THE EFFECT OF ALUM

UPON THE HUMAN SYSTEM,

WHEN USED IN

BAKING POWDERS.

ELABORATE EXPERIMENTS UPON LIVING ANIMALS.

RESEARCHES MADE BY

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SUPPLEMENTED BY REPORTS OF THE

EXPERIMENTS BY ALPH. DEVERGIE, M. ORFILA,
R. F. RUTTAN, M.D., ETC., ETC.

AND THE LATER

IMPORTANT INVESTIGATIONS OF PAUL SIEM.

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THE EFFECT OF ALUM BAKING POWDER, WHEN USED IN BREAD, UPON THE HUMAN SYSTEM

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Page 13. Before proceeding to a consideration of the effect of alum baking powders, the author thinks it advisable to briefly present the principal points so elaborately set forth in the following chapters. In the first chapter on the "Provings of Alum in Animals and Man," from the elaborate investigations of Devergie and Orfila, it is conclusively demonstrated that alum in its hydrated and anhydrous (or calcined) 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 follow.

It is the opinion of both Orfila and Devergie that if the stomach of man be not in a perfectly healthy condition the evil effects of alum, when taken internally, manifest themselves much sooner, as the alum acts more energetically.

The base of alum, that is to say alumina, may be detected in the liver, the spleen, and the urine.

Several cases of poisoning by the accidental use of alum are reported in the first chapter, some of which terminated fatally. The first case was of a Mrs. B., reported by Dr. Fournier, who took by mistake a swallow of about three teaspoons of a solution of 16 grammes of calcined alum dissolved in a litre of water. Scarcely had she drunk it when she pushed it away, "complaining of nausea, severe heat, tearing pains in all parts that had come in contact with the alum; the 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 unextinguishable." Under treatment of the physician she recovered in time. It must be remarked that Mrs. B. was an invalid, but it must also be remarked that the quantity of alum contained in the swallow of the solution she took was very small, demonstrating how powerfully active alum is in persons of weak constitutions.

The case of death reported by Dr. Ricquet is not without interest. In this case a Mr. V. M., wishing to purge himself, ordered some sulphate of magnesia, but, in mistake, alum was given him. On dis-

* Subsequently rewritten and enlarged by the author and republished as here given.

solving 30 grammes in water and drinking the same, he succumbed after horrible pains. "He felt a burning sensation in the mouth, throat, and stomach, followed by a single sanguineous vomiting. No stools, extreme uneasiness, then insupportable anguish, repeated lipothymies; intelligence and senses intact. Finally intermittent, filiform pulse; cold skin. The deglutition of liquid was almost impossible. He died eight hours after taking the remedy." 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 wilfully murdered her three-months-old child by administering to it about 0.9 gramme (fourteen grains) of alum. In the majority of other cases the alum was taken by mistake for other medical preparations. Von Hasselt states that cases of poisoning arise sometimes from the administration of too large doses of alum by order of the physician.

In the case cited by Dr. Ricquet, at the autopsy yellowish-gray deposits were found on the mucous membrane of the mouth, pharynx, and œsophagus; the tongue and palate were swollen; the stomach, intestines, and kidneys were hyperæmic, but without noticeable loss of substance. Chemical tests were repeatedly employed for the poison, continually demonstrating its presence. From the above recapitulation of the first chapter, it is conclusively shown that alum is a powerful poison, producing a series of disorders in the system when taken internally, and finally ending in the death of the victim.

It now becomes important to look into the effects of alum, when used in bread, upon the human system. To this part of the subject the second chapter (omitted from this reprint) has been devoted. To review all the expressions of opinion of the prominent authorities mentioned in this chapter is unnecessary. The conclusions they arrive at, as to the effect produced in the system by the continued use of alumed bread is, that such bread will produce headache, indigestion, flatulence, constipation, diarrhœa, dysentery, palpitation, and urinary calculi. Dumas says: "It is to be feared that this salt exerts a deadly action by its daily introduction into the stomach, especially in persons of a weak constitution." Dr. Ure says: "The habitual and daily introduction of a portion of alum into the human stomach, however small, must be prejudicial to the exercise of its functions, and particularly in persons of a bilious and costive habit. . . . Every precaution of science and law ought therefore to be employed to detect and stop such deleterious adulterations." Dr. Pereira says: "Whatever doubt may be entertained as to the ill effects of alum on the healthy stomach, none can exist as to its injurious influence in cases of dyspepsia." Lombard says: "There is no need of saying how much these different modes of falsification are injurious to the health, though they do not provoke fatal accidents."

Dr. Gibbon says: "Its use in the manufacture of bread is injurious to health, and concurs, indirectly with other things, in increasing the mortality, especially of young children, the staple article of whose dietary is bread. The fatal diarrhœa of infants under three years of age may also have arisen from or been aggravated by this cause."

Dr. Dauglish says: "Its effect on the system is that of a tropical

astringent on the surface of the alimentary canal, producing constipation and deranging the process of absorption. But its action in neutralizing the efficacy of the digestive solvents is by far the most important and unquestionable . . . and the consequence is that a large portion of the gluten and other valuable constituents of the flour are never properly dissolved, but pass through the alimentary canal without affording any nourishment whatever."

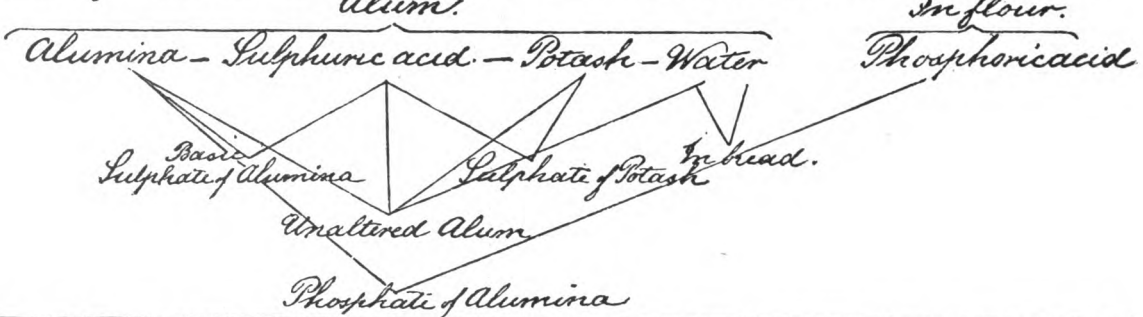
Meyer says: "Alum exerts, especially in continued use, very injurious (constipating) effects on the body, and exactly this method of adulteration is one of the most dangerous, being carried on very often in the most refined way." Dr. Parkes says: "Looking, then, to the positive evidence, and the reasonableness of the evidence, it seems to me extremely likely that strong alumed bread does produce the injurious effects ascribed to it." Benoit says: "The habitual introduction of alum into the stomach of man, however slight it may be, must necessarily trouble the exercise of the functions of this organ, particularly in persons of a bilious or feeble constitution and constipated by temperaments, and especially in individuals leading sedentary life. Such a fraud should, therefore, be severely repressed by the police."

It is a notable fact that, in the whole course of my research on this subject, I was unable to find one scientific man who recommended the use of alum in bread making. Such being the case, it is my opinion that any intelligent person cannot help but condemn such a fraud, especially as it is denounced by the leading scientific men of the world, such as Dumas, Chevalier, Ure, Benoit, Gibbon, Schlossberger, Parkes, Booth, Morfit, Pereira, Normandy, the late Baron Liebig, and many others.

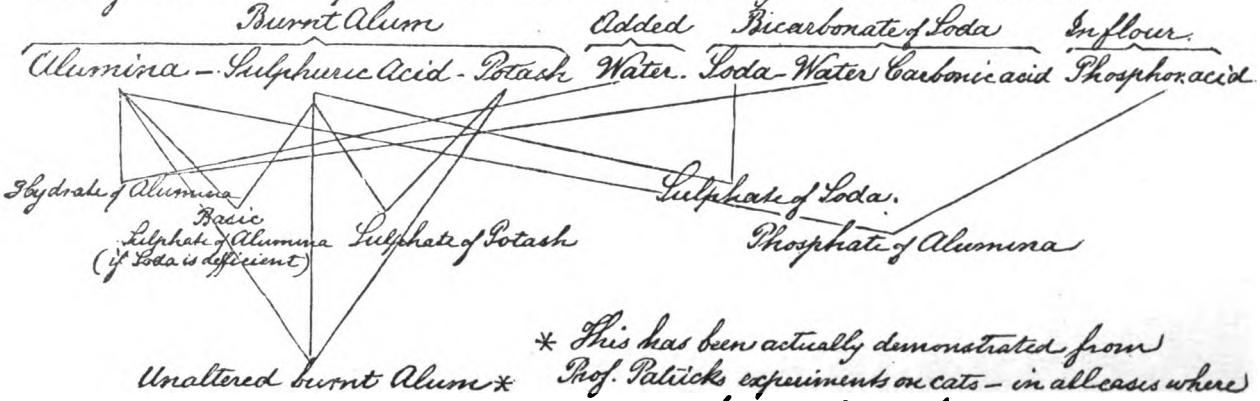
The introduction of alum as a substitute for cream of tartar in baking powders is a recent fraud on the public, and, strange to say, has been upheld by a few scientific men who, it would be supposed, in the face of losing a large fee, would condemn its introduction in the strongest possible terms, but unfortunately, for lack of time to properly investigate the subject, or tempted by the fee, have been influenced away from the proper line of action, which should be, not to see how near it is possible to poison a man and not do it, but rather how far it is possible to keep from poisoning him.

When alum is used alone in bread, it is partly decomposed into phosphate of alumina and basic sulphate of alumina; this change is brought about by the soluble phosphates of the flour; there is also some unaltered alum left in the bread. In an *alum baking powder*, another 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 to 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 in the bread. This was clearly demonstrated by Professor Morton in his experiments. He found, by steeping a biscuit made with alum baking powder in water, that such water, when filtered, evaporated to dryness and ignited, and the residue dissolved in hydrochloric acid, and again evaporated, and then

Changes which take place when Alum is used alone in Bread.



Changes which take place when an Alum Baking Powder is used in Bread.



* This has been actually demonstrated from Prof. Pattick's experiments on cats – in all cases where an excess of water is not first used. .

dissolved a second time, did contain a small quantity of alumina after the phosphate of lime had been separated out. I have found the same thing myself any number of times. This experiment shows the presence of alum, as this is the only alumina salt present in the biscuit which could be soluble in water.

From this it will be seen that just the same alumina salts are present in the baked products, when an alum baking powder is used in baking, as when alum is used alone, with the addition of a far more soluble salt hydrate of alumina, and this in large quantities. It, therefore, naturally follows as the simplest logical deduction, that, whatever has been said against the use of alum used alone in bread, applies with all the more force to an alum baking powder. Because of the decomposition of the alum by the bicarbonate of soda, some scientific men have been induced to say "there was no alum in the baked product in which the powder was used," thus leading the public to believe by a trick in wording that the elements which compose the alum are driven off in the process of baking, while the truth of the matter is that every element which composes the alum remains in the baked product, which, if eaten, enter the stomach and are absorbed by the blood, acting the same as alum.

This is not only my opinion, but it is the opinion of the leading scientific men of this country, such as Chandler, Barker, Johnson, Hays, Willard Parker, Alonzo Clark, Wm. A. Hammond, Ryland T. Brown, J. A. McCorkle and J. H. Raymond, of the Brooklyn Board of Health, and many others.

THE EXPERIMENTS ON DOGS

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 thorough scientific investigation of the subject can lead to no other conclusion. Still, as Professor Patrick, of Missouri, conducted some elementary experiments on cats to sustain his position in stating that alum baking powders are not injurious to health, and as such experiments were interpreted by him favorably —although I hope to show, and am quite positive I will, that his experiments are most detrimental to his views, and most favorable to the side which condemns the use of alum baking powders—I thought it advisable, in search of the truth, to conduct an exhaustive series of experiments on dogs, believing that such an investigation would meet with the approbation of the public.

