr>
<td>II (Iodide check)</td>
<td>112.0</td>
<td>1.52</td>
<td>Corn*, Suppl.em't</td>
<td>5.22</td>
<td>6.44</td>
</tr>
<tr>
<td>III (Iodide fed)</td>
<td>102.5</td>
<td>1.65</td>
<td>Mineral Mixture A, Corn*, Suppl.em't</td>
<td>5.03</td>
<td>6.37</td>
</tr>
</tbody>
</table>

*11% moisture basis.
Fig. 9. This pig did unusually well; he had potassium iodide in his mineral mixture.

He is a representative of lot III, experiment 220, as taken November 25. This lot made 8.3 percent greater average daily gain and required 9.4 percent less feed for the hundred pounds of gain than did their mates of lot II, in the same experiment. The pigs of lot III received 1 pound potassium iodide to the hundred pounds of other minerals fed.

Fig. 8. This pig received no minerals with his basal ration, and he did not do very well.

He is a representative of lot I, experiment 220, as shown on December 21. This lot was fed a basal ration of corn grain, cottonseed meal and blood meal, without an added mineral mixture. His group had poor appetite, in comparison with comparable groups fed simple minerals plus potassium iodide. Note that this pig is exhibiting slight symptoms of rickets, the front legs knuckling forward a bit, and the hind legs showing unsteadiness.

Fig. 10. This pig made good gains on ration with minerals but without potassium iodide.

This representative pig of check lot II, experiment 220, (photo taken Dec. 12) was helped by the mineral mixture even tho it did not have potassium iodide added to it. This group made less gain but required more feed than the iodide fed pigs to which they were directly comparable.
The statistical study of the average daily gains gives the mean daily gain and the corresponding probable error by lots as follows: Lot I, 1.485 ± .057; Lot II, 1.518 ± .072, and Lot III, 1.644 ± .058. The median daily gains by lots were: I, 1.483; II, 1.606, and III, 1.671. The medians approximate closely to the means, this making the data more significant.

The mean difference between daily gains in Lots II and III, together with its probable error, was: .126 ± .092. The mean difference is therefore 1.37 times its probable error. This would lead us to expect that future experiments, similarly planned and conducted, would result in approximately 82 percent of the cases showing that the addition of the iodide would result in an increased average gain.

The coefficients of variability for the three lots were: I, 14.91 percent; II, 18.58 percent, and III, 13.74 percent. These coefficients show quite clearly that the individual pig gains made in the iodide fed lots were more uniform than in either of the other two groups. The gains in this Lot III, iodide fed, show a much greater consistency of increase among the various individuals.
than in Lot II, receiving no iodide in addition; Lot III shows somewhat greater uniformity than Lot I, this speaking well for iodide feeding.

Chart 5 presents the total pounds of average daily feed consumed per pig by 10-day periods throughout the experiment; it also covers the average of the entire period.

Table VI gives the total average daily feed consumed per pig by periods during the entire experiment. It is self-explanatory.

Lots reached 225 pounds weight as follows: I, 113.5; II, 112, and III, 102.5 days.

The appetite for feed did not seem to be altered much in this experiment by iodide feeding, altho, as in the first experiment the iodide fed pigs consumed a little less. (Compare Lots III and II.)

Table VII gives the average daily potassium iodide and its iodine equivalent as consumed per pig by periods in Lot III during the entire experiment.

The potassium iodide intake per pig averaged for the 110 days of feeding .85 grain daily, this being equivalent to .51 grain
TABLE VI. TOTAL AVERAGE DAILY FEED CONSUMED PER PIG BY PERIODS BASED ON 14% MOISTURE CORN, MINERALS INCLUDED

