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CASES OF POISONING IN CATTLE BY FEEDING ON MEAL FROM SOYA BEAN AFTER EXTRACTION OF THE OIL.

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SEVERAL members of the Order Leguminosæ, to which soya belongs, have poisonous properties. There can be little doubt, however, about the non-poisonous character of soya, as it has formed an important article of human food for many years in the East, and of late years has been widely used in the feeding of stock in all parts of the globe.

The following table indicates the composition of soya as a feeding stuff:—

TABLE I.

Total Dry Matter.	Percentage of Constituents of Soya Beans. Total.				Digestible.			Starch Equivalent per 100 lbs.
	Albuminoids.	Oil.	Carbo-hydrates.	Fibre.	Albuminoids.	Oil.	Carbo-hydrates and Fibre.	
89	36	17	26	5	28½	15½	20	82 lbs.

It will be observed that it is very rich in oil; too rich in fact to be a good feeding stuff alone. Moreover, the oily constituent is much more valuable for other purposes than the feeding of cattle. It is

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usually extracted, and the residue is sold in the form of meal or made up into cake for feeding stock.

The soya meal which has been chemically extracted contains about 2 per cent. of oil, but the proportion depends upon whether the method of extraction is good or bad from a manufacturer's point of view, the object being to extract as much as possible.

Extracted soya, whether in the form of meal or cake, has been widely used for the feeding of stock. The solvent, or extracter, generally used has been naphtha, and, so far as report goes, the residue has been used without accident, and has been highly appreciated by stock-owners.

A certain time ago it was reported to the Board of Agriculture and Fisheries that a good many deaths amongst cows had occurred in a district in the south of Scotland. It was found on inquiry that no less than sixty-seven cows on nine different farms had shown visible and definite symptoms of disease. Fifty-four of these died and thirteen recovered. There seems little doubt, however, that several of the other cattle on these farms were slightly affected, although they did not show sufficiently definite symptoms to enable their ailment to be exactly established with that of the others. Mr Berry, one of the Board's Superintending Veterinary Inspectors, and Mr D. B. Rodger, Veterinary Inspector, visited the district, and furnished reports on the symptoms and *post-mortem* appearances.

Symptoms.

The first sign was a falling off in the quantity of milk. This was followed later by the appearance at one or both nostrils of what the owners described as "a trickle of bright red-coloured blood." The other visible mucous membranes, such as those of the eyes and vagina, were sometimes congested, and bleeding took place therefrom. Although the animals, when carefully watched, generally showed preliminary signs of indisposition, they appeared to be quite suddenly attacked, as far as serious symptoms are concerned. Rumination became suspended, the animals had staring coats, shivered, and showed high temperatures ranging from 105° F. to as high as 109° F. The bleeding from the nostrils increased in quantity, and after the owners had become acquainted with the disease they looked for indications of it in the form of blood specks on the mangers and walls.

The dung was at first normal in appearance, but afterwards contained small blood clots and blood-stained mucus. In the later stages the dung became darker in colour and the clots larger, but sometimes the blood contained in the bowel was so discoloured by mixture with dung that its presence was not recognisable by the ordinary appearances of blood.

The urine appeared normal, and there was no suggestion of blood admixture to the naked eye.

Symptoms of abdominal pain were evidenced by paddling of the feet, and striking with the feet at the abdomen was frequently observed.

Nodules varying in size from that of an egg to that of a child's head appeared under the skin, and apparently extended into the muscles. These were found on *post-mortem* examination to be caused by hæmorrhage. In certain cases in which the bleeding occurred into the muscles of the limbs the affected animal became lame. When they occurred in the region of the throat they interfered with the swallowing, and in such cases dribbling of saliva from the mouth was noticed.

It was observed that if an affected animal showed an inclination to eat and ruminate about the third day of the attack there was a reasonable prospect of it surviving. The majority, however, died suddenly, or became weaker and weaker and finally died.

The lapse of time between the first appearance of definite symptoms and death was as follows: One day in three animals, two days in six, three days in six, four days in four, five days in five, six days in two, seven days in two, eight days in four, ten days in one, thirteen days in two, and seventeen days in one animal.

A curious feature of the outbreak was that in no instance was a bull, a young heifer, a calf, a yearling, or a two-year-old not in milk, attacked, although some of them had received the feeding stuff which the owners suspected of being the cause of the trouble. The same applied to some sheep and pigs which received the suspected food on certain premises.

All the animals, in accordance with the custom of the district, were being turned out daily for an hour or so, and were receiving a mixed diet.

Post-mortem Appearances.