It was with difficulty I found a suitable place to conduct the experiments so that the animals would not disturb the neighborhood; but 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 of dog—Coach.	Food of dog—Bread and crackers.
Age of dog—1 year.	Color of dog—Spotted black and white.
Health of dog—Perfect.	Weight of dog—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 ounces—time of baking, 20 minutes.

At half-past eleven, just three hours and twenty minutes, 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 a 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.	Food—Crackers.
Age—Nine years.	Color—Brindle.
Health—Perfect.	Weight—30 lbs.

At 8.15 on September 9th, 8 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;
1⅞ 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 of dog	Cur	Spitz Cur	Shepherd.
Age of dog	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, were 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 of dog	Mongrel	Mongrel	Terrier.
Age of dog	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.
Time of baking 20 minutes.
26 small biscuits. Weight, 27 oz.

The biscuits given to dog No. IX 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 did not eat 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 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 were 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 oz. 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 oz. of precipitated hy-

drate of alumina (54½ grains $Al_2 O_3$. 3 H_2 O) 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 grains) 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 ($Al_2 O_3$. 3 H_2 O) 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 of dog—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 were given to a dog made with less than 7 times the quantity of an 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 ⅛th 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:

	No. XIII	No. XIV
Breed	Terrier	Terrier.
Age	2 years	2 years.
Health	Perfect	Perfect.
Food	Bread	Bread.
Color	Black and tan	Tan.
Weight	20 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 ¼ of an ounce. At 9.30 he was very sick, trembling in his limbs, losing all vim and brightness of eye, and vomited. 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. At 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 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 clearly be seen that hydrate of alumina acts in the same manner as alum, causing the animal to vomit profusely, show great weakness in the limbs, and loss of ambition.

The next experiments conducted were 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 Professor J. W. S. Arnold, who inserted a canula in each of them. When the dogs were in a perfectly healthy condition, Professor Arnold sent me some gastric juice, which was produced by tickling the lining of the stomach 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 Professor 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 deter-

mined in this sample, and found to be per cent. 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 per cent. hydrochloric acid.

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

Experiments were then made with this sample as follows:

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

To three grammes more of the juice were added 0.5 gramme of hydrate of alumina (precipitated and dried between blotting paper), and then 0.0403 gramme of fibrine was added. The mixture was stirred and kept at the temperature of 95-100° F. for two hours, and of 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 grammes more of the juice were added .500 gramme of alum, and then .0403 gramme of fibrine, and this was treated the same as in the last experiment. In this case about three-quarters of the fibrine was dissolved 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 grammes of gastric juice was added .25 gramme of albumen, and the juice was kept at 95-100° for two hours, when half of the egg was dissolved. Three grammes more of juice were then added, when in two hours all the egg was dissolved. This showed that 100 grammes of gastric juice would dissolve 4.16 grammes of albumen. Lehmann claims it will dissolve 5 grammes, and Schmidt 3.95 grammes, although the latter authority states it may dissolve more.

To three grammes more of gastric juice were added .25 gramme of precipitated hydrate of alumina (really only .031 gramme $Al_2O_3.3H_2O$), and then .25 gramme 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 grammes more of the same juice were added .25 gramme of alum, and then .25 gramme 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 2400 drops of water; it was

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

afterwards macerated again in the mortar with pure water, then dried between filter paper and weighed.

The first three experiments demonstrate beyond a shadow of a doubt 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.

The alumina renders the pepsin entirely inactive, by combining with it as organic matter and probably converting it into a species of leather, and in the stomach the lining membrane and cells are probably thus affected, and thereby destroyed or rendered incapable of performing their normal functions.

Experiments were next made with phosphate of alumina and basic sulphate of alumina.

To three grammes of a fresh sample of gastric juice were added 0.1 gramme of precipitated hydrate of alumina and 0.1 gramme of boiled white of egg.

To three grammes more of the gastric juice were added 0.1 gramme of precipitated hydrate of alumina and 0.1 gramme of boiled white of egg.

These two mixtures were kept between 95° F. and 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. They 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 Professor Arnold, of which the following is a description:

Breed of dog—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. $\frac{1}{20}$ 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., ¼ 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 Professor Arnold's laboratory. I supplied Professor Arnold with freshly precipitated hydrate of alumina, and he fed the animal with the same for four days, when the dog was killed. I received the kidney, heart and blood for analysis, in all of which I separated out alumina in large quantities. Professor Arnold examined the stomach and intestinal canal, and also analyzed the spleen and liver. His report is given below.

The next dog experimented on was also a black and tan. To this dog Professor Arnold fed 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. Professor Arnold examined the stomach, etc., and also analyzed the heart.

Report of Prof. J. W. S. Arnold:

UNIVERSITY OF THE CITY OF NEW YORK,
MEDICAL DEPARTMENT, 410 EAST TWENTY-SIXTH ST.,
NEW YORK, Dec. 12, 1879.

This is to certify that I have supplied Dr. Henry A. Mott with a number of samples of gastric juice from the dog, the juice being pure and in the normal condition.

I have also made a number of gastric fistulæ in dogs: some of the animals I delivered to Dr. Mott, from others I obtained the juice with which I supplied him.

I fed a dog upon meat mixed with precipitated hydrate of alumina (containing much water); the amount of this hydrate of alumina given the dog was twelve ounces. I killed the animal, and examined the viscera. The duodenum was highly inflamed in its upper portion. The spleen and liver, upon analysis, showed the presence of a considerable quantity of alumina. The heart, kidneys, and samples of the blood from the animal were given to Dr. Mott for analysis.

I fed another dog with precipitated phosphate of alumina (containing much water), mixed with meat, to the amount of five ounces of this phosphate of alumina. Upon killing the animal, both the stomach and duodenum were found very much congested. Upon testing, the heart showed the presence of considerable alumina in its tissues.

Dr. Mott received portions of liver and spleen for analysis.

I also prepared microscopical slides of a dog's stomach in a healthy condition, and of the stomach of the dog fed with precipitated phosphate of alumina in a congested condition. These I sent to Dr. Mott.

J. W. S. ARNOLD, A.M., M.D.,
Prof. Physiology and Histology, Med. Dep't University of N. Y.

From these elaborate experiments it will be seen that both hydrate of alumina and phosphate of alumina are very injurious substances to introduce into the stomach, as these are sure to produce acute inflammation.

It may be advisable to say a few words with respect to some experiments conducted by Prof. Patrick, of Kansas, on cats, with an alum baking powder.

Some biscuits were made with 3 teaspoons of an alum baking powder to 1 pint of flour, equal to six teaspoons to one quart of flour; 6 biscuits were baked in a batch, and from 1 to 1½ were fed to a cat. After digestion had gone on a certain length of time (from 20 minutes to 2½ hours), varying in the different subjects, the cat was killed, and the entire contents, not only of the stomach, but of the small intestines also, were examined for dissolved alumina. The mass was digested in water, filtered, evaporated, and ignited to destroy organic matter; extracting with strong acids, filtering, and finally adding ammonia hydrate. "In every case," says Prof. Patrick, "a large amount of sodium sulphate was found (in solution as was expected), and also a certain amount of hydrate of alumina undissolved." What the Professor means by "a certain amount of hydrate of alumina undissolved," it is difficult to ascertain. Surely if it was undissolved he might have dissolved it by the aid of a little heat and a little more acid.

The truth of the matter is, if the *filtered* solution contained any alumina, it was combined with the organic matter. On ignition, the alumina would be rendered insoluble. If not insoluble, where did the insoluble alumina obtained come from?

Perhaps he obtained it on the filter. This would clearly show that it was still in the stomach, not having been as yet absorbed. If this was not the case, and no alumina was found in solution in the digestive fluids, then the alumina must have been absorbed into the system, for it certainly entered the stomach through the biscuits.

Prof. Patrick further states: "Now if bread is carelessly mixed with an insufficient amount of water, part of the flour (and with it the powder) remains nearly or quite dry; and after baking, such bread would contain a certain small amount of alum." This is certainly a very fair admission. We all know that bread is very carelessly mixed at times, as there are few who make good bread. Patrick's experiments actually prove this to be the case. He says: "To insure the entire absence of alum in the bread, the mixing must be done with plenty of water; and to effect this I would suggest (although I do not consider it an absolute necessity) that the batter, with the powder added, be made rather thin at first, and then thickened by addition of more flour without powder." In other words, Prof. Patrick would upset the whole system of bread-making so as to insure the use of an alum baking powder with safety (!).

It is certain a few intelligent cooks might be persuaded to adopt this new method, but the majority could not be persuaded to do so; or if they did, they would only do so once or twice, and then fall back in their old ways, which would result in having alum in the bread.

I think we can safely discard Prof. Patrick's experiments as proving anything in favor of alum baking powders, for in my opinion they only strengthen the view I have always taken, and which my elaborate experiments have conclusively demonstrated, that alum baking powders are most injurious to health.

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.

It must not be inferred from what has just been said that the amount of alumina salts present in a biscuit is so very small. The following experiment will throw some light on this subject:

Sifted flour taken (1 quart)	15½ oz.
Alum baking powder (2 teaspoons)	⅝ oz.
Lard	1¼ oz.
Milk	10¾ oz.
Weight of dough	28⅓ oz.
Weight of (hot) biscuit	24¼ oz.
Loss in baking	3⅞ oz.
Weight of biscuit (cold)	23⅛ oz.
Loss on cooling	1⅛ oz.

The baking took 15 minutes. The biscuits were heavy. Another experiment was conducted, using 3 teaspoons of an alum baking powder. The biscuits produced 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.

1 lb. of biscuits contained alumina salts, if calculated as common alum (when 3 teaspoons of an alum powder is used), equivalent to 163 grains.

If the alumina in biscuit be calculated as hydrate of alumina, then one pound of biscuit would contain over 54 grains.

One biscuit would contain 3 grains of hydrate of alumina. A person would eat about four of these biscuits at a meal, and would therefore introduce into his stomach 12 grains of hydrate of alumina.

THE ACTION OF ALUMINIUM AND BERYLLIUM ON THE ANIMAL ORGANISM

BY

PAUL SIEM

University Dorpat, 1886. Reported by R. Kobert, Schmidt's Jahrbucher d. gesammt. Med., Vol. CCXI. 1886.

ALUMINIUM

Page 128. Actual pharmacological experiments on aluminium have not been made heretofore. A few statements, made by Orfila (1843), Mitscherlich (1840), Taylor (1863), Hasselt (1862) and Ricquet (1873), show that large doses of alum induced gastro-enteritis with fatal results in man and animals. Siem undertook the study of this heretofore so little known metal under the direction of Hans Meyer.

On account of the reasons given by the students of Schmiedeberg, he employed the organic double salts of the metal. The double sodium salts with tartaric and citric acid employed in the first experiments were prepared in the following way: Sulphate of aluminium was dissolved in distilled water and precipitated with ammonium, and aluminium hydrate was collected on a filter and washed with boiling water until all traces of sulphuric acid disappeared. The pure aluminium hydrate was dissolved in the least possible amount of concentrated tartaric or citric acid, filtered and neutralized with sodium hydrate.

The clear solution has a light yellow color, does not coagulate blood serum and contains 2 per cent. of the oxide of aluminium.

The slight solubility of aluminium hydrate in these acids necessitates very large amounts of tartaric and citric acid (about 30 per cent. of the sodium salt). It had already been shown by Kobert that these salts have an effect on frogs and consequently they would not be suitable for the experiments.

Steinfeld has shown that large doses of the tartarate and citrate of sodium (from .2 to .5 gramme) cause in frogs after a short time nerve and muscle paralysis, followed by death. Meyer has also shown that smaller amounts of these salts cause disturbances in control animals.