Experiment 220

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot I (Basal ration) pounds</th>
<th>Lot II (Iodide check) pounds</th>
<th>Lot III (Iodide fed) pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>2.789</td>
<td>3.242</td>
<td>3.412</td>
</tr>
<tr>
<td>11-20</td>
<td>4.310</td>
<td>4.391</td>
<td>4.062</td>
</tr>
<tr>
<td>21-30</td>
<td>4.522</td>
<td>4.063</td>
<td>4.992</td>
</tr>
<tr>
<td>31-40</td>
<td>5.171</td>
<td>4.654</td>
<td>5.600</td>
</tr>
<tr>
<td>41-50</td>
<td>5.299</td>
<td>5.486</td>
<td>5.256</td>
</tr>
<tr>
<td>51-60</td>
<td>6.332</td>
<td>6.607</td>
<td>5.915</td>
</tr>
<tr>
<td>61-70</td>
<td>6.255</td>
<td>7.800</td>
<td>7.631</td>
</tr>
<tr>
<td>71-80</td>
<td>7.358</td>
<td>7.350</td>
<td>7.732</td>
</tr>
<tr>
<td>81-90</td>
<td>7.800</td>
<td>8.901</td>
<td>8.724</td>
</tr>
<tr>
<td>91-100</td>
<td>7.941</td>
<td>8.434</td>
<td>9.650</td>
</tr>
<tr>
<td>111-120</td>
<td>5.573</td>
<td>9.843</td>
<td></td>
</tr>
<tr>
<td>Average to 225 lbs.</td>
<td>6.064</td>
<td>6.447</td>
<td>6.386</td>
</tr>
</tbody>
</table>

of iodine added. At this rate of iodine feeding the daily milligram ingestion was approximately 42. It will be remembered that in the first experiment the iodide fed lot consumed .67 grain daily, the equivalent of .51 grain of iodine; under the circumstances of the experiment it appears that this is rather a close agreement, from the quantitative ingestion viewpoint.

The feed required by periods for 100 pounds of gain is presented in table VIII.

Lots reached 225 pound weight as follows: I, 113.5; II, 112, and III, 102.5 days.

Lot II was clearly excelled by Lot III receiving iodine, the feed required for 100 pounds of gain being, respectively, 425 and 385 pounds. Here is an added feed requirement of 40 pounds due to the lack of iodide feeding. On a percentage basis this amounts to better than 10 percent more feed being required for the unit of gain where the extra iodide was omitted from the ration.

Chart 6 shows the feed requirement in pounds by 30-day periods in the various lots; it also gives the average feed re-

TABLE VII. POTASSIUM IODIDE AND ITS IODINE EQUIVALENT DAILY AVERAGE CONSUMPTION PER PIG IN GRAINS

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Days in period</th>
<th>Average daily consumption per pig, Lot III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Potassium iodide grains</td>
</tr>
<tr>
<td>1-30</td>
<td>30</td>
<td>.83</td>
</tr>
<tr>
<td>31-60</td>
<td>30</td>
<td>.99</td>
</tr>
<tr>
<td>61-90</td>
<td>30</td>
<td>.75</td>
</tr>
<tr>
<td>91-110</td>
<td>26</td>
<td>.80</td>
</tr>
<tr>
<td>1-110</td>
<td>110</td>
<td>.85</td>
</tr>
<tr>
<td>1-102.5</td>
<td>102.5</td>
<td>.85</td>
</tr>
</tbody>
</table>
TABLE VIII. TOTAL FEED REQUIRED FOR 100 POUNDS GAIN BY PERIODS UP TO 225 POUNDS WEIGHT

Based on 14% Moisture Corn, Minerals Included

Experiment 220

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot I (Basal ration) pounds</th>
<th>Lot II (Iodide check) pounds</th>
<th>Lot III (Iodide fed) pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-30</td>
<td>341</td>
<td>410</td>
<td>331</td>
</tr>
<tr>
<td>31-60</td>
<td>454</td>
<td>412</td>
<td>435</td>
</tr>
<tr>
<td>61-90</td>
<td>369</td>
<td>398</td>
<td>350</td>
</tr>
<tr>
<td>91-110</td>
<td>446</td>
<td>486</td>
<td>492</td>
</tr>
<tr>
<td>Average to 225 lbs.</td>
<td>406</td>
<td>425</td>
<td>385</td>
</tr>
</tbody>
</table>

requirement for the hundred pounds of gain made during the period extending up to the time the average weight of the pigs in the lots was 225 pounds. Lot III, receiving iodide, was the most consistent producing lot from the standpoint of the amount of feed required to produce a unit of increase, clearly excelling, on the average, the other two lots.

At the close of 110 days feeding, measurements were taken

**CHART 6**
TABLE IX. PIG MEASUREMENTS AT THE END OF 110 DAYS FEEDING  
Experiment 220  

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Length, ear base to tail root (Inches)</th>
<th>Height, shoulder (Inches)</th>
<th>Circumference, fore shin (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>45.11</td>
<td>24.57</td>
<td>5.93</td>
</tr>
<tr>
<td>II</td>
<td>43.40</td>
<td>23.49</td>
<td>5.90</td>
</tr>
<tr>
<td>III</td>
<td>46.39</td>
<td>24.46</td>
<td>6.11</td>
</tr>
</tbody>
</table>

upon the pigs in Lots I, II and III, with the results as given in Table IX.  
The iodide fed lot, III, showed at that time (November 22) a better development from the standpoint of dimensional growth as well as weight. In all three measurements the iodide fed group, Lot III, excelled the no iodide fed group, Lot II; this appears to be more evidence indicating the benefits of iodide feeding under the conditions of this second experiment.  