The lesions might be described generally as those of hæmorrhage into the tissues and organs. On removing the hide small and large hæmorrhages were found underneath. Some extended into the muscles, and at the borders of these there was a gelatinous œdema.

Respiratory Organs.—Hæmorrhages varying in size from a pin point upwards were present in the mucous membrane of the larynx, trachea, and bronchial tubes. The lungs were usually of a pale hue, but the pleura covering these organs and the chest wall showed patchy hæmorrhages in its substance.

Heart.—The pericardial covering showed similar lesions to the pleura. Small hæmorrhages were present in the heart muscle.

Abdominal Organs.—On the serous covering of the alimentary tract and on the lining of the abdominal wall numerous small hæmorrhages were present. Small circumscribed areas due to clotted blood in the intestinal wall could be seen through the bowel. In some cases loops of bowel had become adherent to each other as the result of a localised peritonitis. On opening into the stomachs, small areas of hæmorrhage were found on the mucous membrane of the fourth stomach. The small and large intestine showed similar hæmorrhages, but in some cases they extended over much larger areas. In certain parts, particularly in the neighbourhood of Peyer's patches, the hæmorrhages had caused rupture of the mucous membrane, giving the lesions the appearance of hæmorrhagic ulcers, like what is sometimes seen in cattle plague and East Coast fever. In the region of the rectum the blood vessels were engorged, and stood out in linear form. Clots of blood were present in the bowel, sometimes forming a complete cast of the tube. Many of the lymph glands of the abdomen were hæmorrhagic, but the other important organs, such as the liver, spleen, and kidneys, showed no marked alterations.

These lesions recall those seen in very acute cases of cattle plague, East Coast fever, the so-called bracken poisoning, and to a less extent hæmorrhagic septicæmia. They are also somewhat indicative of anthrax. The symptoms, however, are not those of cattle plague, and hæmorrhagic septicæmia, East Coast fever, and anthrax were eliminated by inoculating animals and by bacteriological examination. The possibility of bracken poisoning was inquired into, and it was definitely ascertained that the animals could not have had access to bracken.

All the animals had been receiving a ration of extracted soya bean meal or cake, and the various owners, who amongst themselves had naturally discussed the extraordinary happening, were almost unanimous in attributing the trouble to the soya. They had fed soya for months with great benefit, but their idea was that a recent consignment must have contained some other grain of a poisonous nature. It might here be stated, however, that the feeding material was examined at the Government Chemical Laboratory for evidence of poisonous seeds, such as castor, but the result was negative.

Although no other cases of the kind were reported to the Board, it was learned that others had occurred in other parts of Great Britain, and that soya cake and meal had been used for feeding.

Important particulars in relation to eight of the farms upon which disease occurred are summarised in Table II. The point of interrogation after certain dates means that the particulars available were not sufficient to establish the date with accuracy.

TABLE II.

Farms.	*Began to feed Soya.*	*Amount Daily.*	*Discontinued Feeding.*	*Duration of Feeding.*	*First Case after.*	*Last Case after.*	*Remarks.*
		lbs.		*days.*	*days.*	*days.*	
1	1st March	3	10th May	70	50	91	Last case 21 days after soya was discontinued. Died.
2	14th April?	2½	9th May	25	8	52	Last case 27 days after soya was discontinued. Recovered.
3	17th April?	3	30th May	43	9	45	Last case 2 days after soya was discontinued. Died.
4	8th April?	3	4th May	30	19	54	Last case 24 days after soya was discontinued. Recovered.
5	12th April?	3½	10th May	28	25	27	No cases noticed after discontinuing meal.
6	4th April?	4	11th May	37	36	65	Last case 28 days after soya was discontinued. Recovered.
7	3rd March	3	13th May	71	71	80	Last case 11 days after soya was discontinued. Died.
8	14th March	3	17th May	64	62	81	Last case 19 days after soya was discontinued. Recovered.

Table III. gives important particulars which were available in relation to forty-six individual animals on the various farms. The point of interrogation means that the duration was not definitely known.

TABLE III.