In consequence of the unsuitability of these compounds for experi-

ments on frogs, Siem prepared a double lactate. By preliminary experiments with the lactate of sodium it was shown that doses of from .05 to .1 gramme of this salt have no effect upon frogs, with the exception of a local irritation following the injection and lasting only from one to two minutes.

With still larger doses (from .3 to .4 gramme) there resulted, within one hour after the injection, a numbness of the animals, so that when placed on their backs, they remained in this position for a long time. However, there was no fabrillar tremor of the skeleton muscles observable after the lactate of sodium, as had been the case with the use of the tartarate and citrate. In about half the animals treated with these large doses, death resulted after a few hours from general paralysis; the other half of the animals recovered quickly and on the following day seemed to be perfectly normal.

Meyer succeeded in preparing a beautifully crystalline double lactate of the following composition:

$$Al_2 \begin{matrix}(C_3\,H_5\,O_3)_3 \\ (C_3\,H_4\,Na\,O_3)_3\end{matrix}$$

This salt is prepared by treating carbonate of barium with an excess of lactic acid. The neutral filtrate, consisting of barium lactate, is precipitated with sulphate of aluminium. On concentrating the acid filtrate the lactate of aluminium crystallizes. These crystals are dissolved in sodium hydrate, exactly neutralized and concentrated to crystallization. The crystals dried over sulphuric acid contain 15.2 of $Al_2\,O_3$.

All the experiments on frogs were made with this crystalline preparation, and the dose is figured on the amount of the oxide of aluminium.

The experiments show that both kinds of frogs (rana esculenta and temporaria) are affected in the same manner by aluminium. For animals of medium size doses of from .02 to .03 of a gramme of the oxide of aluminium caused death in within 10 to 24 hours. In a few cases death did not result until after some days.

The general effects may be described in brief as follows: Immediately after injection the animal becomes very restless. It stretches out its hind legs, but after a few minutes it becomes quiet. In the course of the next 4 to 6 hours, as a rule, there is nothing especially observable in the behavior of the animal, except that it remains motionless for hours at a time, but when touched it jumps like a normal animal. Gradually, however, movements become slower. The frog stretches itself out and lies flat on its abdomen with closed eyes; but when placed on its back at this stage, it speedily regains its normal position. Irritation of the skin at this time with acetic acid is followed only by feeble reflex movements or is wholly without effect. However, irritation of the cord with an induced current causes powerful tetanus of the posterior extremities. A few hours later, if the animal be placed upon its back, it remains in this position. The reflex excitability is speedily lost and injections of strychnine are without effect. The respiration is wholly absent or very infrequent and irregular, but the heart beats powerfully and rhythmically. Even at this stage, irritation with an induced current causes severe

tetanus of the posterior extremities. In a few instances this does not happen, but the peripheral nerves and muscles still respond, and, in fact, this continues to be the case several hours after death. Gradually the heart increases in frequency and energy and finally it stops in diastole; after it has stopped, tactile irritation will still cause a few contractions.

The action of the auricles ordinarily continues for some hours after the ventricles have stopped.

From these phenomena, it is evident we have to do with a general paralysis of the central nervous system, which is due to the direct paralytic action of the aluminium on the ganglia of the brain and cord. Even when there is complete loss of reflex excitability the heart remains unchanged and the muscles and peripheral nerves are normally excitable.

The organs of circulation are not affected by aluminium and the heart is the last to die.

From the fact that atropine is without action on the heart arrested in diastole, while mechanical irritation still causes marked contraction, it is concluded that there is paralysis of heart ganglia, while the heart muscles themselves are not affected.

The experiments on warm-blooded animals were made with cats, dogs and rabbits.

There is no marked difference in susceptibility to the poison among these animals. From a large series of experiments the fatal doses per kilogram of body weight are found to be as follow:

For rabbits, about .3 gramme of $Al_2 O_3$.
For dogs, about .25 gramme.
For cats, from .25 to .28 gramme.

These averages were obtained from those experiments in which small doses were used in the beginning and gradually increased in the course of from two to three weeks. On the other hand, if larger doses were given in the beginning, or if a single large dose was given, the fatal average is smaller, and is for cats about .15 gramme per kilogram. Before detailing these experiments it may be remarked that with mammals the double tartarate was invariably used, because the tartarate of sodium is without effect upon these animals. In most of the experiments the aluminium was administered by subcutaneous injection.

During the first days, in cases in which the experiments were continued from 3 to 4 weeks, the animals showed no abnormality. The initial symptoms of the action of the poison generally appear from the third to the fifth day and were referable to the digestive organs. In some instances these disturbances were so great as to lead to complete refusal of food. Constipation was obstinate, so that in some cases within a space of five days there would be only one defecation. The small stool passed was very hard and of dark color. In many instances just before death diarrhœa appeared. The discharges were thin, watery and contained bits of undigested food.

Simultaneously with the above-mentioned phenomena, there was marked emaciation of the muscles of the skeleton and a rapidly progressive general emaciation. This sometimes continued until the

animal was a mere skeleton. The emaciation is especially marked in dogs.

In connection with these disturbances of the digestive organs there were also evidences of psychic depression. The animals sit in their cages without observing their surroundings, and when compelled to move, their movements are uncertain and apparently performed with difficulty.

Generally after this condition has continued for a few days, there is repeated vomiting of mucous substances colored with bile. The apathy increases; the animals remain for a few hours at a time motionless, in sitting posture with drooping heads. When the animals are compelled to stand and made to move they show a peculiar condition. When a leg is raised to step the extended extremity shows marked tremor. Finally the tremulous foot reaches the floor and the animal moves forward and sideways. In other cases, especially in dogs, there was noticeable a general weakness and incomplete paralysis of the posterior extremities.

Frequently there was a general tremor or convulsive movement noticeable in the head or in the extremities. Gradually, there seems to be a complete loss of sensation. The sensorium is even in this stage tolerably free, for the animals attempt to reach the dishes of milk placed near them. On doing so, they are able to bring their mouth in contact with the fluid, but apparently unable to lap it. The tongue lies motionless on the floor of the mouth or shows occasional fibrillar twitchings. Pieces of meat carried behind the tongue may be swallowed. In artificial feeding by means of a tube, it was evident in some cases that there was a complete anæsthesia of the gums and of the posterior pharyngeal wall. Usually there is marked salivation. The animal sits with drooping under jaw, from which the saliva flows, because he is not able to swallow it. Sometimes the saliva is bloody. In these cases small ulcers will be found in the mouth.

At the end of the third or the beginning of the fourth week the weakness of the animal reaches its maximum. The animal lies on its side in a soporific condition, and is able to manifest only the slightest movements. The temperature gradually sinks under the normal, and in one it was as low as 32 degrees (C.).

Generally death comes on without marked disturbances, while in other cases there are marked disturbances of respiration. The respiratory movements are shallow and irregular and râles are heard; in consequence of this, death in these cases is often accompanied or preceded by clonic convulsions.

The amount of the urine during the whole of the time of the experiment is small; albumin is not constantly present.

In animals poisoned with a single large dose, the first symptoms appear within from 5 to 10 hours after the injection. The general picture of the poisoning is analogous to that already described.

Under the pathological anatomical changes found we may mention the following: The mucous membrane of the stomach and small intestines in all cases show slight hyperæmia and swelling. This condition, however, never reaches that of a powerful toxic gastro-enteritis such as is produced in poisoning with beryllium. Small ulcers are found here and there, especially in the mucous membrane of the stomach. The large intestine shows no marked abnormality. The

kidneys are unusually rich in blood and intensely red; in some cases the cortical substance was markedly fatty, of yellowish color and showed some pin-head blood extravasations. The liver is also very dark red. The substance in the liver is soft.

Pieces of the liver and of the kidneys were placed in osmic acid (1 per cent.) and examined with a microscope on the following day.

All the liver cells showed uniform, finely granular fatty degeneration. There are also numerous dark points which seldom coalesce to form large drops. In fresh samples these spots are glistening. Fatty degeneration was found in the kidneys, but this is sometimes physiologically observed.

Pieces of the liver and of the kidneys which were placed in Mueller's fluid, then hardened in alcohol, showed in the kidneys distended vessels both in the cortex and in the parenchyma, but especially in the glomeruli. In the uriniferous tubules the ends of the tubuli contorti showed characteristic changes in the epithelium. These cells were glistening and swollen. The nuclei (even after staining with hematoxylin) were undiscernible. Inside the tubes were found hyaline balls or lumps, which apparently consist of epithelial cells. In other places the contents of the tubules consist of granular material. Some of the tubules contained hyaline cylinders, which filled the tubes. No changes could be found in the connective tissue.

From the above it is evident that aluminium causes a parenchymatous nephritis. The heart was always soft and filled with dark blood.

THE DIGESTIBILITY OF CERTAIN VARIETIES OF BREAD: AN EXPERIMENTAL STUDY OF THE ALUM QUESTION

BY

R. F. RUTTAN, B.A., M.D.

Transactions Royal Soc. Canada, 1887, Sec. 3.

Page 61. In the digestion of bread, all the three most important digestive juices of the body may take part, viz., the saliva, the gastric, and the pancreatic juices. The first being only amylolytic, acts solely on the starch; the second being only proteolytic, affects the fibrin and gluten; in tryptic digestion there is both an amylolytic and a proteolytic action. While all three stages of digestion have been studied, the relative digestibility of the different forms of bread has been studied chiefly with reference to salivary and tryptic digestion.

The experiments made may be arranged into three divisions, viz.:

A—Experiments on the digestion of breads made with different baking powders.

B—The influence of three baking powders on the digestion of known quantities of certain simple substances, such as starch, fibrin, and gluten.

C—The influence of alum and of some salts formed during the decomposition of baking powders on the digestion of starch, fibrin, etc.

A

The Relative Digestibility of Some Varieties of Bread

The following varieties of bread were used in these experiments: (1) Yeast bread, (2) Bread made with tartaric acid baking powder, (3) Bread made with a phosphate powder, (4) Bread made with two varieties of alum powder, (5) Unleavened bread, i. e., plain flour and water. The yeast bread, or the unleavened bread, was taken as a standard, all the experiments being strictly comparative. In each series the same flour, used to prepare the bread made with the baking powders, was employed to make the standard bread. In each case, also, the directions given for the use of the powder were strictly followed and the loaves were made as nearly as possible of the same size.

Method.—In every experiment, unless otherwise noted, two grammes of the crumb were taken. This quantity in a few cases includes the natural moisture of the bread, but usually it was dried at 100° C., and reduced to powder before weighing to eliminate the error of variation in moisture.

The digestions were all carried on in a carefully regulated incubator at a constant temperature of 40° C., and the relative digestibility of the breads was determined either by weighing the dried undigested residues after an hour or two, or by determining the quantity of dextrose formed by the amylolytic ferments under similar conditions. The ferments used were obtained as follows: A cold glycerine extract of pig's stomach yielded the pepsin, the trypsin was prepared from fresh dog's pancreas by the method recommended by Dr. Cranston Charles of St. Thomas Hospital,* and the ptyalin was from fresh mixed human saliva diluted to ten volumes and filtered.

SERIES I.—*The Digestibility of Breads made with Alum Baking Powder compared with that of Yeast Bread made from the same Flour. Peptic Digestion*

TABLE 1.—PEPTIC DIGESTION

	Residues.			Average Residue in grm.	Quantity digested in grm.	Proportion.
	a.	*b.*	*c.*			
Yeast Bread	·627	·592	·601	·606	·594	100·0
A. B. P. do.	·701	·686	·675	·688	·512	86·1

The influence of the baking powder salts on the proteolytic action of pepsin was tested by taking two grammes of the crumb of each bread with its natural moisture. To this, in a 70 c. c. beaker, were added 5 c. c. of the glycerine extract, and 45 c. c. of 0.25 p. c. solution of hydrochloric acid. The relative digestion was determined by weighing the undigested residue dried at 100° C., after two hours' digestion at 40° C. The residues *a*, *b*, and *c*, are results from breads made with different flour by different persons, using the same yeast and baking powder.