Summarizing, it appears that the young growing swine fed in this, the second iodide feeding experiment (220) in dry lot, showed beneficial results from iodide feeding. The average daily gain was 8.3 percent greater when potassium iodide was fed, and the feed required for a unit gain was lessened by 9.4 percent. The iodide fed pigs likewise showed greater dimensional growth. The results of this second experiment are in practical accord with the results of the first.  

THIRD EXPERIMENT IN FEEDING POTASSIUM IODIDE TO YOUNG SWINE  

In the winter of 1923-24 we fed in Experiment 255 two lots of six pigs each from December 28, 1923, until the pigs reached an approximate weight of 300 pounds, and then we continued the experiment for a full 180 days, or until June 25, 1924. When the experiment started these pigs were better than three months old, and weighed on the average practically 67 pounds per head.  

The allotment and rations fed were as follows:

LOT XII—Dry lot. (Check.) Shelled corn grain, mixed color, yellow and white, self-fed; plus supplemental protein feed mixture, (cottonseed meal, 30; corn oil cake meal, 20; linseed oilmeal, 15; standard wheat middlings, 10; soybean oilmeal, 14; peanut meal, 7, and alfalfa meal, 4 pounds; total 100 pounds), self-fed; plus Simple “Back-Bone” Mineral Mixture A, potassium iodide omitted, (flake salt, 20; high calcium limestone, finely ground, 40, and spent bone black, 40 pounds; total 100 pounds), self-fed.

LOT III—Dry lot. (Iodide fed.) Same as Lot XII except that .05 pound potassium iodide was added to 99.95 pounds of Mineral Mixture A. The Mineral Mixture B resulting had the following composi-
Fig. 11. This representative pig of lot III, experiment 255, received iodide in his mineral mixture.

His group made an average daily gain of 1.551 pounds, which was 13.1 percent greater than the comparable group not receiving potassium iodide. Note the sleekness and healthiness of this pig of June 3. These iodide fed pigs took 446 pounds of feed for the hundred pounds of gain or 8 percent less than the competitive group fed in lot XII of the same experiment. (See fig. 12.)

Fig. 12. This representative pig did not receive iodide in his mineral mixture.

Typical of the pigs from check lot XII, experiment 255, on June 3. Her group made an average daily gain of 1.372 pounds, not so large as where iodide was fed. This pig does not show the finish of her mate in lot III (fig. 11); neither is there exhibited as great height, length, depth or leg circumference, her group falling below the iodide fed pigs.

Fig. 13. This representative pig, lot I of experiment 255, did not make satisfactory gains.

This lot was directly comparable to lots XII and III of experiment 255, but did not receive any added minerals, nor potassium iodide. Note that this pig on June 3 is of much lighter weight, and smaller size, than the representative pigs shown in figs. 11 and 12.
TABLE X. THIRD IODINE FEEDING EXPERIMENT—FEEDING AND GAINS RECORD UP TO 300 POUNDS
(Both Groups in Dry Lot)
Experiment 255

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>No. of days required to reach 300 lbs.</th>
<th>Av. daily gain per pig lbs.</th>
<th>Feeds used</th>
<th>Av. daily feed eaten per pig</th>
<th>Feed required for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>XII (Check)</td>
<td>170</td>
<td>1.372</td>
<td>Corn</td>
<td>5.44</td>
<td>396</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supplement</td>
<td>1.21</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mineral Mixture A</td>
<td>.017</td>
<td>6.67</td>
</tr>
<tr>
<td>III (Iodide fed)</td>
<td>150</td>
<td>1.551</td>
<td>Corn</td>
<td>5.62</td>
<td>362</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supplement</td>
<td>1.29</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mineral Mixture B</td>
<td>.023</td>
<td>6.93</td>
</tr>
</tbody>
</table>

Flake salt, 19.99; high calcium limestone, finely ground, 39.98; spent bone black, 39.98, and potassium iodide, .05 pound: total 100 pounds.

Table X gives some pertinent facts regarding the average daily gain, average daily feed and the feeds required for the hundred pounds of gain.