Animal.	*Duration of Feeding.*	*Amount Consumed.*	*Remarks.*
	days.	*lbs.*	
1	50	150	
2	53	159	
3	70	210	Became ill 21 days after soya was discontinued.
4	8 ?	20	
5	13 ?	33	
6	25 ?	63	,, ,, 10 ,, ,, ,, ,,
7	25 ?	63	,, ,, 20 ,, ,, ,, ,,
8	25 ?	63	,, ,, 26 ,, ,, ,, ,,
9	25 ?	63	,, ,, 27 ,, ,, ,, ,,
10	25 ?	63	,, ,, 27 ,, ,, ,, ,,
11	9 ?	27	
12	15 ?	45	
13	40 ?	120	
14	42 ?	126	
15	43 ?	129	,, ,, 2 ,, ,, ,, ,,
16	43 ?	129	,, ,, 2 ,, ,, ,, ,,
17	19 ?	57	
18	21 ?	63	
19	26 ?	78	
20	26 ?	78	
21	30 ?	90	
22	30 ?	90	,, ,, 12 ,, ,, ,, ,,
23	30 ?	90	,, ,, 19 ,, ,, ,, ,,
24	30 ?	90	,, ,, 28 ,, ,, ,, ,,
25	30 ?	90	,, ,, 28 ,, ,, ,, ,,
26	25 ?	87	
27	26 ?	91	
28	27 ?	94	
29	27 ?	94	
30	36 ?	144	
31	37 ?	148	,, ,, 5 ,, ,, ,, ,,
32	37 ?	148	,, ,, 5 ,, ,, ,, ,,
33	37 ?	148	,, ,, 14 ,, ,, ,, ,,
34	37 ?	148	,, ,, 24 ,, ,, ,, ,,
35	37 ?	148	,, ,, 28 ,, ,, ,, ,,
36	37 ?	148	,, ,, 27 ,, ,, ,, ,,
37	37 ?	148	,, ,, 28 ,, ,, ,, ,,
38	71	213	
39	71	213	,, ,, 2 ,, ,, ,, ,,
40	71	213	,, ,, 7 ,, ,, ,, ,,
41	71	213	,, ,, 9 ,, ,, ,, ,,
42	62	186	
43	64	192	,, ,, 5 ,, ,, ,, ,,
44	64	192	,, ,, 10 ,, ,, ,, ,,
45	64	192	,, ,, 10 ,, ,, ,, ,,
46	64	192	,, ,, 17 ,, ,, ,, ,,

It appears from the above tables (*a*) that in twenty-six cases out of forty-six (65 per cent.) the symptoms appeared in from two to twenty-eight days after the extracted soya was discontinued; (*b*) that in twelve cases in which the date of commencing to feed on extracted soya was accurately known, the duration of feeding before illness appeared varied from fifty to seventy-one days (average 64·5), and the amount consumed varied between 150 and 213 lbs. (average 193·6 lbs.); (*c*) that in view of the constantly longer periods, and the greater amounts consumed in the cases in which the duration of feeding was accurately known, it seems probable that in the apparently shorter periods, about which the information was not accurate, the animals had in reality been fed for a longer period than that stated by the owners, some of whom only spoke from memory. The apparently very short periods and the comparatively small quantities consumed do not seem to merit very serious consideration. It would seem rather that a certain amount, approximately 150 lbs. and upwards, must be consumed before the symptoms are likely to appear. It would also seem that a certain time is required for the production of the diseased condition, since in many cases it did not show itself until a considerable time after the extracted soya had been discontinued.

Some of the suspected feeding material was obtained directly from farms in the South of Scotland on which the trouble had occurred. Similar material was also obtained from a factory, the manufacturer being most anxious to give every assistance in elucidating the problem.

With the above materials the following feeding experiments were conducted at the Board's laboratory.

Experiment I.—Heifer 312.

On 11th June a sample—2 cwt.—of soya cake was received at the laboratory. It was forwarded by Mr Berry, one of the Board's Superintending Veterinary Inspectors, and had been taken from the same consignment which had been distributed throughout the district.

From 12th to 26th June 4 lbs. of the above cake were fed daily, together with hay, bran, and crushed oats, to Heifer 312 (about fourteen months old).

From 27th June to 10th July the ration of soya cake was increased to 8 lbs. daily; total amount fed, 162 lbs.

From 12th June to 10th July the animal was kept under close observation. The temperature, which was taken twice daily, was always normal, and the animal remained apparently healthy.

On 11th July the animal was turned out in a paddock of grass.

On the morning of 18th July, thirty-six days from the beginning of feeding and eight days after extracted soya was discontinued, the temperature was 107° F., and the animal while in the field was noticed to be bleeding slightly from the left nostril. It was not feeding, and there was suspension of rumination. Examination of the visible mucous membranes revealed numerous petechial blood spots. Microscopical examination of the blood showed nothing abnormal. In the evening the temperature was 106·8° F., and the animal was bleeding from both nostrils. The fæces were very liquid, almost black in colour, fetid in odour, and mixed with blood clots.

On 19th July the temperature in the morning was 105° F., in the evening 107° F. The animal was much worse; depressed and shivering, and the bleeding from the nostrils was continuous. Large clots of blood were being passed with the fæces.