The breads were found to contain 40 p. c. of water, so the calculations are made for 1.2 grammes of dried bread.

TABLE 2.—PEPTIC DIGESTION

	Residues.			Average Residue in grm.	Quantity digested in grm.	Proportion.
	a.	*b.*	*c.*			
Yeast Bread.....	1·058	1·072	1·039	1·056	·944	100.0
A. B. P. do.....	1·321	1·337	1·364	1·340	·660	69·9

* Charles's Physiological and Pathological Chemistry, ed. 1885, p. 169.

Here two grammes of each bread were taken, after drying it to constant weight at 100° C., and reducing to fine powder. Other conditions were the same as Table 1.

SERIES II.—*The Digestibility of Breads made with Alum and other Baking Powders compared with that of Breads made with Yeast or of Plain Unleavened Bread. Pancreatic (Tryptic) Digestion*

Here, as in Series I, two grammes of bread were taken in each case, either dry or with natural moisture. To this 2 c. c. of the extract of pancreas above mentioned were added, and the whole made up to 50 c. c. with a 1 p. c. solution of sodium carbonate. The full action of the pancreatin was compared by weighing the dried residues, while the amylolytic action was determined by comparing the quantity of dextrine formed.

TABLE 1.—PANCREATIC DIGESTION

Average of two experiments.	Residue in grm.	Quantity digested in grm.	Proportion.
Yeast Bread	·25	·97	100·0
A. B. P. do.	·63	·57	58·7

Fresh breads were used in these experiments which at the time averaged the following quantities of water: Yeast bread, 39.1 p. c.; that with alum baking powder, 40 p. c. So the calculations in the above table are made from 1.22 grammes and 1.20 grammes respectively of dry bread.

TABLE 2.—PANCREATIC DIGESTION

Average of three experiments.	Residue in grm.	Quantity digested in grm.	Proportion.
Yeast Bread	1·093	·907	100·0
A. B. P. do.	1·506	·494	54·3

In the experiments of Table 2 the same conditions were maintained as in Table 1, but the two grammes of bread taken were dried at 100°, and reduced to powder before weighing. In each of the above sets of experiments (Tables 1 and 2), two hours' digestion was given, and the different breads, as in Series I, were baked by different persons, using the same yeast and baking powder.

TABLE 3.—PANCREATIC DIGESTION

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Residues.....	·943 grm.	·999 grm.	1·115 grm.	1·125 grm.
Relative digestion	100·000	94·300	69·000	67·000

The breads used in this set of experiments were: (*a*) plain flour and water baked (*O* in the table); (*b*) bread made with a pure tartaric acid baking powder containing tartaric acid, acid tartrate of potassium, bicarbonate of sodium and starch (TARTARIC B. P. of the tables); (*c*) a phosphate baking powder containing acid phosphate of calcium, sulphate of calcium, bicarbonate of sodium and starch (PHOSPHATE B. P. of the tables); (*d*) an alum baking powder containing burned ammonium alum, acid phosphate of calcium, bicarbonate of sodium, a very small quantity of bitartrate of potassium and starch (ALUM B. P. of the tables).

In this set of experiments and in all that follow, the breads were first dried at 100°, reduced to fine powder, two grammes taken, 5 c. c. of boiling water added to each, and stirred well until a similar paste was obtained in each beaker. This of course was cooled before the ferment was added. The great objection to experimenting with fresh bread, leaving out of consideration the time required to determine the water in each sample, is that the different samples cannot be reduced to the same state of mechanical division, thus rendering comparisons between different series of experiments useless. Indeed, it was found most difficult to obtain similar results in the same series, where every other precaution was taken to establish precisely similar conditions. The texture of different parts of the same loaf varies greatly; still more do the different loaves vary that are made with the same flour, the same material being used to generate the carbonic acid gas. Very constant results have been obtained by the author whenever the foregoing method of obtaining similar mechanical conditions was employed. In a number of experiments made to ascertain the effect of mechanical division on the rapidity of digestion, it was found that a very slight difference in the porosity of otherwise similar samples would decidedly affect the result.

In the experiments of Table 3, 2 c. c. of the pancreatic ferment were used, and each digestive mixture made up to 50 c. c. with 1 p. c. solution of sodium carbonate. Digestion was continued for two hours at 40° C.

TABLE 4.—PANCREATIC DIGESTION

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Residues.....	1·283 grm.	1·298 grm.	1·516 grm.	1·52 grm.
Relative digestion	100·000	98·600	67·500	66·80

This set of experiments was made with a view of ascertaining the effect of a weaker digestive mixture on these breads. The mixtures were made as in Table 3, with the exception that only half the quantity of ferment was added, i. e., 1 c. c. of the extract instead of 2. The result shows a much smaller quantity digested in each of the samples, but, strangely enough, the relative digestion is practically unchanged; the phosphate powder, however, was slightly more retarding in this mixture than in the full digestive mixture shown in Table 3.

TABLE 5.—PANCREATIC DIGESTION.

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.	Time.
Residues.....	1·25 grm.	1·364 grm.	1·531 grm.	1·55 grm.	End of
Relative digestion	100·00	84·800	62·500	60·00	1½ hrs.
Residues.....	·96 grm.	1·025 grm.	1·067 grm.	1·067 grm.	End of
Relative digestion	100·00	93·700	88·600	88·700	2½ hrs.
Residues.....	·83 grm.	·82 grm.	·89 grm.	·92 grm.	End of
Relative digestion	100·00	101·50	95·00	92·70	3½ hrs.

These experiments were made to ascertain the effect of variations in the time of exposure. The conditions of experiment were otherwise as in Table 3.

It is plain that under the conditions of the experiment, the products of digestion accumulating in the beakers soon became a more powerful retarding agent than the constituents of the powders. The greatest difference in the digestibility of these breads is seen at the end of one and a half hours' digestion, viz., 100, 84.8, 62.5, and 60. At the end of three and a half hours, the bread made from the tartaric acid powder has a smaller residue than the plain bread. These experiments are interesting, as they show well how difficult it is to express the relative digestibility of substances in terms of the time occupied to complete digestion. Those who regard favorably this latter mode of experimentation, do not always consider the fact that the products of digestion may vary with the speed of digestion. Grutzner * found that the intensity of the ferment action in the case of salivary digestion determined the nature of the digestion product—a slow action producing erythrodextrin from starch, while during rapid digestion, sugar was chiefly formed. Now, if the products of digestion accumulating in two digestion mixtures are not alike, their effects on the ferment will not be similar, and it would be manifestly erroneous to compare the results without a correction of this source of error. Indeed, if the digestion be prolonged, the retarding influence of the accumulating products may become so powerful as to lead to conclusions absolutely false. In all the experiments made by the author, digestion was stopped, while still active, by boiling the mixtures simultaneously, thus reducing to a minimum any error arising from accumulating products of ferment action.

* Phlüger's Archiv der Physiologie, xii. 297.

The experiments detailed in Series II, Tables 1 to 5, show the influence of these baking powders on both the amylolytic and proteolytic ferments of the pancreatic fluid. To study the effects on the former alone the following experiments were made: One gramme of each bread was taken with 2 c. c. of ferment made up to 50 c. c. and kept at 40° C. for two hours. Digestion was stopped by boiling, and the mixture filtered, the residue well washed and the dextrose in the filtrate estimated by standard Fehling's solution. The results were as follows:

TABLE 6.—PANCREATIC DIGESTION (Amylolytic action)

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Per cent. of dextrose	22·7	18·9	17·8	16·8
Per cent. of starch converted.	26·1	22·6	21·3	20·3

In these experiments the amount of reducing substance formed was for the sake of convenience estimated as dextrose. This, of course, only expresses comparative results, as dextrose is but the final product of the change. Between dextrin, which has no reducing power, and dextrose, there are other bodies, notably maltose, formed in much larger quantities, the latter has a reducing power of but 66 (dextrose 100), while achroodextrin and other intermediate products have very slight reducing action. The total reducing power of the mixture must, however, be a concise expression of the relative diastatic action of the ferment in each case.

The percentage of starch converted into reducing bodies is calculated according to the following reaction:

$$\underset{\textit{Starch.}}{4\ C_6H_{10}O_5} + 3\ H_2O \qquad \underset{\textit{Dextrin.}}{C_6H_{10}O_5} + 3\ \underset{\textit{Dextrose.}}{C_6H_{12}O_6}$$

i. e., 6 parts of starch yield 5 parts of dextrose by weight.

SERIES III.—*The Relative Digestibility of Breads made with Different Baking Powders and Plain Unleavened Bread. Salivary Digestion*

TABLE 1

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Total dextrose formed	·250 grm.	·189 grm.	·181 grm.	·172 grm.
Dextrose in each bread before digestion ...	·025 grm.	·028 grm.	·032 grm.	·030 grm.
Total dextrose formed by action of ptyalin	·225 grm.	·161 grm.	·149 grm.	·142 grm.
Per cent. of starch converted	27·000	19·300	17·800	17·000

In these experiments 1 gramme of dried bread was taken in powder, reduced to a pulp, as in Series II, with 5 c. c. of water, 2 c. c. of filtered saliva added, and each mixture made up to 50 c. c. After digesting for thirty minutes and being boiled to kill the ferment, the mixture was filtered; the filtrate and washings were then made up to 75 p. c. and the dextrose estimated by Fehling's solution.

From the experiments detailed in Division A, one may conclude: (1) That of the forms of bread experimented on, yeast bread and plain flour and water are the most digestible, and next, breads made with tartaric acid powder, lastly those other breads made from alum and phosphate powders, with a preference for the latter. (It is to be remembered that the phosphate powder contained calcium sulphate—about 13 p. c.—which is shown later to be a strong retarding agent.) (2) That the amylolytic ferment of the saliva is more influenced by these salts than is that of the pancreas.

In order (*a*) to estimate more accurately the products of digestion, (*b*) to determine, if possible, which of the ferments was most influenced by the constituents of the baking powders, and (*c*) which one of the constituents of bread was most affected, the experiments detailed in the next division were tried.

B

The Influence of Certain Baking Powders on the Digestion of Fibrin, Gluten, and Starch

The materials to be digested consisted of, (1) a 1 p. c. solution of potato starch, made neutral by washing with large excess of water; (2) gluten obtained from gluten flour, thoroughly washed, separated as completely as possible from starch and dried at 100 to 120° C.; (3) fibrin, separated from blood clot, washed with water, alcohol, and ether, slowly dried at 100° and reduced to powder.

To each digestion mixture, made up to 50 c. c. was added 0.05 p. c. of one of the powders. This quantity corresponds approximately with the amount required by the directions for the use of each powder. The ferment was added after the powder had been thoroughly incorporated with the mixture.

Table 1.—*The Relative Influence of the three Powders on the Amylolytic Ferment of Saliva*

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Total dextrose	·222 grm.	·2 grm.	·16 grm.	·158 grm
Per cent. starch converted	26·600	24·0	19·20	18·800

Here, as in previous experiments, 2 c. c. of filtered mixed saliva were taken, and the mixture made up to 100 c. c. with 1 p. c. starch solution. The digestion was stopped at the end of thirty minutes and the reducing substances estimated as glucose by a standard

Fehling's solution. *O* in the table represents control experiment, composed of 100 c. c. of 1 p. c. starch and with 2 c. c. of saliva.

In the following experiments 2 grammes of the material for digestion were taken and 2 c. c. of glycerine extract of pepsin added to each mixture, which was made up to 50 c. c. by 0.2 p. c. solution of hydrochloric acid. Time, 2 hours. Control experiment taken at 100, the weight of the undigested fibrin and gluten was estimated as the measure of the relative action of the ferment.