It is to be again noted that the addition of potassium iodide to a ration fed young swine under Ames conditions resulted in a greater average daily gain and a lessened feed requirement. In addition, Mineral Mixture A as fed in this experiment was considerably improved thru the potassium iodide addition.

Table XI gives the results of feeding Lots XII and III in the third iodine feeding experiment for a period of 130 and 180 days, respectively.

The results as given in table XI are substantially similar to those in table X, the iodide fed pigs in both periods showing considerable superiority over the check pigs not receiving iodide. As the feeding period progressed the spread in liveweight as well as the difference in feed requirement for the hundred pounds of gain widened.

Chart 7 shows the progressive gains per pig in pounds, this being based on the average of the groups by months (30-day periods) throughout the experiment. It will be noticed that the iodide fed Lot III took the lead after some 70 days of feeding and then gradually increased that lead up until the 300 pound weight was reached. Table XI shows that the lead was still further increased up to 180 days.

The statistical study of the average daily gains gives the mean daily gain and the corresponding probable error by lots as follows: Lot XII, 1.372 ± .043, and Lot III, 1.551 ± .029. The computed median, which in this case consists of the average of
the two intermediate items, inasmuch as there is an even number of animals represented, is for Lot XII, 1.371, and for Lot III, 1.537. On both bases, that of compared means or compared medians, Lot III, iodide fed, clearly excelled Check Lot XII. This agreement makes the data concerning gains in favor of Lot III, receiving iodide, more significant.

The mean difference in daily gains between Lot XII, Check, and III, iodide fed, together with its probable error was: .179 ± .052. The mean difference is therefore 3.4 times its probable error. This would lead us to expect that future experiments, similarly planned and executed, would result in approximately 99 percent of the cases showing that the addition of the iodide would result in an increased average gain.

The coefficients of variability for these two lots were: XII, 11.43 percent, and III, 6.71 percent. These coefficients show clearly that the individual pig gains made in the iodide fed lot were more uniform than in the check lot. Apparently iodide feeding brought about a greater consistency of increase among the various individuals in Lot III.
### TABLE XI. THIRD IODINE FEEDING EXPERIMENT—FEEDING AND GAINS RECORD FOR 130 AND 180 DAYS
(Both Groups in Dry Lot)

Experiment 255

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>Av. weight per pig</th>
<th>Av. daily gain per pig lbs.</th>
<th>Feeds used</th>
<th>Av. daily feed eaten per pig lbs.</th>
<th>Feed required for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XII (Check)</td>
<td>68</td>
<td>247</td>
<td>1.375</td>
<td>Corn Supplem’t Mineral</td>
<td>4.93</td>
</tr>
<tr>
<td>III (Iodide fed)</td>
<td>67</td>
<td>266</td>
<td>1.531</td>
<td>Corn Supplem’t Mineral</td>
<td>5.28</td>
</tr>
</tbody>
</table>

**December 28—May 6,—130 Days**

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>Av. weight per pig</th>
<th>Av. daily gain per pig lbs.</th>
<th>Feeds used</th>
<th>Av. daily feed eaten per pig lbs.</th>
<th>Feed required for 100 lbs. gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>Final</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XII (Check)</td>
<td>68</td>
<td>318</td>
<td>1.391</td>
<td>Corn Supplem’t Mineral</td>
<td>5.55</td>
</tr>
<tr>
<td>III (Iodide fed)</td>
<td>67</td>
<td>348</td>
<td>1.561</td>
<td>Corn Supplem’t Mineral</td>
<td>6.02</td>
</tr>
</tbody>
</table>

**December 28—June 25,—180 Days**

Chart 8 presents the average daily feed consumed per pig by 10-day periods up until the 300 pound average weight was reached; it also covers the average of the period up to that weight.

Table XII gives the total average daily feed consumed per pig by 30 day periods and for the entire 180 day period. It is self explanatory.

Lots reached 300 pound weight as follows: XII, 170, and III, 150 days.

Table XIII gives the average daily potassium iodide and its iodine equivalent, as consumed per pig by periods in Lot XII during the entire experiment.

