Iodine Requirements of Poultry

By Dr. H. S. Wilgus, Jr., Colorado Agricultural Experiment Station, at Cornutt Nutrition Conference

So far as is known, the function of iodine in the body is its use by the thyroïd gland in the formation of thyroxin. This amino acid, iso- lated by Kendall in 1914, is an active constituent of thyroglobulin, the main protein in the thyroïd gland. Thyroglobulin is assumed to be the thyroïd hormone, with most of its properties due to thyroxin and a minor portion to iodothyroxine, although the latter is present in greater amounts.

The thyroïd hormone controls metabolic rate and the general oxidative processes in the body. It is interrelated with the general endocrine system in the body. For example, it is probable that thyroid activity is governed to a large extent by the thyroïdotropic factor from the pituitary gland. Reproduction is related to thyroid function, possibly through the gonads. Calcification is also affected in some cases of dysfunction, possibly through the parathyroid glands.

Results of Thyroid Dysfunction

Low thyroid activity most commonly results from insufficient iodine for thyroxin formation, although organic disorders may be primary causes in some cases. Iodine deficiency results in simple goiter. This is evidenced by compensatory hypertrophy or enlargement of the thyroïd gland. The resulting insufficiency of thyroxin causes lowered rate of body metabolism, impaired weight gains, and mental responses, lethargy and sterility. If the deficiency is not relieved, death may ensue.

Offspring from goitrous human mothers are frequently underdeveloped and fail to grow normally. This condition is known as cretinism. In adults suffering from thyroid insufficiency, possibly not owing to iodine deficiency, a disease like cretinism is sometimes observed. This is called “toxic goiter,” or goiter of the adult. It is characterized by local enlargement of the thyroïd gland, while the general oxidation processes in the body are not influenced. Thyroid goiter is inherited, as is demonstrated by the breed of Jersey cattle, with large thyroïd glands and low milk yield. The condition is associated with a low metabolic rate, in which case it is called “simple goiter.” Thyroid goiter is found in many domestic animals, including pigs, rabbits and horses. Among wild animals, it is known in the wolf, cat and dog. In the human race, it is present in people of older age, particularly in those living in areas of low iodine content.

Goiter in Farm Animals

The amount of iodine in ordinary rations in these areas is usually not enough to cause extreme symptoms in mature farm animals. However, off- spring from goitrous animals may be seriously affected. Thus goiter may be extreme in newborn calves, lambs and kids if the dam’s diet is very deficient in iodine. Under such circumstances pigs are born hairless, are usually bloated and have thick skins. Foals may show only extreme weakness. All such severely affected young animals ordinarily die or remain weaklings.

Goiter in Chickens

Goiter has been found in chickens in a few instances in Minnesota, Montana and British Columbia. Greenwood and Blythe have reported good growth, production and fertility in chickens thyroidectomized during the early stages of growth. However, Winchester and Taylor and Burmester have reported that thyroidectomized hens laid at greatly subnormal rates. Various workers have observed that a lack of thyroid hormone in the chicken causes increased length of feather, a fringed appearance resulting from lack of barbules, and less melanin and more red pigment. Excess of thyroxin causes shorter, blunter feathers with more melanin and less red pigment and advances adult plumage in young birds. Theoretically we might expect extreme iodine deficiency in the chicken to result in goiter, lowered metabolic rate, lower body temperature, more phlegmatic temperament, increased feather length and fringing, deeper feathering, lower production, fertility and hatchability and lower body weight in the offspring.

Feeding Iodine to Poultry

Considerable work has been reported on the effect of iodine feeding to poultry. This has been reviewed by other workers. Generally speaking, the evidence from the United States has been negative, whereas that from Europe has been conflicting. The only agreement is that the iodine content of eggs varies in proportion to the iodine content of the hen’s ration. Much experimental work with poultry was done with basal rations of unknown iodine content and covered but a short portion of the life cycle. In some work the test diet was lacking control. In other instances there were insufficient numbers. In no experiment was there a thorough effort to select feeds known low-iodine content and to study iodine deficiency symptoms, especially in the thyroid glands.

Purpose of Colorado Experiments

The investigation at Colorado Experiment station was initiated in 1928 with the following object in view: 1. To ascertain the minimum amount of iodine feeding for chickens. 2. To study the response of chickens fed various levels of iodine throughout several generations. 3. To ascertain the distribution of iodine in common poultry feedstuffs.