On 20th July the temperature in the morning was 105·4° F. The bleeding from the nostrils continued, and the animal drank large volumes of water. At 2 P.M. on this day the animal was found dead.

Post-mortem Examination.—There were hæmorrhages throughout the whole of the carcase. On the serous membranes they varied in size from a pin-point to a five shilling piece. There was one extensive hæmorrhage extending over the whole of the peritoneal surface of the omasum. There were numerous hæmorrhages up to a diameter of 4 mm. throughout the mucous membrane of the alimentary tract. In the small intestines there were blood clots, some of which were 18 inches in length, and these occluded the lumen of the bowel. The larger muscular masses of the arms and thighs showed areas of hæmorrhagic infiltration up to the size of an orange. All the lymphatic glands of the body were enlarged and hæmorrhagic. The lungs were not collapsed, but they were bloodless. There were no signs of inflammatory changes in any tissue.

Diagnosis.—Death was due to internal and external hæmorrhage, and the condition was regarded provisionally as similar to scurvy.

Experiment II.—Heifer 313.

On 13th June a sample of extracted soya bean meal—1½ cwt.—was received at the laboratory. It was forwarded by Mr Berry from another of the farms on which trouble had occurred.

From 13th to 26th June 4 lbs. of this meal, together with hay, bran, and crushed oats, were fed daily to Heifer 313 (about fourteen months old).

From 27th June to 6th July the daily ration of the meal was increased to 8 lbs.; total amount fed, 136 lbs.

During the period of observation — twenty-three days — the temperature of this animal was normal, and it remained apparently healthy.

Note.—This animal was subsequently used for a further experiment (*see* Experiment XII.).

Experiment III.—Heifer 316.

On 29th July a sample of soya cake—2 cwt.—was received at the laboratory, and on 6th August a further quantity of 4 cwt. was received. These were sent from the same district.

From 29th July to 4th September 2 lbs. of the cake, together with hay, crushed oats, and bran, were fed each day to Heifer 316.

From 4th to 16th September the daily ration of cake was increased to 4 lbs.

From 17th to 24th September the daily ration was 5 lbs.

From 24th September to 7th November the ration was increased to 8 lbs. daily; total amount fed, 476 lbs.

Throughout the period of the observation—seventy days—the temperature of the animal was normal.

On 6th September the animal was scouring and passing fæces almost black in colour, but on 7th September it was apparently normal again. Throughout the remainder of the period of observation the animal remained apparently healthy.

It seems probable that this animal had a mild attack and recovered.

Experiment IV.—Ewe 56.

From 29th July to 8th September—forty-two days—this animal was fed daily with 1 lb. of soya cake, together with bran, crushed oats, and hay; total amount of cake fed, 42 lbs.

Throughout the period of observation the temperature of this animal was normal, and it remained apparently healthy.

Experiment V.—Pig 2233.

From 30th July to 25th August—twenty-seven days—this animal was fed daily with 1 lb. of soya cake and middlings.

During the period of observation the temperature of this animal was normal, and it remained apparently healthy.

Experiment VI.—Pig 2232.

From 30th July to 5th August this animal was fed daily with ½ lb. of soya cake and middlings.

From 6th August to 17th November the ration of soya was increased to 2½ lbs. daily, and no other food was given; total amount fed, 263½ lbs.

During the period of observation—111 days—the temperature of this animal remained normal, and it appeared healthy.

Experiment VII.—Heifer 314.

From 12th to 16th September this animal was fed daily with 2 lbs. of the soya cake and about 18 lbs. of hay.

From 17th to 23rd September the ration of soya was increased to 5 lbs. daily.

From 24th September to 15th October the daily ration of soya was increased to 8 lbs., and the ration of hay reduced to 6 lbs.; total amount fed, 221 lbs.

From 12th September to 15th October the temperature of this animal was normal.

On the morning of 16th October—thirty-four days from the beginning of feeding on the extracted soya—the temperature was 103·6° F. The animal was observed to be off its feed, and it was bleeding slightly from both nostrils. In the evening the temperature was 105° F.

On the morning of the 17th October the temperature was 105·2° F., the animal was dull, and was still bleeding slightly from both nostrils. In the evening the temperature was 105·2° F.

On 18th October, in the morning, the temperature was 106° F. The animal was passing very liquid fæces, almost black in colour, and fœtid in odour. In the evening the temperature was 107° F. As there was reason to suspect internal hæmorrhage a blood count was made on this date, and it showed 4,192,000 red blood corpuscles per cm. (normal number of red blood cells in the ox about 6,000,000 per cm.).