### TABLE XII. TOTAL AVERAGE DAILY FEED CONSUMED PER PIG BY PERIODS BASED ON 14% MOISTURE CORN, MINERALS INCLUDED

Experiment 255

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot XII pounds</th>
<th>Lot III pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-30</td>
<td>4.215</td>
<td>4.490</td>
</tr>
<tr>
<td>31-60</td>
<td>5.303</td>
<td>5.993</td>
</tr>
<tr>
<td>61-90</td>
<td>6.186</td>
<td>7.407</td>
</tr>
<tr>
<td>91-120</td>
<td>8.234</td>
<td>7.940</td>
</tr>
<tr>
<td>121-150</td>
<td>7.732</td>
<td>8.859</td>
</tr>
<tr>
<td>151-180</td>
<td>8.222</td>
<td>8.852</td>
</tr>
<tr>
<td>1-180</td>
<td>6.731</td>
<td>7.257</td>
</tr>
<tr>
<td>Average to 300 lbs.</td>
<td>6.659</td>
<td>6.938</td>
</tr>
</tbody>
</table>
TABLE XIII. POTASSIUM IODIDE AND ITS IODINE EQUIVALENT
CONSUMPTION DAILY AVERAGE PER PIG IN GRAINS

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Days in period</th>
<th>Average daily consumption per pig, Lot XII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Potassium iodide grains</td>
</tr>
<tr>
<td>1-30</td>
<td>30</td>
<td>.06</td>
</tr>
<tr>
<td>31-60</td>
<td>30</td>
<td>.11</td>
</tr>
<tr>
<td>61-90</td>
<td>30</td>
<td>.09</td>
</tr>
<tr>
<td>91-120</td>
<td>30</td>
<td>.07</td>
</tr>
<tr>
<td>121-150</td>
<td>30</td>
<td>.05</td>
</tr>
<tr>
<td>151-180</td>
<td>30</td>
<td>.08</td>
</tr>
<tr>
<td>1-130</td>
<td>130</td>
<td>.07</td>
</tr>
<tr>
<td>1-180</td>
<td>180</td>
<td>.08</td>
</tr>
<tr>
<td>1-150</td>
<td>150</td>
<td>.08</td>
</tr>
</tbody>
</table>

The iodine intake per pig daily averaged for the 180 days of feeding approximately one-thirty-third of a grain, which was rather a small intake. At this rate of iodine feeding the daily milligram ingestion was approximately two. The consumption in this experiment shows a very small iodine intake; perhaps this is accountable for the fact that the iodide fed pigs in this experiment did not take the lead in liveweight until about the

CHART 8
seventieth day, whereas in the first experiment the iodide fed pigs took the lead in about 40 days, and in the second experiment the iodide fed pigs took the lead from the very first day. In both the first and second experiments the iodine consumed daily was much in excess of the intake in this third experiment.

The average iodine consumption in grains for the 140 days of the first experiment was .5 per pig daily; in the second experiment or for a period of 110 days, it was .65, about 11 percent more; and in the third experiment, it was .03 for a period of 180 days, or about one-seventeenth of the daily ingestion in the first experiment. Of course the quantity of iodine in the feeds and water when determined may greatly affect these relationships.

In this connection the progressive consumption of minerals is suggestive. This consumption is given in chart 9, it being presented progressively in pounds per group of six as well as in pounds per head.

The pigs receiving potassium iodide in their mineral mixture, those fed in Lot III, consumed more minerals during the 180 days of feeding than did the no iodide fed pigs of Lot XII. The mineral mixture carrying potassium iodide was consumed in larger quantity from the beginning of the experiment, so that

**CHART 9**

![Chart 9](Image)
TABLE XIV. TOTAL FEED REQUIRED FOR 100 POUNDS GAIN BY PERIODS BASED ON 14% MOISTURE CORN, MINERALS INCLUDED

<table>
<thead>
<tr>
<th>Period days inclusive</th>
<th>Lot XII (check) pounds</th>
<th>Lot III (iodide fed) pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-30</td>
<td>375</td>
<td>403</td>
</tr>
<tr>
<td>31-60</td>
<td>380</td>
<td>430</td>
</tr>
<tr>
<td>61-90</td>
<td>382</td>
<td>376</td>
</tr>
<tr>
<td>91-120</td>
<td>602</td>
<td>467</td>
</tr>
<tr>
<td>121-150</td>
<td>645</td>
<td>583</td>
</tr>
<tr>
<td>151-180</td>
<td>528</td>
<td>550</td>
</tr>
<tr>
<td>1-180</td>
<td>484</td>
<td>465</td>
</tr>
<tr>
<td>Average to 300 lbs.</td>
<td>485</td>
<td>446</td>
</tr>
</tbody>
</table>

Lots reached the 300 pound weight as follows: XII, 170 days, and III, 150 days.

by the end of 180 days the total minerals consumed per pig showed clearly in favor of the iodide fed lot. Evidently the iodide addition did not make the simple mineral mixture less palatable.