TABLE 2.—*The Influence of the Powders on the Proteolytic Action of Pepsin-hydrochloric acid* (a) *with gluten,* (b) *with Fibrin*

a.—Gluten.	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Undigested gluten ..	·69 grm.	·78 grm.	·793 grm.	·994 grm.
Relative digestion ..	100·00	·93	92·20	76·700
b.—Fibrin.				
Undigested fibrin...	·76 grm.	·85 grm.	·85 grm.	1·09 grm.
Relative digestion ..	100·00	92·70	92·70	73·40

It will be observed that there is in these experiments a much greater difference between the alum and the phosphate powders than in any other series. This may be explained by the solubility of phosphate of aluminium in hydrochloric acid of this strength. The author had no difficulty in dissolving 0.5 gramme in 50 c. c. of 0.2 p. c. hydrochloric acid—more than twice the quantity present in the experiment.

TABLE 3.—*The Influence of the Powders on the Proteolytic Ferment of Pancreatic Digestion*

	O.	Tartaric B. P.	Phosphate B. P.	Alum B. P.
Residues	·79 grm.	·91 grm.	·92 grm.	·99 grm.
Relative digestion ...	100·00	90·00	89·10	83·40

The conditions of this experiment are similar to those of Table 2: 2 c. c. of the ferment extract in a 1 p. c. solution of sodium carbonate were caused to act for two hours on 2 grammes of fibrin at 40° C.

These results indicate that the alum powder retards the proteolytic action of the pancreatic ferment to a less degree than it does pepsin. In the latter, the relative digestion was 100 to 73.4; in the former, 100 to 83.4. This is doubtless due to the solubility of the aluminium salts in pepsin-hydrochloric acid and their insolubility in an alkaline medium. Indeed, the proteolytic ferment of the pancreas is but slightly influenced by the powders and not much more by one than

another. The contrast between the effect of the baking powders on the amylolytic and proteolytic ferments of pancreatic fluid must be most marked, since the powders have very decided retarding influence on the pancreatic digestion of bread (see Tables 4, 5, and 6, Div. A, Series I).

C

The Influence of Alum and of the Decomposition Products of Some Baking Powders on the Digestion of Starch

From the experiments recorded in Divisions A and B it appears that by the decomposition of the phosphate and alum baking powders, salts are formed which decidedly retard the action of the digestive ferments. Moreover, the almost unanimous verdict of these experiments is that the alum powder produces salts of greater retarding power than the phosphate, while there is a very marked retardation of both these mixtures over the tartaric acid powder. Now, as the salts formed by these powders are well known, it seemed of great interest to ascertain to which of them this power of hindering digestion is due. Experiments to elucidate more fully this important part of the question will form the subject of a future paper. In the meantime the following series will indicate the effects of the salts on one of the ferments, viz., the diastatic ferment of the saliva.

Series I.—*The Influence of the Salts produced by the Decomposition of Certain Baking Powders on the Amylolytic Action of Saliva*

The purity of each salt was carefully ascertained and the percentage of each in dried powder was taken and dissolved or made into an emulsion with a small quantity of water. To this was added a 1 p. c. solution of starch, 2 c. c. of filtered mixed saliva added, and the whole made up to 50 c. c. with the starch solution. Ferment action was stopped by boiling after thirty minutes, and the relative diastatic action in each mixture was determined by estimating its reducing power with a standard Fehling's solution.

The salts are arranged in order of their retardation.

			Total dextrose formed in grm.	Percentage of starch converted.
	Control.	(O)	·113	27·0
0·1 p. c.	Rochelle salt	($NaKC_4H_4O_6$)	·109	26·0
	Neutral sodium phosphate	(Na_3PO_4)	·103	24·6
	Sodium sulphate	(Na_2SO_4)	·100	24·0
	Potassium sulphate	(K_2SO_4)	·094	22·4
	Aluminium hydrate	($Al_2O_6H_6$)	·090	21·6
	Calcium sulphate	($CaSO_4$)	·087	20·8
	Acid sodium phosphate	(NaH_2PO_4)	·082	19·6
·05 p. c.	Rochelle salt	($NaKC_4H_4O_6$)	·115	27·6
	Aluminium hydrate	($Al_2O_6H_6$)	·120	24·4

This table speaks for itself, and as far as it goes indicates the relative retarding power of 0.1 p. c. of the usual salts found after the expulsion of the carbonic acid gas from the baking powders used in the preceding experiments. This order, of course, might be changed, were other ferments employed or different quantities used; for instance, it is seen that while 0.5 p. c. of Rochelle salt acts as a stimulant to the ferment, the same quantity of the pulpy aluminium hydrate still retards nearly in proportion to the quantity used.

SERIES II.—*The effect of different quantities of Alum and other Aluminium Salts on the Diastatic Ferment of Saliva*

	Percentage of each salt taken.	Total dextrose in grm.	Per cent. starch converted.
Control.	0.	·142	34·0
Potassium alum	·002	·132	31·9
	·004	·128	30·7
	·010	·090	21·6
	·020	·058	13·9
	·050	Traces	. . .
	·100	None	. . .
Aluminium hydrate	·100	·096	23·0
	·050	·129	30·9
	·020	·140	33·6
Aluminium phosphate	·100	·117	28·0
	·050	·136	32·6

The experiments of Series II were conducted under similar conditions to those in Series I. The results would seem to indicate a destructive action towards the ferment on the part of alum, while loss of diastatic power in the experiments of Series I may be due either to precipitation of the proteids of the saliva by the salts, or simply to their clogging action. That many neutral salts have a specific action on the digestive ferments, and do not always act mechanically only, has been shown by numerous experiments. Chittenden, of Yale University, found that 0.5 p. c. of magnesium sulphate diminishes the amylolytic action of saliva by 55 p. c., while 0.5 p. c. of tartar-emetic ($KSbOC_4H_4O_6$) increases the amount of starch converted by 68 p. c. This is interesting in view of the fact that Rochelle salt in small quantity also acts as a mild stimulant to this diastatic ferment (see Div. C, Series I).

Now, though one can scarcely conceive of any other than a clogging action on the part of insoluble salts, yet in the above experiments, the hydrate and phosphate of aluminium seem to induce a condition more unfavorable to ferment action than would be the case if their influence were purely mechanical. It has been suggested that neutral salts may form compounds with the ferment, which have of themselves little or no digestive power. This offers an explanation for the marked retarding powers of soluble sulphates, which, however, can scarcely be made to apply to insoluble pulpy precipitates.

Conclusions

In comparing the results described under Divisions A and B with those of Division C, one seems quite justified in arriving at these conclusions. In the first place, the bread made with the tartaric acid powder is most quickly digested, because the Rochelle salts formed by the decomposition of this baking mixture possess a very weak retarding influence on ferments. On the other hand, the presence of alkaline sulphates and of the pulpy viscid hydrate and phosphate of aluminium among the decomposition products of the other powders, is quite sufficient to explain the relative indigestibility of bread containing these salts. That every experiment should have shown the alum powder to be the most noxious to the ferments, is manifestly due to the combined retarding influence of two agents left in the bread by this mixture, viz., an alkaline sulphate and the phosphate of aluminium.

The phosphate powder, it must be remembered, contained about 13 p. c. of a sulphate ($CaSO_4$), which probably accounts for its high retarding power. Soluble phosphates do not appear to interfere seriously with the proper action of digestive ferments; at all events, no experimenter has found them possessed of that specific retarding power which is so characteristic of the sulphates as a class.

Generally, then, the inferences to be drawn from these experiments do not coincide with the views usually expressed by either the opponents or the defenders of alum baking powders, though they may favor the former. Here, as is so often the case in hotly contested questions, the truth seems to lie between the extremes of opinion expressed by the two parties. For, on the one hand, there is nothing in common between the specific destructive action of alum itself and the semi-mechanical, retarding influence of these products of its decomposition. A quantity of alum that would entirely prohibit ferment action will (as shown in Division C), when converted into its equivalent alkaline sulphate and aluminium phosphate, only delay digestion from 20 to 30 p. c. On the other hand, although there is no similarity between the effects of alum itself and of the salts left in bread by alum baking powders, yet the retarding influence of the latter on digestion is certainly well marked.

The unanimous verdict of the foregoing experiments is, that alum powders introduce into a form of food of universal use agents which are detrimental to the functional activity of the digestive ferments. They must, therefore, be prejudicial to health, and the only safe course is to carefully avoid them. Whether they are sufficiently injurious to be excluded from the market is a question that the interpreters of the law alone can decide.

THE POISONOUS EFFECTS OF ALUM

IN ANIMALS AND MAN, AS PROVEN BY THE EXPERIMENTS OF ALPH. DEVERGIE

Medicine Legale. (Tome 3.) Paris, 1851

ACTION OF ALUM ON THE ANIMAL ECONOMY

Page 355. Experiments have been made at the same time by M. Orfila and myself with the view of confirming the deleterious properties of alum. The results of our experiments differ in several respects; I will report both:

M. Orfila made a little dog weighing eight pounds swallow successively and with the interval of a day: 1st, 28 grammes of crystallized alum reduced to a fine powder; 2d, 28 grammes of the same alum; 3d, 26 grammes of alum calcined to powder; this time, after having introduced the alum, he tied up the œsophagus. In the first two experiments, the animal vomited white, ropy matter, containing alum, and an hour afterwards he ate with appetite. In the last, it was not remarked that the dog made any efforts to vomit; the ligature was removed four hours after its application; the next day he was weak and tormented by thirst; he died three days afterwards without having presented other symptoms than a state of weakness and prostration continually increasing. The autopsy disclosed no alteration that could account for death.

Another dog, weighing 5 kilogrammes, was made to take 28 grammes of alum calcined to powder. The animal vomited stringy, white matter; half an hour afterwards there was also a stool. He ate towards the end of the day. The experiment was made at noon. The following day, at noon, fasting, he was made to swallow 20 grammes of calcined alum; he experienced the same symptoms as on the previous day, and was not long in recovering. Three days afterwards, at noon, 18 grammes of calcined alum, diluted and in part dissolved in three ounces of water, were injected into his stomach. He vomited at the end of ten minutes; half an hour afterwards he had two solid stools near together, and experienced no other trouble. Next day 28 grammes of calcined alum, partly dissolved, partly diluted with four ounces of cold water, were injected into his stomach. The animal, who was fasting, vomited at the end of six minutes a part

of the matter injected; eight minutes after, renewed vomiting, and in the following ten minutes he vomited twice more. In the evening he was in his natural condition and ate with appetite. Finally, after having opened the œsophagus of this dog, 64 grammes of calcined alum, diluted and partly dissolved in 90 grammes of water, were there introduced. The ligature was then terminated. Two hours after, marked dejection, great difficulty in standing up, little sensibility, for one may prick and pinch him without his making the least movement. He died five hours after the ingestion of the alum. On opening the body the mucous membrane of the stomach was found inflamed in all its extent, particularly towards the large cul-de-sac, where it is of a dark brown. A slight effusion of blood in the sub-mucous cellular tissue, near the pylorus; the walls of the stomach indurated in this place and as if tanned.

Sixty grammes of calcined alum administered in the same manner to a dog weighing 12½ kilogrammes; the animal died at the end of fourteen hours. The alimentary canal presented analogous alterations.

I will now relate my own experiments, and first those which were made with calcined alum in part dissolved, in part suspended in water.