Procedure in Colorado Experiments

Most of the experiments were conducted with single comb white leghorn chickens from one strain. The all-mash system of feeding was used. Each ration was made by thoroughly mixing solutions of the known nutrients as estimated by calculation. In short term experiments battery brooders were used. In longer experiments the floor system was used, brooding being done with electric hovers. The birds have been entirely confined in rooms with sufficient heat to prevent freezing in winter. A 14-hour day was provided throughout the use of supplementary light. Up to the summer of 1941, all feed ingredients were selected for low iodine content by actual analysis, using a modification of the very sensitive colorimetric method. Iodine supplementation was made by thoroughly mixing solutions of potassium iodide in alkaline ethanol into the feed. Each mix was analyzed for iodine content. Recently potassium iodide powder has been used.

Criteria Used

The criteria used in these experiments were weight and microscopic structure of the thyroid glands at 6, 12, 18 and 24 weeks of age and often later, body weight at 6, 12, 18 and 24 weeks and at 4 week intervals thereafter, feed consumption, mortality and general condition, trapnest records of egg production, egg size every fourth week, interior egg quality, fertility and hatchability and growth of offspring. Additional criteria used in a few cases include iodine content of eggs and thyroid glands, pigmentation and feathering. The first 10 experiments were classified as exploratory. Subsequent experiments were done primarily to determine the iodine requirements of chickens in a give environment. The last 8 experiments were definitive. The last 3 experiments were made by the Cornell University as experiment 21. This paper is a report of the progress to date and is given with the approval of the Director as paper No. 114, Colorado Agricultural Experiment station.

Exploratory Experiments

The exploratory series of experiments was designed to ascertain symptoms of iodine deficiency in poultry and the effect of iodine supplementation at various levels. Through such observations the limits of iodine supplementation in which more comprehensive experiments should be confined could be determined. The experimental rations used in these experiments included ground yellow corn, soybean oil meal, steamed bone meal, salt, manganese sulphate, activated yeasts and vitamin D in the oil solution and some Vitamin G carrier, usually dried brewer’s yeast residues. More comprehensive experiments in this series also included some casein and oat groats; since these were found essential in this type of ration for maximum growth. Liminiodine was used in laying rations.

We were fortunate in obtaining as low as 6 gamma (micrograms) of iodine per...
kilo of feed in some of these experiments. This is 0.0000006 per cent. Levels of iodine attained through supplementation ranged as high as 36,000 gamma per kilo in starting and growing mashies. In laying rations the level went as high as 360,000 gamma per kilo.

The results obtained during the growth period showed that chickens require a minimum of 200 gamma of iodine per kilo for normal thyroid weight and a minimum of 1,000 gamma per kilo for normal thyroids according to microscopic examinations. The average weight of the thyroid glands in birds fed the basal ration rose as high as 15 times normal, with individual cases approaching 60 times normal. The degree of goiter in such cases was extreme. Body weight of the females fed the basal ration in one experiment was lower after they attained sexual maturity than that of females whose ration was supplemented with iodine. Body weight at 12 weeks of age was significantly lower in males fed the basal diet in one experiment. Mortality was higher in the pen fed the basal ration. Efficiency of feed utilization was not affected by iodine. Congenital goiter was noted in chicks hatched from hens fed the basal ration and also from hens fed the practical ration when it happened to run low in iodine.

In view of these results it was decided to use the practical type of ration in ensuing experiments. This ration consisted of ground yellow corn, pulverized oats, wheat gray shorts, wheat bran, alfalfa leaf meal, dried buttermilk, meat and bone scrap, soybean oil meal, pulverized limestone, salt, manganese sulfate and activated animal provitamin D in oil solution. Soybean oil meal was used at a standardized level of 6 per cent in all rations. This basal ration has contained between 160 and 440 gamma of iodine per kilo.

Preliminary Experiments

The purpose of this series of experiments was to extend observations already made on the simplified ration but using the practical ration. Two major experiments were intended to provide chicks representing the second and third generation on each of the various levels of iodine used. Observations on feathering and on the effects of different sources of iodine were made in minor experiments.

Major Experiments

Moderate to mild goiter was observed in chicks on the unsupplemented ration up to time of sexual maturity, at which time normal or even slightly resting glands were observed. This observation merits further study. There was a marked trend for those glands from birds fed the higher levels of iodine to be larger, particularly after 18 weeks of age. This was explained by the fact that the higher iodine levels caused the thy-
Iodine Requirements of Poultry

(Continued from Page 19)

Iodine deficiencies were found to be essential until sexual maturity to prevent microscopic evidences of goiter. A minimum of about 1,000 gamma of iodine per kilo of ration was found to be essential until sexual maturity to prevent microscopic evidences of goiter. No consistent effect of the various iodine levels has been noted on body weight up to time of sexual maturity. Apparently, the amount found in the basal ration sufficed for growth. The birds not receiving iodine supplementation in one experiment failed to increase their weight during the first laying year to the same extent as those receiving iodine. Efficiency of feed utilization during the first 18 weeks was not affected. From these experiments it would appear that 500 to 1,000 gamma of iodine per kilo would be the minimum required to maintain adult body weight.

