III.—The Effects of Alumina Salts on the Gastric Juice in the Process of Digestion.

By Henry A. Mott, Jr., Ph. D.

The introduction of alum into flour for various purposes, has been a trick of the baker for the past one hundred years; fortunately, its introduction is limited now to a few unscrupulous bakers—as in England, France and Germany, it is an offense punishable by fine and imprisonment, to use alum in any connection with articles of food.

That alum is a poison, numerous experiments have demonstrated. The experiments conducted by Devergie and Orfila on living animals, with alum, clearly demonstrate its poisonous nature. They conclusively demonstrated that alum, in its hydrated and anhydrous (or calcined, exsiccated) condition, has a corrosive action on the mucous membrane; and, further, that it is sure to produce vomiting, constipation, extreme weakness, and loss of appetite, even in very small doses; and in such cases, if either by accident or intention, vomiting is prevented, death is sure to result.

Several cases of poisoning by the accidental use of alum have been reported from time to time. A Mrs. B., reported by Dr. Fournier, "took by mistake a swallow of about three teaspoons of a solution of 16 grms of calcined alum in a liter of water. She at once complained of nausea, severe heat, tearing pains in all parts in contact with the alum; her pulse had become rapid, and the face animated; the muscles had been agitated by slight convulsive movements; the desire to vomit had increased; the thirst had become inextinguishable."

Another case is reported by Dr. Ricquet, where a Mr. V. M., wishing to purge himself, ordered some sulphate of magnesia, but by mistake alum was given him; on dissolving 30 grains in water and drinking the same, he succumbed after horrible pains, eight hours after taking the poison.

Besides the last mentioned case of death resulting from taking alum internally, must be mentioned three cases of alum poisoning by Von Hasselt, Taylor and Husemann, and two cases by Tardieu—all of which terminated fatally.

Tardieu speaks of a woman who murdered her three months' old child by administering about 0.9 grm of alum.

When alum is used in flour in the manufacture of bread, some of the alum is decomposed by the phosphates of the flour, and phosphate of alumina, basic sulphate of alumina, and some unaltered alum, are left in the bread. The introduction of alum as a substitute for cream of tartar in baking powders, is a recent fraud on the public, and, strange to say, has been upheld by a few men, who, it would be supposed, would condemn its introduction in the strongest terms. In an alum baking powder, another chemical change takes place—owing to the presence of bicarbonate of soda—and hydrate of alumina is formed, a very soluble modification of alumina, as compared with the phosphate or basic sulphate—but only just so much of the hydrate of alumina is formed as there is bicarbonate of soda present in the powder to form it—and as the alum is always in excess, being the acid of the compound, there is also formed phosphate of alumina, basic sulphate of alumina, and some alum is left unaltered.

Some of the manufacturers of alum baking powders have induced a few scientific men, besides saying there is no alum in the baked product, to say that the alumina hydrate of the alum is rendered insoluble by the processes of baking, and that it would pass through the system like clay, or any other inert substance.

This might seem plausible at first thought, but when we consider that it takes only ten to twenty minutes in a suitable oven to bake biscuit, and that, after the biscuit is baked, it contains, itself, about fifty per cent. of water, we see how utterly impossible it would be to drive off the water of combination of the hydrate of alumina, so as to render it insoluble, as aluminic oxide.

It hardly seems necessary for any experiments on animals to decide a question of this nature, so that the use of alum baking powders can be condemned; for a scientific consideration of the subject can lead to no other conclusion. Still, as Prof. Patrick, of Missouri, conducted some experiments on cats, to sustain his position in stating that alum baking powders are not injurious to health, I thought it advisable to conduct a series of experiments on dogs, in search of the truth.

Through the courtesy of the Commissioners of the Dock Department, I secured a shed on their premises foot of Sixteenth street and East River. This shed I had completely remodeled into a suitable house, having the dimensions of about 16x14x12 feet high. Sixteen stalls were made inside, having the dimensions of 3½ feet by 2 feet by 2½ feet. The bottom of each compartment was covered with straw, making a pleasant bed for the dogs. I then secured 16 dogs from the pound, which were all carefully examined to see if they were in a perfect state of health. None but strong, healthy dogs were selected. The breed, age, food, color and weight, of every dog was carefully noted. Each dog was then consigned to a stall, and securely chained, and they all received a number, from one to sixteen. I commenced my experiments on the 9th of September, and finished December the 3d. My assistant was with the dogs from morning until night, and never left the animals without first securely bolting and locking the dog-house. No stranger was allowed to enter the house unaccompanied either by myself or by my assistant, and the dogs never received a mouthful of food or anything else from any one except my assistant and myself.