The feed required by periods for 100 pounds of gain is presented in table XIV.

It may be noted that the feed requirement during the first 60 days of the experiment was clearly in favor of the Check Lot XII, the one not receiving potassium iodide. The significant turn in the third period in favor of the iodide fed pigs indicates that any inferiority in the pigs of Lot III as compared to XII was more than overcome by the beneficial effects of the iodide addition. Inasmuch as Lot III was excelled by Lot XII in economy of gains during the first two months, it may be inferred that in the experimental division of the pigs into these two respective lots that the favor turned to Lot XII, and that Lot XII had, in spite of the careful precautions that were taken in making the allotment, or division, the natural advantage. The superiority of Lot III during the remainder of the experiment was outstanding, in that the early lead of Lot XII was not only overcome, but more than counterbalanced. The kind of experimental performance as herein exhibited by Lot III as compared to Lot XII speaks all the better for iodide feeding.

Chart 10 shows the feed requirements in pounds by 30 day periods,—this for 180 days of feeding; it also gives the average feed requirement for the hundred pounds of gain up to the 300 pounds average weight.

Lot XII, not receiving iodide, is clearly shown in this chart to have made the poorest showing.

The growth of the pigs receiving iodide was considerably better, not only from the weight, but also from the dimensional viewpoint. The measurements of the pigs as taken throughout the experiment demonstrate clearly the truth of the above statement of superiority on the part of the iodide fed pigs.
Table XV gives the average measurements of the pigs in the two lots, XIII and XIV, at the beginning of the experiment, after 130 and 180 days feeding, and at the time the pigs reached the average weight of 300 pounds.

It is apparent that in every instance the growth (dimensional) of the iodide fed Lot III was the greater. This is true where the comparison is made on the absolute or on the percentage basis.

In body length as well as in height at shoulder the iodide fed lot clearly excels the check, no iodide fed lot. In circumference of fore-shin, the results are somewhat close, but iodide feeding appeared to be beneficial.

Summarizing, it appears that young swine fed in this, the third iodide experiment (255), in dry lot, showed beneficial results from iodide feeding. The average daily gain was greater when potassium iodide was fed by 13.05 percent, and the feed requirement for the unit gain was lessened by 8.04 percent. The iodide fed pigs showed a marked increase in dimensional growth. The results of this third experiment are in practical accord with
TABLE XV. THE MEASUREMENT AND GROWTH OF THE PIGS BY PERIODS

Experiment 255
(Measurements on the average pig basis, inches)

<table>
<thead>
<tr>
<th>Measurement designation</th>
<th>Lot XII</th>
<th>Lot III</th>
<th>Lot XII</th>
<th>Lot III</th>
<th>Lot XII</th>
<th>Lot III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lenght, body—ears to tail</td>
<td>Initial</td>
<td>31.5</td>
<td>30.1</td>
<td>17.6</td>
<td>16.9</td>
<td>4.6</td>
</tr>
<tr>
<td>At 130 days</td>
<td>46.7</td>
<td>48.0</td>
<td>26.2</td>
<td>26.7</td>
<td>6.1</td>
<td>6.2</td>
</tr>
<tr>
<td>Increase, absolute</td>
<td>15.4</td>
<td>17.8</td>
<td>8.6</td>
<td>9.8</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Increase, percentage</td>
<td>48.7</td>
<td>59.1</td>
<td>48.9</td>
<td>59.3</td>
<td>33.9</td>
<td>37.2</td>
</tr>
<tr>
<td>At 180 days</td>
<td>52.2</td>
<td>54.8</td>
<td>27.8</td>
<td>27.8</td>
<td>6.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Increase, absolute</td>
<td>20.7</td>
<td>24.6</td>
<td>10.2</td>
<td>11.0</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Increase, percentage</td>
<td>65.9</td>
<td>81.8</td>
<td>58.1</td>
<td>65.1</td>
<td>47.3</td>
<td>50.0</td>
</tr>
<tr>
<td>At 300 pounds**</td>
<td>50.6</td>
<td>51.5</td>
<td>27.4</td>
<td>27.1</td>
<td>6.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Increase, absolute</td>
<td>19.2</td>
<td>21.4</td>
<td>9.8</td>
<td>10.3</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Increase, percentage</td>
<td>61.0</td>
<td>70.9</td>
<td>56.0</td>
<td>61.0</td>
<td>42.7</td>
<td>46.0</td>
</tr>
</tbody>
</table>

*Carried out one place in all instances.
** Lot XII, 170 days; and Lot III, 150 days.