First Experiment. At half-past eleven we made a dog swallow 16 grammes of calcined alum partly dissolved in three ounces of water; abundant vomitings of greenish, frothy, ropy matter, in the midst of which much alum is found. The animal remained dejected. At four o'clock he ate with quite a good appetite, but ten minutes afterwards threw up the food he had taken, and he drank with much avidity. His walk was troubled, and he evidently showed weakness in the hind-quarters. At seven o'clock of the evening he eats a little; has difficulty in moving his hind-paws; however, he is quite calm. The next day, at ten o'clock in the morning, he appeared recovered, but his gait was still rather wavering. The third day he was in his natural condition.

Second Experiment. At noon 24 grammes of calcined alum are introduced into the stomach of a dog. Ten minutes afterwards, vomitings of mucous, foamy matter, very white and sprinkled with alum; same state of weakness. At four o'clock the animal is shrunken; his abdomen is contracted; the skin is tightly drawn over the ribs, which show up very well. A marked weakness of the hind-quarters exists. He refuses to drink or eat. There was an alvine evacuation of liquid matter. At seven o'clock he seems much better, takes some food. Next day he appears restored to health. All our experiments were made on very strong dogs. The calcined alum we employed was procured from Messrs. Boudet & Delondre, apothecaries; but principally from M. Boudet.

Third Experiment. At half-past ten o'clock, a dog was made to swallow thirty grains of calcined alum mixed and partly dissolved in four ounces of water. This ingestion was followed by only a slight uneasiness; ten minutes pass, the animal grinds his teeth, and soon falls into a condition of very pronounced weakness. Half an hour afterwards, vomitings take place with quite severe efforts; there appears at the mouth a great quantity of white, ropy froth; the vomitings are renewed, and much alum is distinguished in the

matter vomited. At four o'clock the animal seems less sad, but presents a very pronounced weakness in the paws. At six o'clock he refuses to take food. Next day he eats and drinks with considerable avidity, but vomits up the food a little while after having taken it. The third day he appears recovered, and ate with appetite. Having killed him and opened him on the eighth day, we found in the large cul-de-sac of the stomach a white, rounded plate two inches in diameter. The injected mucous membrane came off easily at this point. The rest of the organ was quite healthy.

Fourth Experiment. At a quarter past twelve a dog is made to take sixty grains of calcined alum partly dissolved in six ounces of water. At once weakness, uneasy air, suffering; quarter of an hour afterwards, attempts to vomit; then vomitings of a small quantity of green, frothy matter; much foaming at the mouth, shuddering, horripilations, prostration more and more pronounced; at half-past two the animal is flat on his belly, eyes dim, sad; it is impossible for him to stand on his feet. At half-past four o'clock he appears a little less suffering; he sits up but carries his head very high and stiff; he breathes slowly, and with difficulty. At seven o'clock in the evening he lies supine; his respiration is stertorous; he appears in a profound state of suffering, for he endeavors to change his position at every instant. At eight o'clock the animal had succumbed. Opened the next day, we observed the following changes: Red color of the stomach and intestines, examined externally; the epiploon is itself strongly colored. All the vessels of the intestines are filled with blood. The internal surface of the œsophagus is of a grayish white; that of the stomach is white in the upper four-fifths of its extent, and yellow in the rest. This organ contains much food; its mucous membrane is as if shagreened; it is cracked at several points. In general it is so softened, that friction with the pulp of the fingers suffices to detach it; it appears disorganized in almost the whole of its extent. When it is raised, a brick-red coloration of the muscular tunic is observed, which contrasts with the grayish tint of the mucous membrane. The consistency of the muscular tunic does not appear altered. From the stomach to the end of the small intestine, a brick-red coloration of the mucous membrane exists. The lungs are edematous. When they are compressed a large quantity of sanguineous serosity oozes forth.

Fifth Experiment. At ten o'clock the œsophagus of a dog is tied up, after having injected into the stomach eight grammes of calcined alum, partly dissolved in two ounces of water. A short time after the animal fell into a state of great weakness; he made repeated attempts to vomit. They were followed by rattling of the intestines, by quite a strong agitation, by momentary contractions of the paws. The animal then lay down and remained prostrated. In the evening the belly was stretched and warm; the dog changed his place with much difficulty. Next day he kept in the same situation; he could nevertheless be made to walk a little better than the day before. Having killed this animal in the morning, we proceeded to open him. Examined on the exterior, the stomach and intestines appeared to be in their natural state. The mucous membrane of the stomach was generally injected; it presented a brick-red color along the large curve. In the centre of the large cul-de-sac existed

a whitish plate of an inch and a half in diameter, evidently due to the action of the alum. The mucous membrane was strongly altered at this point; it was raised with ease, like that of the stomach of the dog who had swallowed two ounces of alum.

Experiments made with Alum Dissolved in Water. Sixty grammes of calcined alum were treated with nine ounces of water and submitted to ebullition. The filtered liquor was injected into the stomach of a dog of strong build by the aid of an opening made in the œsophagus. This channel was tied up after the injection. The animal, left to himself, presented at first no remarkable phenomenon, but soon attempts to vomit occurred, and were prolonged during the space of two hours, becoming, however, less and less considerable. During these attempts the animal gave out at the mouth a large quantity of thick, viscid saliva. He then fell into weakness; his belly became swollen; an alvine evacuation took place. The next day he appeared very suffering; strove to change his position; little by little the prostration became greater and greater, and death occurred forty-eight hours after the injection of the poison. On opening the body we found the stomach unequally bilobated. The most extended portion, which had seven or eight times the capacity of the other, followed after the œsophagus. The internal membrane was of a greenish gray, shagreened and as if marbled; it was strewn with blackish furrows, which did not correspond with the course of the venous vessels. It was dense, hardened, and cracked in almost its whole extent, and particularly in the large cul-de-sac of the stomach. The same was not the case with the lining of the second division of this organ; this membrane had preserved its ordinary density, but it offered an extremely marked brick-red coloration. This color diminished in intensity in the duodenum, and was lost in the upper third of the small intestine. In general all the vessels of the intestines were gorged with blood, but particularly those of the stomach and large epiploon. It is important to note that the stomach and intestines contained no food.

This experiment was repeated on two other dogs, and in the same manner. One died in the space of fifty hours, and the other fifty-four hours after the injection of the poison, all presenting the same symptoms. The stomach of these two dogs contained food. Their mucous membrane was of a lively red, very much corrugated on itself. All the vessels of this organ were injected, but we have not met with this augmentation of density resulting from the evident action of the alum on the stomach of the first dog.

Twenty-six grammes of calcined alum, dissolved in six ounces of water by boiling, are introduced at two o'clock into the stomach of a very large dog by an opening made in the œsophagus. The animal at first appears little disturbed by the action of this substance; half an hour afterwards he makes some efforts to vomit, and soon becomes weak. The next day his condition was little changed; the second day he seemed to suffer more; he changed his place with difficulty; his belly had much diminished in volume, and his ribs began to show under the skin. The third day the dog lay on his side, with head resting on the ground, paws half bent, ribs showing plainly, belly very much shrunken. A sanguineous alvine evacuation took place in the morning. He succumbed at three o'clock in the after-

noon, seventy-three hours after the injection of the alum. This dog had refused food before being operated on. On opening the abdomen, the stomach and intestines appeared injected and of a rose color. The gastric mucous membrane was of a very dark red in almost its whole extent; it appeared a little softened.

Following are the facts concerning the administration of alum to man. Excepting the first, they all relate to the use of crystallized alum.

A lady who from childhood was troubled with diseases of the stomach, having to use a solution of gum arabic, by order of her physician, received from an apothecary calcined alum for powdered gum. Fifteen grammes of alum are put into a pint of lukewarm water; a cup of this drink is presented to Madame B., who seizes it eagerly, but scarcely has she drunk a few swallows, when she pushes it away, complaining of very severe pains in the mouth, pharynx, and stomach, saying that she was poisoned. Nausea, great heat, harrowing pain in all the organs that have received the medicament. Rapid pulse, agitated face, muscles attacked by slight convulsive movements, increased desire to vomit, inextinguishable thirst. Quarter of an hour afterwards vomitings, which were repeated all day, but the patient was made to take thirty-two glasses of tepid water. By the report of the physician, Madame B. was so ill that her life was in danger. The condition of the stomach made an application of leeches necessary. There was, perhaps, an exaggeration in the consequences of this medication, but it evidently produced an irritating effect the more marked as the digestive passages were diseased. Professor Dumeril often employs in chronic diarrhœas a drink composed of 4 grammes of alum dissolved in 1 kilog. of vehicle, to be taken in twenty-four hours. More frequently makes use, in passive hemorrhages, of 8 grammes of alum dissolved in a pound of whey. Messrs. Kapeler and Gendrin employ alum in the treatment of painter's colic. They put the dose at 12 and even at 24 grammes in twenty-four hours. The patients have never complained of a burning sensation. In some cases, instead of giving the dose of alum in twenty-four hours, they have administered at once a dose of 12 grammes dissolved in 180 grammes of vehicle. But generally, the alum is given in solution in one or two pots of drink, which are taken in twenty-four hours. I have treated several cases of lead colic in this way without any accident. It is well to observe, I think, that no comparison is to be established between a man afflicted with painter's colic and a man in a state of health. Also Messrs. Kapeler and Gendrin's facts are only of a secondary value, as they should be compared with poisonings by this substance. Let an individual in good health undergo the treatment of the Charite, which causes no accident daily in these sorts of cases, and from which on the contrary great advantages are derived, and it will be seen in what a state the person will be at the end of a few days.

M. Orfila has concluded from the experiments he made on animals and from the last facts:

First. That dogs, even the weakest and smallest, can endure very strong doses of calcined alum without experiencing other accidents than vomitings and stools; that they are perfectly recovered one or two hours after the ingestion of the alum.

Second. That if, in consequence of the ligature of the œsophagus, or from any other cause, a strong dose of calcined alum is not vomited, death occurs at the end of a few hours, even in robust dogs and of a very strong build.

Third. That, applied externally in the sub-cutaneous cellular tissue of a dog's thigh, calcined alum at the dose of thirty grammes determines a deep burning, which causes a suppuration sufficiently abundant to kill the animal in from fifteen to twenty days.

Fourth. That an adult man can swallow in a day and without inconvenience several drams of alum calcined and dissolved in water.

Fifth. That it is not doubtful, after what is observed in animals, that an adult man who should swallow 30 to 60 grammes of calcined alum dissolved in water would have vomitings and stools, and would be no more disturbed by it than these animals. On the contrary, it is certain that by reason of his greater stature and strength, a much stronger dose of alum would be required to produce in him accidents as intense as in dogs.

After having given with exactness the experiments and views of M. Orfila respecting alum, I will now enunciate the conclusions I have drawn from my researches and from all the facts I have just made known.

First. The calcined alum of commerce always contains a quantity of sub-sulphate of aluminium and of potash insoluble in boiling water; so that 30 grammes of calcined alum never represent the quantity of alum which has furnished it — that is, nearly 60 grammes.

Second. Calcined alum may be badly enough prepared to lose all its deleterious properties, and to be transformed into a probably inert matter.

Third. Calcined alum boiled in a sufficient quantity of water, and during a long enough time, recovers all the properties of crystallized alum, at least with regard to the quantity of soluble alum not decomposed.

Fourth. Calcined alum treated with cold water is dissolved in it with difficulty, and requires much more water than if treated with boiling water; so that a portion of alum may escape the solvent action of the water and remain suspended in it. Crystallized alum only dissolves in fourteen or fifteen times its weight of water at 15 degrees, while it does not even require its weight of boiling water; and if it is in the state of calcined alum, it resists the action of water a long time.

Fifth. Calcined alum is a corrosive substance for the mucous membranes.

Sixth. Calcined alum may cause the death of dogs at the dose of 60 grammes, even in cases when vomiting is not prevented, and when the stomach contains food.

Seventh. A dose of 28 grammes may cause death, when the œsophagus has been tied up, and though it may have been preliminarily dissolved in water.