I will now detail the result of my experiments:

DOG NO. I.

Breed—Coach.
Age—1 year.
Health—Perfect.
Food—Bread and crackers.
Color—Spotted black and white.
Weight—35 lbs.

To this dog, on the morning of the 9th of September, was given 8 biscuits, at ten minutes past eight o'clock. The biscuits were made by myself, as follows:

1 quart sifted flour; 20 teaspoons alum baking powder; 2 cups of water; 1 tablespoon of butter. 22 biscuits made, weighing 27 oz. Time of baking, 20 minutes.

At half-past eleven, the dog was taken very sick, vomiting profusely ; his vim and brightness of eye had departed, and he trembled considerably in his limbs.

At four o'clock, five more biscuits of the same nature were given, but he would not eat them.

The next morning, eight more fresh biscuits were given him; he ate only part of one. During the day previous he was quite loose in the bowels; but he had now become very constipated, and it was only with great effort and pain he was able to relieve himself for several days.

On September 11th, as he would not eat the biscuits alone, they were mixed with meat; this he ate, but remained very dejected in spirits and extremely constipated.

To dog No. V. the same food was given. The description of the dog was as follows:

Breed—Terrier.
Age—9 years.
Health—Perfect.
Food—Crackers.
Color—Brindle.
Weight—30 lbs.

At 8.15 on September 9th, eight biscuits, made as described above, were given. At 12.15, the dog became very sick and vomited profusely. At 4 P. M., five more biscuits were given him, but he would not eat. He was very constipated towards night. On the following morning, eight biscuits were given him, which he ate in part during the day; in the afternoon he was very sick, vomiting at 4.30 and again at 5.45 P. M.

Experiments were next made, using only half the quantity used above of an alum baking powder.

The biscuits were made as follows:

1 quart sifted flour; 10 teaspoons alum baking powder; 1¼ cups of water; 1 tablespoon of butter. 27 small biscuits, weight 25½ oz. Time of baking, eleven minutes.

Three dogs were fed with biscuits thus made, with the following results:

	No. II.	No. IV.	No. VI.
Breed..........	Cur.	Spitz Cur.	Shepherd.
Age	15 months.	1 year.	4 years.
Health..........	Perfect.	Perfect.	Perfect.
Food...........	Bread.	Crackers.	Crackers.
Color...........	Black.	Yellow.	White.
Weight.........	16 lbs.	10 lbs.	40 lbs.

Eight biscuits were given to dogs Nos. II. and VI. in the morning; in the afternoon, dog No. II. was very loose in his bowels, and dog No. VI. very constipated. Five more biscuits were given in the afternoon, and eight more the following morning, part of which were eaten. Both the dogs then were extremely constipated and apparently quite sick, although they did not vomit. To dog No. IV., in perfect health, was then given three biscuits, which were eaten at 9 o'clock. At 10.35 A. M., the dog became quite sick and vomited. In the afternoon and next morning, more biscuits were given him, but he would not eat.

This demonstrates that some animals are more susceptible to the action of poisonous substances than others.

It now became necessary to know if the same effects would not be brought about by using the same quantities of cream of tartar powder. I therefore conducted a series of experiments to arrive at this point. Three dogs were experimented on. The following is a description of the animals:

	No. IX.	No. X.	No. XVII.
Breed	Mongrel.	Mongrel.	Terrier.
Age	4 years.	10 years.	2 years.
Health.........	Perfect.	Perfect.	Perfect.
Color....	Black and White.	Black and White.	Black and Tan.
Weight........	20 lbs.	35 lbs	15 lbs.

The biscuits were composed as follows:

1 quart sifted flour; 20 teaspoons cream of tartar baking powder; 2 cups of water; 1 tablespoon butter. 20 minutes baking. 26 small biscuits. Weight 27 oz.