The results of the first two, this being all the more interesting, particularly in that the iodide addition, quantitatively speaking, was about a seventeenth of the ingestion in the first experiment, and a twenty-secondth of the allowance in the second experiment.

GENERAL DEDUCTIONS BASED ON THE THREE EXPERIMENTS

The fact that the probable error in all comparable cases, namely, in the three comparisons between iodide and no iodide feeding as made in the three specific experiments, was less in the iodide fed lot than in the corresponding check, or no iodide fed lot, and the further fact that the coefficients of variability were likewise less in all three comparisons, make the beneficial results secured from iodide feeding, under Ames conditions, quite significant. Inasmuch as the results were positive in three successive experiments under different conditions of feeding and management, one of the three comparisons being made on pasture wherein the animals are supposed to gain a store of iodine, the evidence is all the more in favor of the conclusion that iodide feeding was beneficial to young swine under the conditions of our experiments.

The positive results secured in the three experiments in favor of iodide feeding suggest the wider and more general use of iodide in animal feeding practice, particularly in those goitrous regions wherein the water carries a low percentage of iodine. The two samples of water, one from Ames, and the other from Iowa City, analyzed by McClendon and Hathaway (15) hereinbefore mentioned, showed respectively 1.2 and 1.5 parts of iodine
per hundred billion parts of the water. If the spring pigs of Ames consumed on the average 10 pounds of water per day (and this figure is high*) it would take them 119,048 days to secure a single grain of iodine from their water supply. If these pigs averaged 300 days on the farm they would, in that time, on the basis of this maximum consumption of 10 pounds of water, get approximately one-four-hundredth of a grain of iodine in their drinking water. Surely the drinking waters of Ames and Iowa City, as reported by McClendon and Hathaway, supply but a very insignificant part of the needed iodine.

Furthermore, it is to be considered that the work of Forbes (5), Bohn (2), and others, in regard to the quantitative presence of iodine in feeding stuffs, show its occurrence to be very erratic and apparently accidental; also, that Cameron (3) and Von Fellenberg (30) conclude that the foods in a goitrous region or environment are likely to run lower in iodine than in those sections where there are non-goitrous conditions. These considerations indicate that an adequate supply of iodine for livestock under conditions at Ames is not, by any means, always assured. The air source of iodine to the animal is considered a negligible factor. The feed, the water and the soil or "licks", sometimes are the potent and practical iodine sources; the feed and water are the primary sources.

Inasmuch as swine may be handicapped because of a deficient supply of iodine, and yet show no gross or unusual signs of goitre or other iodine deficiency troubles, it appears to us that it is good practice in goitrous regions, such as Iowa and all of the northern half of the United States, to use iodine in the feeding ration. This iodine, fed in the form of iodide, may be put in the drinking water, or with the feed; in the latter case we believe that it is sound practice to use from one-third to an ounce of either sodium or potassium iodide to the hundred pounds of mineral mixture, which is kept before swine at all times. Our experiments have indicated that one could add one-tenth pound (1.6 ounces) of potassium iodide to the hundred pounds of mineral mixture without causing any noticeable untoward effects; we have added three-tenths pound (4.8 ounces) to a hundred pounds of mineral mixture without noting any unfavorable developments.

Common salt, being one of the most important mineral substances regularly needed by livestock, suggests itself as a splendid carrier for iodine and provides a way for the practicable administration of iodine in sufficient and adequate amounts.

*Our Ames records on a group of pigs taken from weaning time to the 300 pound weight show the following consumption of water in pounds by months,—1st, 7; 2nd, 9; 3rd, 10; 4th, 11; 5th, 7; 6th, 7; 7th, 5; 8th, 6; 9th, 5, these figures being in round pounds; fall pigs, on the other hand, will consume during a similar period from 60 to 100 percent as much, with a rough average around 70 to 80 percent.
TABLE XVI. A BRIEF SUMMARY OF THE THREE IODIDE FEEDING EXPERIMENTS; GAIN AND FEED REQUIREMENTS ONLY CONSIDERED