Eighth. Calcined alum, incorporated with cold water and partly suspended, constitutes a mixture much more deleterious than if it had been prepared with hot water and entirely dissolved.

Ninth. This substance would act with much more energy on man, though at the same dose, his stomach being endowed with

much more sensibility, and his sympathies much more active than in the dog.

Tenth. If the stomach were diseased, affected by chronic phlegmasia, for example, no doubt its action would be still more energetic.

Eleventh. The alum is absorbed, carried into the torrent of the circulation, and the presence of the base of aluminium may be confirmed in the liver, the spleen, and the urine. (Orfila.)

Treatment. In case the ingestion of alum in the stomach should cause accidents, the physicians should favor the vomitings that are almost always the consequence of it, by employing lukewarm water, without, however, exaggerating the quantity of it. It would then be necessary to attempt to arrest the progress of the phlegmasia of the digestive tube, by the aid of the ordinary antiphlogistics. Magnesia has been employed in an analogous case; it is quite useless, for alum is not so acid a salt that it can act upon the stomach as a poison of this kind.

ORFILA'S EXPERIMENTS, DEMONSTRATING THE POISONOUS NATURE OF ALUM

Traite de Toxicologie. (Tome 1.) Paris, 1852

ON ALUM. ACTION ON THE ANIMAL ECONOMY

Page 366. *Experiment* 1. I made a little dog weighing four kilogrammes, fasting, swallow twenty-eight grammes of crystallized alum with a base of potash, reduced to a fine powder. At the end of twenty-five minutes, the animal vomited quite a large quantity of liquid, white, ropy matter containing alum. Three quarters of an hour afterwards, he had a solid stool. At the end of an hour he ate, and showed no sign of uneasiness. The next day he was very well, and devoured the food given him. The following day, at noon, he was still fasting, when he was made to take again twenty-eight grammes of the same alum; half an hour afterwards he vomited twice matter similar to the preceding, and seemed no more troubled than the day before. On the next day he was perfectly well.

Experiment 2. A little dog, aged three months, weighing five kilogrammes, and fasting, was made to take at noon twenty-eight grammes of calcined alum in a fine powder; half an hour afterwards the animal vomited ropy, white matter, evidently containing alum; he had a stool after a short time. He ate towards the end of the day, as well as the next day, and appeared perfectly recovered. The following day at noon, fasting, he was made to swallow twenty grammes of the same calcined alum; he experienced the same troubles as the day before, and was not long in recovering.

Three days afterwards, by the aid of a syringe and a gum elastic sound, eighteen grammes of calcined alum diluted and partly dissolved in 96 grammes of water, were injected into his stomach at noon. He vomited at the end of ten minutes. Half an hour after-

wards he had two solid stools near together, and experienced no further trouble. The next day his stomach was injected with 28 grammes of calcined alum, partly dissolved, partly diluted in 125 grammes of cold water. The animal, who was fasting, vomited at the end of six minutes a part of the ingested matter; eight minutes after another vomiting, and in the ten minutes following, he vomited twice more. In the evening he was in his natural condition, and ate with appetite. The next day he showed no uneasiness.

Experiment 3. By the aid of a syringe and a gum elastic sound, 64 grammes of calcined alum, partly diluted, partly dissolved in 125 grammes of cold water, were introduced into the stomach of a dog much stronger than the preceding, weighing 12½ kilogrammes; ten minutes afterwards the animal vomited a considerable quantity of alimentary matter, whitened with powder of alum. These vomitings were twice renewed in the following half hour, and it was not long before the dog was perfectly recovered.

Experiment 4. By the same process 64 grammes of calcined alum, mixed with 100 grammes of water, were injected at noon into the stomach of a small dog, weighing 5 kilogrammes, aged about three months, and fasting. The animal vomited ropy, white matter in quarter of an hour; fifty minutes afterwards he had vomited five times. At two o'clock he appeared very well. The following days he ate with appetite and gave no signs of uneasiness.

These experiments support what I published on alum in the year 1814. I said, "I made a dog take 24 grammes of alum in powder; an hour afterwards the animal vomited without effort, and he did not appear much distressed. The next day he ate as usual, and was perfectly recovered. This experiment goes to prove that alum mixed with wines might occasion accidents in certain circumstances." (Note on page 274 of 2d part of vol. i. of my *Toxicologie Generale*, 1st edition, 1814.)

Desiring to know the effects of alum on dogs, when vomiting is prevented, I made the following experiments:

Experiment 5. The dog, who was the subject of the first experiment, whom I said to have perfectly recovered after having taken 56 grammes of common alum, swallowed 26 grammes of *calcined alum* in powder; five minutes after his œsophagus was tied up. At the end of four hours the ligature was removed, and it was not remarked that the dog made any efforts to vomit. The next day he was feeble and tormented by thirst. He died three days afterwards, without having presented any other symptom than a state of weakness and prostration, continually increasing. On opening the body nothing was discovered to account for death.

Experiment 6. The dog, that was the subject of the second experiment, who was perfectly restored after having swallowed 94 *grammes of calcined alum*, took 64 grammes of *calcined alum* diluted and partly dissolved in 96 grammes of water; the œsophagus was tied up immediately. Two hours afterwards, marked dejection, great difficulty in standing up; little sensibility, for he may be pinched and pricked without making the least movement. He died five hours after the ingestion of the alum.

Opening of the body. The stomach contains quite a large quantity of liquid; its internal surface is covered in almost its whole

extent with a reddish matter mixed with greenish and bilious-like portions. The mucous membrane is inflamed throughout, particularly near the large cul-de-sac, where it is of a dark brown; towards the pylorus there is a little effused blood, and the mucous membrane is there of a quite dark red. The walls of the stomach are extremely thick in the pyloric extremity; they are hardened, as if tanned, and resist a cutting instrument. The parietes of the small intestine are slightly thickened; this intestine is lined internally by a granulated substance of a slightly yellowish white. The large intestines contain liquid, yellowish, fetid matter. There is, however, nothing remarkable in this intestine. The other organs are the seat of no appreciable alteration.

Experiment 7. At eight o'clock in the morning the œsophagus of a robust dog, weighing 12 kilogrammes, was detached and pierced with a hole; by the aid of a funnel 64 grammes of calcined alum, partly diluted and partly dissolved in 128 grammes of water, were introduced into his stomach; the œsophagus was tied up. Fourteen hours after the dog died, after having experienced the same symptoms as the preceding. The digestive canal presented changes similar to those I have just spoken of. (See experiment 6.)

Experiment 8. *Thirty-two grammes of calcined alum,* finely pulverized, were applied to the cellular tissue of the thigh of a dog of medium figure; the strips of skin were brought together by a few sutures, so that the alum must remain on the denuded surface.

Eight days afterwards it is seen that the animal appears not to have suffered any notable trouble, the sutures of the wound still exist. On incising the skin corresponding to the parts put in contact with the alum, a resistance is felt owing to this portion of the integuments having become partly dried; the interior of the wound is not inflamed, no trace of reunion is observed. The subcutaneous cellular tissue is dried, yellowish gray, and evidently gangrened. There is still a little alum in the wound. After a few days suppuration is established, and soon becomes very abundant; fragments of the cellular tissue and skin are detached, and the animal dies a fortnight after the external application of the alum. An examination of the limb after death shows that suppuration had destroyed all the cellular tissue of the interior part of the thigh, and even the intermuscular cellular tissue; effusions of pus had taken place as far as the leg. There is no doubt, from the small quantity of alum found in the wound, and from the disorders I have just mentioned, that this salt had been transported to parts of the limb quite removed from that upon which it had been placed.

Conclusions. First. Even the weakest and smallest dogs can support very strong doses of calcined alum (60 grammes, for example) without having other accidents than vomitings and stools; indeed they are perfectly recovered one or two hours after the ingestion of the alum, if they have had abundant evacuations. In combating this conclusion, M. Devergie has brought forward no probable fact, and has put himself in opposition to what is best established. The only experiment he can produce in favor of his opinion, the fourth, proves nothing, for the dog who had swallowed 64 grammes of calcined alum, and who died eight hours afterwards, had *vomited only a small quantity of green, frothy matter.* Experiments 1, 2, and 3,

made by this physician, confirm on the contrary this first conclusion. (See *Med. Legale,* Vol. III., page 337.)

Second. If in consequence of the ligature of the œsophagus, *or from any other cause,* this strong dose of calcined or crystallized alum *is not vomited up,* death occurs in a few hours, even in robust and large dogs. The last five experiments reported by M. Devergie only confirm what I said in regard to this, twelve years before him.

Third. In this case, the mucous membrane of the digestive canal is very much inflamed, as I proved in 1829.

Fourth. Applied externally on the subcutaneous cellular tissue of the thigh of dogs, calcined alum, at the dose of 32 grammes, produces a deep burn, causing suppuration sufficiently abundant to kill the animals in from fifteen to twenty days.

Fifth. An adult man can swallow in a day, and without inconvenience, 4, 6, 8, and 10 grammes of calcined alum dissolved in water. Boerhaave gave 4 grammes of it at a time in intermittent fevers. Helvetius gave every four hours 2 grammes of pills containing 1 gramme 30 centigrammes of calcined alum, making the dose of alum 7 grammes 8 decigrammes in twenty-four hours. M. Dumeril has often administered 4 grammes of this salt in a day, dissolved in a diet-drink. Marc gave, in twenty-four hours, 500 grammes of whey, in which was dissolved 8 grammes of alum. Dr. Kapeler has given without inconvenience, in painter's colic, and in the epidemic disease known under the name of raphania, up to 24 grammes of alum in the course of twenty-four hours, and sometimes he has administered 12 grammes at once dissolved in 200 grammes of vehicle; some of the individuals subjected to this medication were of a *feeble constitution.* The medicament has only very rarely induced nausea or vomiting, never epigastralgia; but it has frequently caused abundant stools.

Sixth. There is no doubt, from what is observed in dogs and from what precedes, that an adult man in good health, who should swallow 30, 40, or 60 grammes of *calcined* alum dissolved in water, would have vomitings and stools, and would not be more troubled by it than these animals; on the contrary, it is certain that by reason of his greater stature and greater strength, a much stronger dose of alum would be necessary to produce accidents in him as intense as in dogs. M. Devergie thinks, on the contrary, that the stomach of man being endowed with much more sensibility, and his sympathies being much more active than in the dog, the alum would act with much more energy. This opinion, purely hypothetical, is contradicted by the only facts that are in the domain of science. (See Fifth.)

Seventh. It is equally certain that a strong dose of alum might occasion the death of a man, if this salt were not expelled by vomitings and stools, as results from experiments 5, 6, and 7, which I published in 1829. (See p. 367.)