The biscuits given to dog No. XI. were twice as large—only 12 being made instead of 26; therefore, each dog was given as many biscuits as he would eat, without in any way affecting them. Their bowels were not in the least affected. Each dog ate sixteen biscuits the first day, eight in the morning and eight at night. Dog No. X. ate but ten biscuits; the next day each dog ate the biscuits again with appetite. Dog No. XVII. was fed four days on the biscuits, and ate the same with appetite, without showing any signs of sickness.

These experiments clearly demonstrate that the salts left in the biscuit, when a cream of tartar baking powder is used, are perfectly harmless; but when an alum baking powder is used, are very dangerous, as in every case where dogs were fed on biscuits made with such powders, the dogs were made very sick, causing them to vomit profusely, lose all energy, and show weakness in their limbs.

The next series of experiments was to ascertain what effect would be produced by feeding dogs with hydrate of alumina mixed in with their food, as also phosphate of alumina. To two dogs, Nos. XV. and XVI., hydrate of alumina was thus given.

The following is a description of the dogs:

	No. XV.	No. XVI.
Breed...............	Mongrel.	Mongrel.
Age..................	1 year.	3 years.
Health................	Perfect.	Perfect.
Food..................	Bread.	Bread.
Color................	White.	White and Black.
Weight...............	18 lbs.	20 lbs.

The hydrate of alumina was prepared by Professor Schedler; it was made by precipitating the alumina in alum by means of ammonia, and then thoroughly washing the same with water until the washings were perfectly free from traces of ammonia. The precipitate was then dried between blotting paper, and analyzed to ascertain the percentage of water it contained. The following is an analysis of the same:

Hydrate of alumina.........	12.48	per cent.
Abnormal water............	87.52	"
	100.00	"

From this analysis it will be seen that 1 ounce of the precipitate is really only ⅛ oz. of hydrate of alumina, or 54½ grains. To dog No. XVI. on the 13th of September, was given 1 ounce of precipitated hydrate of alumina (54½ grains $Al_2O_3.3H_2O$) mixed with meat, at a quarter past eight in the morning. At 12.30 the dog became quite sick, and vomited; at ten minutes of six in the afternoon, ¼ oz. (109.2) more of hydrate of alumina in meat, was given to the dog, and at twenty minutes past six he was again taken quite sick, and vomited; he vomited also considerable during the night, the meat being vomited up *undigested.* The next morning, ¼ oz. (109.2 grains) more of hydrate of alumina mixed with meat, was given to the dog, and he vomited a short time afterwards; he was very constipated, his last stool being quite black. At three o'clock, 109.2 grains more were given him, and he was again taken sick, vomiting, and showing great weakness in his limbs. The next day at three o'clock, he was given ¼ oz. more of hydrate of alumina mixed with meat, when he was taken extremely sick, vomiting several times, and showing great weakness in his limbs, and loss of ambition, the brightness of eye having disappeared; he vomited during the night, and could not be induced to eat any more the next day or the day following.

To dog No. XV. was given ⅜ oz. (163½ grains) of hydrate of alumina mixed with meat. The dog was taken very sick in about two hours, and vomited just two hours and fifty minutes afterwards; he also vomited profusely during the night. At 4.30 the next day, ½ oz. (218 grains) of hydrate of alumina mixed with meat, was given the dog, but he ate only about one-half of it. He was taken very sick a short time afterwards, vomiting, and showing great weakness and restlessness. He would not eat any more after that day. It may be well to state here that hydrate of alumina is almost tasteless, and it was, for this reason, the dogs ate it as well as they did when mixed with meat. To two other dogs hydrate of alumina was given only once, and in each case the dogs were made sick, and vomited.

To dog No. IX. was given phosphate of alumina mixed with meat. The following is a description of the animal:

Breed—Mongrel.
Age—4 years.
Health—Perfect.
Food—Bread.
Color—Black and white.
Weight—20 lbs.

On September 18th, in the morning, 3 oz. of precipitated phosphate of alumina (containing 75 per cent. of water, dried between blotting paper) was mixed with meat, and given to the dog. This was eaten during the day, but the dog did not vomit, although he was evidently quite sick. The next morning, 2 oz. more of the precipitated phosphate of alumina mixed with meat was given him, which was all eaten, and although the dog did not vomit, he was quite sick, showing less life than usual, and his eye not being as bright.