<table>
<thead>
<tr>
<th>Experiment no.</th>
<th>Lot no.</th>
<th>Average daily gain</th>
<th>Feed requirement for 100 pounds gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without added iodide</td>
<td>With added iodide</td>
</tr>
<tr>
<td>208</td>
<td>IX (Check) X (Iodide fed)</td>
<td>1.226</td>
<td>1.329</td>
</tr>
<tr>
<td>220</td>
<td>II (Check) III (Iodide fed)</td>
<td>1.518</td>
<td>1.644</td>
</tr>
<tr>
<td>255</td>
<td>XII (Check) XIII (Iodide fed)</td>
<td>1.372</td>
<td>1.551</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>1.372</td>
<td>1.508</td>
</tr>
</tbody>
</table>

Difference in favor of iodide feeding: 0.136
Percentage in favor of iodide feeding: 9.91%

The beneficial results secured from iodide feeding in the growing and fattening of young swine are forcibly shown in Table XVI, a summary displaying the average daily gains and the feed requirements for 100 pounds of gain in the three experiments.

The extra gain resulting from iodide feeding in the three experiments was, respectively, 8.4, 8.3 and 13.1 percent. For the three experiments there was a greater average daily gain of 9.91 percent (based on a straight average) due to the iodide feeding.

The feed required for a hundred pounds of gain was reduced by iodide feeding in the three experiments, respectively, as follows,—12.5, 9.4 and 8.0 percent. On the average 10.00 percent less feed was required with iodide feeding.
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ADDENDA

Note: This is the first of a series of bulletins dealing with the iodine problem, under the general heading, "Studies in Iodine Feeding". Part II of the series, covering some sheep investigations, will follow.

The Beginnings of This Investigation:

The senior author's first interest in iodine feeding in the Animal Husbandry Section of the Iowa Agricultural Experiment Station was stimulated by correspondence in 1914 with Prof. W. H. Hislop, then of the animal husbandry department, State College of Washington, Pullman, Wash. At that time Professor Hislop sent us considerable data, gathered in the field, in regard to the presence, possible causes, and description of goitrous conditions. In a letter to Professor Hislop in regard to possible interpretations of this material, the senior author wrote as follows:

"You speak of protein deficiency as being a possible cause. On looking over the feeds fed, however, it is hard for me to reconcile this with the actual facts in the case. In nearly all the cases these animals, whether they be cattle, horses or pigs, have had an abundance of protein feeds such as alfalfa, cats, milk, summer grass, and so on. Then, too, those rations which are abundantly supplied with protein as are mentioned by one of the pig men especially,—namely, alfalfa hay, pasture, swill, milk, and wheat, also caused trouble, which was also the case with the ration composed of oats, milk, and alfalfa. From the looks of the rations allowed the problem, if it were based upon protein at all, should be studied from the standpoint of an excess of protein.

"The calcium deficiency will not cause the troubles which are mentioned. I am quite sure of this. We find that corn when fed continuously to hogs will not cause them to produce very many hairless pigs, although we do find a few (in practice), and corn of all of our feedstuffs is most deficient in calcium. The water analyses which are appended in the report you sent run fairly high in calcium, this being especially true of the spring and Libby Creek waters. However, the Methow river water is a bit low, although not very much.

"The truth of the matter is, your water from the spring and Libby Creek run just about the same as the water here at Ames in calcium. This is the water we feed along with corn. The hogs get almost as much calcium in the water as they would get in the corn, and yet it did not help very much to add calcium to this ration, although there was a slight influence. The mere fact that the addition of calcium phosphate gave very poor results would indicate in my estimation that this is not the source of the trouble.

"There is evidently some connection between "Big Neck" in calves and hairlessness of the pigs. It would be well, I think, to make a complete study of the internal secretions and how they are affected. The thyroid and thymus glands of the throat should be especially studied. Big Neck in calves is possibly the same disease as goiter in humans, and if this is true, then it is the thyroid which is playing havoc. Why is this?

"Then again, it may be that your conditions are somewhat similar to those in certain portions of Switzerland, where Big Neck is endemic to the locality. Just what is the reason for the abnormal presence of Big Neck in humans in these endemic communities is not worked out. It is supposed to be associated somewhat with the diet, although there are those who believe that the trouble is due to some sort of organism.

"There is no question but what the thyroid plays a very important role in nutrition. Evidently iodine is associated in some way with thyroid activity. It is somewhat surprising to note that iodine has been used successfully in this trouble. Is there not some connection? I am especially impressed with the mode of procedure of the man who put two teaspoonsful of iodine upon the backs of his cows twice yearly. This looks like a foolhardy procedure, and to the novice would appear 'idiotic', but inasmuch as he got results it would seem that this would be a good basis on which to do some experimental research. Why not?"