Eighth. If the stomach of man, instead of being healthy, as I have thus far supposed, was affected by a chromephlegmasia, the alum would act with much more energy, without, however, ever causing a dilatation of the *left ventricle of the heart,* as was inconsiderately announced by Dr. Fournier-Deschamps, in a medico-legal affair for which I was consulted, January 24, 1829, and of which

this is the summary: Madame B. was attacked, while she was still in boarding-school at Aigle (Orne), by almost continual vomiting, and so obstinate that it resisted all the remedies indicated; whatever the substances given to the stomach, not excepting water, they were immediately rejected. Dr. Emangard succeeded, at the end of six weeks, by an appropriate treatment, in making the patient support a slightly lacteous water; the alimentation was progressively increased, and her health became as good as could be expected in a person whose infancy and youth had been marked by a constantly valetudinarian condition. In 1827 Madame B. was ill enough to keep to her bed during a large part of the winter. In February, 1828, she summoned, for the first time, Dr. Fournier-Deschamps, who attended her nearly two months. In the course of the summer irregularities arose in her menstruation, which necessitated recourse to sinapisms, an infusion of saffron, etc. September 10, 1828, as declared by Dr. Fournier, Madame B. was troubled by a sanguineous derangement, with inflammatory predisposition proceeding from the diminution of the menstrual flux. However vague and insufficient such a diagnostic may be, the prescription was sixteen leeches and gum arabic for a drink; unfortunately the apothecary delivered, by mistake, two packages containing each 16 grammes of *calcined alum*. One of these packages had been dissolved in about a litre of lukewarm water; *a cup* of this drink was presented to Madame B. Scarcely had she drunk *two or three spoonfuls*, when she pushed it away, complaining of very severe pains in the mouth, pharynx, and stomach, saying she was poisoned and her mouth was burned. By Dr. Fournier's report "she complained of nausea, severe heat, tearing pains in all the points that had come in contact with the alum; the 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. Madame B. commenced to vomit quarter of an hour after having taken this drink; the patient had no rest; the vomitings continued all day—(Note. Dr. Fournier does not say that he had made Madame B. take, in the course of the day, the 22d, contrary to all the rules of the art, 32 glasses of tepid water); they relax in the evening and are less frequent during the night. But the patient was troubled by insomnia and acute pains. The next day there was some fever; the vomitings were less frequent, but the pains continued. The night was again very much disturbed. The following day, the 24th, there was no more fever; the epigastric region had become very sore to the touch, and was very tense. Twelve leeches having been applied, the patient was better the 26th." Though Madame B. had been in the enjoyment of perfect health, says Dr. Fournier in one of his depositions, the use of such a beverage was of a nature to incommode her very much.

Called upon to give my opinion in this affair, I thus expressed myself: *Calcined* alum is an irritating salt which may, however, be taken in quite a strong dose without occasioning the least disturbance; a quantity five times that swallowed by Madame B. is daily administered to patients without their having even any desire to vomit. However, I do not dispute that Madame B. may have experienced some unpleasant symptoms from the alum; for a long time she seems to have been afflicted with an *affection of the stomach*,

and we know that with such dispositions, a substance will not be supported which would be perfectly so if the stomach were not diseased. As Dr. Marc had done, I reduced to its just value Dr. Fournier's strange assertion, namely, that alum, in a dose of some centigrammes, could have caused *an aneurism of the heart.* The fine, inflicted by the tribunal of correctional police on the apothecary, was reduced by half. (See my consultation in vol. i. of the *Annales d'Hygiene*, year 1829.)

TREATMENT OF POISONING BY ALUM

Vomiting is to be favored by lukewarm water and titillation of the uvula, then the gastro-intestinal phlegmasia is to be combated by general or local bleedings, emollient drinks, diet, etc.

Journal de Pharmacie et de Chimie. (4e Serie, Tome XVIII). 1873.

Page 333. A case of poisoning by alum, by Dr. Ricquet, of Liège. Mr. V. M., wishing to purge himself, as he was accustomed to with sulphate of magnesia, sent to an apothecary for 30 grammes of this substance, and took them, after dissolving in cold water. He succumbed after horrible pains. Immediately after the administration of the pretended salts of magnesia, he felt a burning sensation in the mouth, throat, and stomach, followed by a single sanguineous vomiting. No stools, extreme uneasiness, then insupportable anguish, repeated lipothymies, intelligence and senses intact. Finally intermittent, filiform pulse, cold skin. The deglutition of liquids was almost impossible. He died eight hours after having taken the remedy.

On opening the body a grayish-yellow coat was found covering the mucous membrane of the mouth, pharynx, and œsophagus; the tongue and uvula were swollen; the stomach, intestine, and two kidneys injected.

A chemical analysis was then made; a search was made in vain in the organs for oxalic acid, arsenious acid, and other metallic poisons, but sulphate of aluminium and of potash were found. In the liquors, properly prepared, the presence was recognized of sulphuric acid, aluminium, potash, and magnesia (lemonade with citrate of magnesia had been given to the patient), by means of the ordinary reactives, chloride of baryum, chloride of platinum, sulphhydrate of ammonia, carbonate of potash, and ammonia phosphate of soda.

Only one case of poisoning by alum, observed by Mr. Taylor in England, was known before this, but we have no details about it. Orfila mentions another case of poisoning not followed by death. Dr. Ricquet's observation is, therefore, the only complete observation possessed by science. (1873).

Boehm-Poisons. Page 380. The reaction of alum with albumen furnishes a simple explanation of the corrosive action of the salt in the solid form or in concentrated solution. The emetic action of the poison also, which we have learned, both from Barthey's experiments on himself, and from the cases of poisoning that have been observed, might possibly be regarded as the consequence of local affection of the mucous membrane of the stomach. The great rapidity with which a case, recently observed by Ricquet, proved fatal, and some symptoms noted in previous cases of poisoning (tremor of the muscles, spasms, depression, etc.), give us reason to suspect that alum exerts also a constitutional action, the more so as in Ricquet's case the local lesions caused by the poison were found at the autopsy to be comparatively slight, and entirely out of proportion to the rapidly fatal cause of the poisoning.

In the mentioned case of Tardieu, 0.9 gramme (fourteen grains); in that of Ricquet, 30 grammes (nearly one ounce) of alum was administered.

Tardieu (loc. cit.) speaks of a woman who willfully murdered her three-months-old child by administering to it about 0.9 gramme (fourteen grains) of alum. In the majority of the other cases of acute poisoning the alum was taken by mistake for other medical preparations (e. g., magnesic sulphate, Ricquet). Von Hasselt states that cases of poisoning also arise sometimes from the administration of too large doses of alum by order of the physician. The sophistication of flour with small quantities of alum, which is much practiced in England, appears to have no toxicological importance, although he finds in it one cause of the prevalence of rhachitis.

To the three cases of alum poisoning by Von Hasselt, Taylor, and Husemann, we must add one case reported by Ricquet, and two cases by Tardieu (loc. cit.), all of which terminated fatally.

Of all the symptoms the most constant are the pains in the cavity of the mouth, in the œsophagus and stomach, which are experienced immediately after taking the poison, and also the vomiting, which comes on very soon, and is, sometimes, bloody. Ricquet also observed severe dysphagia, torturing thirst, and retention of fæces. Several writers mention great weakness of the muscles, and depression. The consciousness is unclouded. There is great anxiety, and sometimes a convulsive tremor of the muscles is observed. The pulse is exceedingly small and frequent. After repeated fainting-fits, and after a considerable reduction of temperature below the normal point, death ensued inside of twenty-four hours.

At the autopsy yellowish-gray deposits were found on the mucous membrane of the mouth, pharynx, and œsophagus; the tongue and palate were swollen. The stomach, intestines, and kidneys were hyperæmic, but without noticeable loss of substance. The chemical tests for the poison were repeatedly employed successfully.

ALUM BAKING POWDER POISONING

Report Dairy and Food Commission, Minn., 1894, Vol. 4.

Page 136. An interesting fact bearing upon the relation of alum in baking powders to public health came under my own observation this summer. As far as I am aware, no case of a similar nature has been recorded. A family of four persons partook of a breakfast consisting principally of corn-cake. The family consisted of the husband and wife, age about forty, their mother, aged about sixty-five, and a robust boy, age about twenty. The husband said the cake tasted "bitter," and would not eat it. The others insisted that the cake was all right, and, to prove their assertion, ate perhaps more of the cake than they ordinarily would, especially the boy, who ate not less than a pound—probably more. While still eating the cake they commenced to feel ill, and the wife and boy vomited. The boy was the most distressed at the time, as the vomiting and retching continued all day, ejecting some blood. The husband, who had not eaten the cake, was unaffected. The aged mother, who did not vomit, was quite sick for three or four days.

A physician was called, who said the physiological effects indicated a metallic poison. The only new material in the cake they had not before eaten was the baking powder. This the cook admitted using in very large quantities. The baking powder they had received free, and the cook was illiterate and could not read the directions.

I found the powder to be an alum phosphate powder, much deteriorated by long exposure. I found no metallic poison, in the usually accepted sense, in the powder.

I also obtained a sample of the corn-cake. This was found to contain .2 p. c. of aluminum oxide, or 1.01 p. c. of potassium aluminum sulphate, or burnt alum. The corn-cake contained, then, 58.15 grains of dried potassium alum, or 106.7 grains of crystallized potassium alum per pound apothecary. This is a larger amount than is usually found in a loaf of bread made from one quart of flour. Some peculiarity in the method of baking this corn-cake must have left at least a part of the alum in the form of the soluble salt—burnt alum. This, and the heaviness or sogginess of the cake, the large quantity eaten, and, above all, the large amount of powder used in baking, were undoubtedly factors which made the physiological effects so severe. At all events, this case proves that under certain conditions alum powders may be decidedly injurious to health.

CINCINNATI, April 10, 1879.

I have met with two cases of poisoning that could be traced to nothing else but alum baking powders. A Mr. Edwards, wife and children, were all made very sick by eating cakes made with it, and their symptoms were so similar to that of arsenical poisoning, that they supposed they had been so poisoned. The case was handed to me and I found nothing in either cakes or powder but alum.

So also with the family of Mrs. W. J. Breed.

We are making efforts here to have a law passed by our legislature to prevent the use of alum in baking powders.

E. S. WAYNE, Ph.D., M.D.

BIBLIOGRAPHY OF ALUM IN ITS RELATION TO THE ANIMAL ECONOMY

Action of Alum in the Animal Economy. Médicine Légale, Tome 3. Paris, 1851.

On Alum: Its Action in the Animal Economy. Orfila, Traité de Toxicologie, Tome 1, p. 336. Paris, 1852.

Cases of Poisoning by Alum. Journal de Pharmacie et de Chimie, 4e serie, Tome XVIII, p. 333. 1873.

Cyclopedia of Practical Medicine (Ziemssen), Vol. XVII, p. 380.

Bulletin Générale Therapeutique, p. 137. 1873.

L'Union Médicale, No. 64. 1873.

Annales de Hygiene Publique, XXXIX, p. 192.

Annales de Hygiene Publique, II, p. 180. 1832.

Annales de Hygiene Publique, II, p. 433. 1845.

Influence of Alum in the Animal System. Schmidt, Jahrbücher der in-und-Auslandischen gesammten Medecin, p. 128. 1886.

Alum in Flour. Dr. Parkes, Practical Hygiene, fourth edition, p. 230. 1873.

The Digestibility of Certain Varieties of Bread; an Experimental Study of the Alum Question. R. F. Ruttan, M.D. Transactions of the Royal Society of Canada, Section III, p. 61. 1887.

The Influence of Alum and the Residue of an Alum Baking Powder on Digestion. Hehner, Analyst, Vol. XVII, 201.

On the Poisonous Effects of Alum in Bread. Dr. Gibbon's Report to the Holborn Board of Works. Pharmaceutical Transactions, Vol. XVI, p. 559. 1857.

The Injurious Effects of Alum upon the Human System when used in Bread and Baking Powder and as Proven by Experiments upon Man and Animals. Pamphlet, pp. 36. London, 1879.

The Effect of Alum on the Animal System. H. A. Mott, Journal of the American Chemical Society, Vol. II, p. 13.

Influence of Alum on the Human System. Bach, Medical Jurisprudence, Vol. II, p. 653. 1851. Pharmaceutical Transactions, Vol. VI, pp. 561, 611, 612. 1857. Analyst, Vol. XVII, p. 201.

Experiments on Double Digestion of the Gastric and Pancreatic Ferments in Presence of Alumina Compounds. Journal of the American Chemical Society, XVI, 587.

Experiments upon Alum Baking Powders and the Effects upon Digestion of the Residues left therefrom in Bread. J. W. Mallet. Chemical News. London, 1889.

On Alum in Bread. Dr. Dauglish, Society of Arts, April 24, 1860.

On Alum and Bread. Watts, Dictionary of Chemistry, Vol. I, p. 659.

Report on Alum in Baking Powders. Reports of the Inland Revenue Department of Canada, 1900.