From this last experiment, it was clearly shown that the alumina in biscuits made with an alum baking powder, must be, to a very great extent, in the condition of hydrate of alumina—as the phosphate, although causing the animal to feel unwell, did not make him vomit. In every case, as has been stated before, when biscuits given to a dog, were made with less than seven times the quantity of alum baking powder usually employed, the dog vomited profusely, and was made very sick, trembling in his knees; and this was the case when hydrate of alumina was given, even in such small quantities as one-eighth of an ounce, or 54½ grains. Experiments were then made to see if the action of hydrate of alumina in any way differed from the action of alum itself. The following is a description of the dogs employed:

	XIII.	XIV.
Breed........	Terrier.	Terrier.
Age..................	2 years.	2 years.
Health................	Perfect.	Perfect.
Food.................	Bread.	Bread.
Color..................	Black and tan.	Tan.
Weight..............	10 lbs.	20 lbs.

To dog No. XIII. was given 2 oz. of burnt potash alum mixed with meat, at 8.15 in the morning. The dog ate only the meat, leaving the alum untouched, with the exception of what adhered to the meat, which was much less than one-quarter of an ounce. At 9.30 he was very sick, trembling in his limbs, losing all vim and brightness of eye, and vomiting. At 9.45 he vomited again. The next day some fresh meat was mixed in with the alum; when he ate part of the meat he was made very sick again, and vomited considerably. He would not eat any more after this.

To dog No. XIV. 1 oz. of ammonia alum was mixed with meat, and fed. At 8.15 only about ⅛ oz. was eaten. A 9.45 he was made very sick, the same as dog XIII., and vomited; he vomited again at 9.45 and again at 9.55, and he was a very sick dog, showing no inclination to eat or play; his brightness of eye had entirely disappeared. To two other dogs alum was given, with the same results. From these experiments it will be clearly seen that hydrate of alumina acts in the same manner as alum, causing the animal to vomit profusely, showing great weakness in the limbs, and loss of ambition.

The next experiments were conducted to ascertain what effect the presence of alum, hydrate of alumina, phosphate of alumina, and basic sulphate of alumina, had on the solvent power of the gastric juice. It was necessary, therefore, to procure some gastric juice for experiment. I therefore sent several dogs to Prof. J. W. S. Arnold, who inserted a canula in each of them. When the dogs were in a perfectly healthy condition, Prof. Arnold sent me some gastric juice, which was produced by tickling the lining of the stomachs of the dogs with a feather or glass rod, which caused the gastric juice to flow out of the fistula into a receptacle placed underneath the dog to receive it. This and other methods were used to excite the flow of the secretion.

In conducting the experiments with the gastric juice, I was greatly assisted by the friendly services of Prof. Robert Schedler. Four samples of gastric juice were received. The following are the experiments conducted with the same.

Sample No. 1.—Obtained by irritating the lining of the stomach with a glass tube; pure and free from food. The acid was determined in this sample, and found to be 0.13388 hydrochloric acid.

Sample No. 2.—Boiled ox heart was fed to the dog, which caused a flow of gastric juice, which was afterward drawn off. The acid in this sample was only 0.006083 hydrochloric acid.

Sample No. 3.—In three grms of this juice the acid was determined and found to be 0.21268 hydrochloric acid.

Experiments were then made with this sample, as follows:

To three grms of juice was added .0403 grm of fibrine,* and the mixture kept at a temperature of 95–100° F., for half an hour, when all the fibrine was dissolved.

To three grms more of the juice wsa added 0.5 grm of hydrate of alumina (precipitated and dried between blotting paper), and then 0.0403 grm of fibrine was added. The mixture was stirred and kept at the temperature of 95–100° F. for two hours, and from 70–80° F. for twenty-three hours. Digestion of the fibrine took place at the start, but was soon arrested, only one-quarter of the fibrine being dissolved.

To three grms more of the juice was added .500 grm of alum, and .0403 grm of fibrine, and this was treated the same as in the last experiment. In this case about three-quarters of the fibrine was dis-

* The fibrine was prepared by Prof. Arnold, from the blood of a dog.

solved at the start, and then further digestion was entirely checked, although it remained in contact twenty-three hours.