Mortality up to 18 weeks of age in first generation chicks was not materially affected by iodine feeding. However, it was higher in one experiment in the second generation chicks fed levels of iodine approximating 200 and 1,000 gamma per kilo. No significant differences in the occurrence of fowl paralysis were noted in these experiments. Losses from laryngotracheitis following a "break" in vaccination at 18 weeks of age in one experiment were in inverse relation to the iodine supplementation, no losses occurring on the highest level. Adult mortality has shown no consistent trends in either experiment. No significant or consistent differences in pullovum reaction have been noted. Egg production and egg size have shown no marked benefit from iodine supplementations in these experiments. Egg quality studies are incomplete but no marked differences have been noted.

Other Experiments

Fertility has not varied appreciably but hatchability has been lower in one experiment in the hens receiving the unsupplemented ration and in those receiving the high level of 180,000 gamma per kilo. Use of males of an entirely unrelated strain has not altered these results. Chicks hatched from hens receiving excessive iodine showed evidences of stickiness, short wiry down, and poorly healed navels. There is slight evidence that chicks hatched from hens receiving supplements of iodine have made slightly better early gains even when reared on the unsupplemented ration.

No marked effects of iodine supplementations have been noted on feathering at any age in Leghorns, but this is not unexpected since Leghorns are genetically a rapid feathering breed. However, slight evidence was obtained indicating that 18,000 gamma per kilo would produce a more pinny condition at six weeks. Such may have been due to advance of juvenile molt rather than to delay of development of chick plumage. In one experiment chicks from a slow feathering strain of White Plymouth Rocks and from a strain of New Hampshire were fed various levels of iodine from iodinated casein. The effect on feathering was striking since the Rocks receiving 500,000 gamma per kilo of iodine showed practically perfect feathering at 6 weeks of age. These observations conform with that of Radi and Warren and are receiving further attention. The thyroid glands in these birds became progressively smaller with increments of iodinated casein. Since iodinated casein has some thyroxin activity, these effects were expected.

Other Experiments

In view of observations on the stimulation of milk secretion in goats by iodinated casein, potassium iodide has been replaced by this casein as a source of iodine in one experiment. No increased beneficial effects on production have been noted. In fact hatchability on the highest iodine level was further depressed and body weight was lowered. Preliminary observations have not indicated any difference in response of chicks during the first six weeks to iodine from potassium iodide, kelp, or iodized oil powder.

Goiter has been inadvertently encountered at this experiment station in pens of breeder turkeys receiving practical rations of different types.

Experiments With Feeds

Analyses of feeds are still in progress to determine iodine distribution in common feed ingredients. Analyses in our laboratory corroborate our observations that practical rations may be very low in iodine at times. An experiment is in progress with chickens representing the second and third generations on various iodine levels. In addition White Plymouth Rock chicks, New Hampshire chicks and Leg-
horn chicks from a different strain are receiving rations with and without iodine. 

Discussion and Summary

The growing rat requires about 20 to 40 gamma per 1,000 calories in the ration, based on thyroid weight. A 6-weeks-old chick will have consumed about 1,000 grams of ration containing about 3,600 to 4,000 calories. With the minimum content of 200 gamma of iodine per kilo required to produce minimum thyroid weight, this would amount to about 50 gamma per 1,000 calories, a figure in excellent agreement with the findings on rats. However, our data indicate that five times this amount is required to produce thyroid glands of normal microscopic structure.

Branion quotes other workers' calculated estimates of the iodine requirements of the adult size fowl to be 4.5 to 5 gamma a day. This would be approximately equivalent to 20 to 100 gamma per kilo of ration. Our preliminary observations indicate that 500 to 1,000 gamma per kilo is closer to the minimum. At least 1,000 gamma of iodine was required per kilo of feed to assure good hatchability.

The amount of iodine frequently recommended commercially for poultry rations was in no way detrimental to the birds. Chickens apparently tolerate much larger amounts of iodine. Large amounts of iodine in the form of iodinated casein materially aid feathering. The results presented in this paper are purely preliminary and constitute a report of progress. Practical recommendations must await the completion of experiments now in progress.

LITERATURE CITED


14. Warren, D. C., and Radel, D. P.


ACKNOWLEDGMENT

The author has been exceedingly fortunate in having the following co-workers: Dr. F. X. Gassner, histologist; Dr. A. R. Patton, chemist, now head, chemistry department Montana Agricultural Experiment station; Dr. G. S. Harshfield, histologist and pathologist; L. P. Ferris, II, chemist, now with American Cyanamid Co.