These three experiments are very valuable, as fibrine is so readily dissolved. They show that both aluminic hydrate and alum can check the digestion of such an easily digested substance as fibrine. They show, therefore, how dangerous it is to introduce these two salts into our stomachs, if we do not wish to excite indigestion and dyspepsia.

Three experiments were then conducted with prepared boiled white of egg. To three grms of gastric juice was added .25 grm of albumen, and the juice was kept at 95–100° for two hours, when half of the egg was dissolved. Three more grms of the juice were then added, when in two hours all the egg was dissolved. This showed that 100 grms of gastric juice would dissolve 4.16 grms of albumen. Lehmann claims it will dissolve 5 grms, and Schmidt 3.95 grms, although the latter authority states it may dissolve more.

To three grms more of gastric juice was added .25 grm precipitated hydrate of alumina (really only .031 grm $Al_2O_3.3H_2O$), and then .25 grm albumen; the mixture was kept at the temperature of 95–100° F. for two hours, and in contact fifteen hours, and not a particle of the egg was dissolved.

To three grms more of the same juice was added .25 grm of alum, and then .25 grm of albumen, and this was likewise treated; but after fifteen hours contact not a particle of the albumen was dissolved. These experiments were duplicated.

The albumen used in the experiments was the boiled white of egg; it was first macerated in a mortar with pure water, then dipped in a solution of 1 drop of hydrochloric acid to 2,400 drops of water; it was afterwards macerated again in the mortar with pure water, then dried between filter paper, and weighed.

The three first experiments demonstrate that both hydrate of alumina and alum check the digestive properties of the gastric juice, and render it incapable of digesting even the most digestible substances; and the last three experiments demonstrate that the digestive power of the gastric juice is entirely destroyed by hydrate of alumina and alum, so far as dissolving the more indigestible substances, such as the boiled white of egg.

Experiments were next made with phospate of alumina, and basic sulphate of alumina.

To three grms of a fresh sample of gastric juice, were added 0.1 grm of phosphate of alumina and 0.1 grm of boiled white of egg.

To three grms more of the gastric juice, were added 0.1 grm of phosphate of alumina and 0.1 grm of boiled white of egg.

These two mixtures were kept between 95–100° F. for two hours, and in contact twenty-four hours, and not a particle of the albumen was dissolved in either case. These experiments were duplicated with fresh gastric juice from another dog, with the same results. These experiments show that all alumina salts interfere with the powers of digestion, having the property of rendering the pepsin inactive.

My next experiments were to ascertain whether alumina could be found in the various organs of the body, if a dog was fed with hydrate of alumina. I therefore secured a dog from Prof. Arnold, of which the following is a description:

Breed—Terrier.
Color—Black and tan.
Age—1½ years.
Weight—20 lbs.

This dog had a gastric fistula, through which the hydrate of alumina suspended in a water solution, was introduced direct into the stomach, by means of an ordinary syringe.

On the 21st of October, at 8.30 A. M., 5 oz. of precipitated hydrate of alumina and 2 oz. of meat, were mixed together, and given to the dog. He ate only one-third of the mixture; at 11.35 his bowels were very loose, and at 12.40 he vomited; at 12.55 he vomited profusely again, the meat coming up undigested.

At 5 P. M., one-twentieth of an ounce of hydrate of alumina, suspended in solution, was injected directly into the stomach. The dog vomited during the night. The next morning, at 9.25 A. M., one ounce of hydrate of alumina was injected into the stomach, and the dog was given meat to eat. He vomited at 1.30 P. M., and was very constipated; vomited at 2 P. M., and again at 2.15 P. M. At 3 o'clock, one ounce more of the hydrate of alumina was injected; at 5 P. M. he vomited; he also vomited during the night, and was very constipated. At 8.45 the next morning, about one ounce more of the hydrate of alumina was injected; he vomited at 11.45, and again at 12.55. At 4.55 P. M., one-quarter ounce more of hydrate was injected, the dog vomiting during the night. The dog now was so completely under the influence of the hydrate of alumina, that I fully believe he would have died if any more alumina was injected. He was a very sick dog, trembling in his knees when he stood up, and wanting all ambition and vim. His eye was dull, all the brightness had departed. On the next morning, at 8 o'clock, I killed the dog, collected some of his blood, and took his liver for analysis. I separated from the blood, by analysis, a considerable quantity of alumina, as also from the liver. The silica and phosphate of lime were first removed before the alumina was precipitated.

My next experiment was on a black and tan dog in Prof. Arnold's laboratory. I supplied Prof. Arnold with freshly precipitated hydrate of alumina, and he fed the animal with 12 oz. of the same during four days, when the dog was killed. I received the kidney, heart and blood, for analysis, from all of which I separated out alumina in large quantities. Professor Arnold examined the intestinal canal, finding the upper portion of the *duodenum* much inflamed, and also analyzed the spleen and liver, proving there the presence of alumina.

The next dog experimented on was also a black and tan. To this dog Prof. Arnold fed 5 oz. precipitated phosphate of alumina (containing 75 per cent. of water), mixed with meat. On killing the dog, I took the spleen and liver for analysis, and separated out large quantities of alumina from them. Prof. Arnold examined the stomach, which he found congested, and also analyzed the heart, finding alumina.

It has never been asserted by me that a person eating one biscuit made with an alum baking powder, would suffer from the alumina salts present in it; but it is certain that persons continually eating biscuits made with an alum powder will suffer from its poisonous effects, as the alumina salts, instead of passing out of the system, accumulate in the various organs, interfering with their proper functions. The following experiment will show the amount of alum necessarily present in well-baked biscuits.

Sifted flour taken (1 quart)	$15\frac{1}{2}$ oz.
Alum baking powder (2 teaspoons)	$\frac{5}{8}$ oz.
Lard	$1\frac{1}{4}$ oz.
Milk	$10\frac{3}{4}$ oz.
Weight of dough	$28\frac{1}{8}$ oz.
Weight of (hot) biscuit	$24\frac{1}{4}$ oz.
Loss in baking	$3\frac{7}{8}$ oz.
Weight of biscuit (cold)	$23\frac{1}{8}$ oz.
Loss on cooling	$1\frac{1}{8}$ oz.

The baking took 15 minutes. The biscuits were heavy.

Another experiment was conducted, using three teaspoons of an alum baking powder. The biscuits were quite light, showing that three teaspoons of the powder are necessary.

2 teaspoons of alum powder weighed	234 grains.
3 " " " "	351 "

The baking powder contained about 30 per cent. of burnt alum.

Therefore, there was introduced into 24¼ oz. of biscuit, 105.3 grains of burnt alum, or what is equivalent to 194.21 grains of common alum; and, as one biscuit would contain 3 grains of hydrate of alumina, a person eating four of these biscuits at a meal, would therefore introduce into his stomach 12 grains of hydrate of alumina.

IV.—Analyses of the Ashes of Certain Weeds.

By F. P. Dunnington.

With a view of obtaining some knowledge of the extent to which certain soils contain available, inorganic plant-food, I have undertaken, in the following analysis, to ascertain the comparative demands made by certain wide-spread and abundant weeds, for the main constituents of plant ashes, though, also, determining other constituents which have little bearing on the solution of this problem.

These plants were gathered just previous to flowering, each from a locality in which they were growing quite abundantly,* taking as a sample the whole previous growth of the season. Not having taken any special precautions to exclude the fine, clay dust of this locality, a small amount of alumina, iron, manganese and silica, is, no doubt, to be thus accounted for. Since some weeds are known in different localities by so different names, I give, also, the botanical names. The plants selected were the following:

1. Broom sedge (*Andropogon scoparius*), beard grass.
2. Wire grass (*Eleusine Indica*), dog's-tail grass.
3. Blue thistle (*Echium vulgare*), blue devils.
4. Potato-weed (*Solanum Carolinense*), horse nettle.
5. Purslane (*Portulaca oleracea*), pot-herb portulaca.
6. Sumach (*Rhus glabra*), common sumach.
7. Sassafras (*Sassafras officinale*).
8. Rag-weed (*Ambrosia artemesiæfolia*), bitter-weed.
9. Mullein (*Verbascum thapsus*), common mullein.
10. Dock (*Rumex obtusifolius*), broad-leaved dock.

The method adopted in these analyses was, with some few exceptions, uniform. The recently gathered plants were weighed, then allowed to slowly dry, at the common temperature, protected from dust, and re-weighed; of this, a weighed portion was heated to 110° C. until it ceased to lose weight, to determine moisture. From

* Blue thistle in flower, and not from a full patch.