On the morning of 19th October the temperature was 107·2° F. The visible mucous membranes were very pallid; there was profuse diarrhœa, but very little bleeding from the nostrils. In the evening the temperature was 107° F.

On 20th October, in the morning the temperature was 105·4° F.

A blood count gave 2,536,000 red blood corpuscles per cm. In the afternoon the temperature was 106·4° F. The animal was drenched with 6 oz. of soya oil, representing the material extracted in the preparation of soya meal. This treatment was tried on the assumption that the extract might contain something vital in which the cake was deficient.

In the early morning of 21st October the animal was found dead, five days after the signs of illness were first noticed.

Post-mortem.—The carcase was in good condition. There was a large quantity of fat present, which was very yellow in colour. There were extensive hæmorrhages into the subcutaneous tissue, and there were hæmorrhages on the peritoneum, pleuræ, pericardium, and the mucous membrane throughout the alimentary tract. All the abdominal lymphatic glands were intensely congested. There were no other macroscopical lesions. Apparently the most extensive hæmorrhages had been into the lumen of the bowel, and had occurred through rupture of the engorged mucous membrane at the sites of hæmorrhages into the tissue of the bowel. These had the appearance of hæmorrhagic ulcers.

Experiment VIII.—Heifer 315.

From 12th to 16th September this animal was fed daily with 2 lbs. of soya cake and 18 lbs. of hay.

From 17th to 23rd September the daily ration of cake was increased to 5 lbs.

From 24th September to 7th November the ration of cake was increased to 8 lbs., and the hay was reduced to 6 lbs. daily; total amount fed, 408 lbs.

Throughout the period of feeding—fifty-seven days—the temperature of this animal was normal. The bowels were relaxed occasionally for a day or two, but beyond this there was nothing further to note, and the animal was turned out to grass on 7th November.

On 14th November—sixty-four days from the start of feeding on soya cake, and seven days after this feeding was discontinued—the animal was found dead, no previous signs of illness having been noticed.

Post-mortem.—There were extensive hæmorrhages into the subcutaneous tissue of the fore limbs and the back, and large blood clots were found in the intestines.

Experiment IX.—Guinea-pig.

On 1st November a sealed tube containing 85 mg. of an albumin fraction extracted from the cake was received at the laboratory. The albumin fraction was prepared at the Government Chemical Laboratory by direction of Sir James Dobbie. The contents of the tube were emulsified with 5 cc. of sterile saline solution and inoculated to a guinea-pig subcutaneously.

On 4th November the guinea-pig was found dead.

Post-mortem.—There were about 5 cc. of an inflammatory exudate beneath the skin at the seat of inoculation, and the tissue had a necrosed appearance. The exudate showed a large variety of bacteria on microscopical examination. There were no other lesions. Apparently the guinea-pig died of septic infection from the albuminous material.

Experiment X.—Guinea-pig.

On 1st November a sealed tube containing 85 mg. of an albumin fraction from authentic soya beans was received at the laboratory from Sir James Dobbie. The contents of the tube were emulsified with 5 cc. of saline solution and inoculated subcutaneously to a guinea-pig.

The animal remained healthy.

Experiment XI.—Guinea-pig and Rabbit.

On 10th December 64 mg. of an albumin fraction from extracted soya meal was received from Sir James Dobbie. The contents of this tube were emulsified with 4 cc. of sterile saline salt solution, and a rabbit and guinea-pig were inoculated subcutaneously with 2 cc. each of the emulsion.

Both the guinea-pig and the rabbit remained healthy.

Experiment XII.—Heifer 313.

On 8th November some extracted soya meal was received at the laboratory. It was kindly forwarded by a manufacturer who desired to help on the investigation. The sample of meal was labelled No. 8 and was said to contain 1·2 per cent. of oil, and the meal had originally been extracted by trichlorethylene.

From 17th to 19th November this animal was fed daily with 3 lbs. of this meal, together with hay, bran, and crushed oats.

From 19th to 26th November the daily ration of the meal was increased to 5 lbs., and from 27th November to 15th December it was increased to 8 lbs. daily; total amount fed, 196 lbs.

Up to this date (15th December) the temperature of the animal had been normal.

On the morning of 16th December—twenty-nine days from the commencement of feeding the meal—the temperature was 107° F.; in the evening it was 106·4° F.

On the 17th, in the morning, the temperature was 106° F. The animal had dysentery (bloody diarrhœa), and the fæces had a putrid odour. In the evening the temperature was 105·8° F.

On 18th December, in the morning, the temperature was 105° F.; evening 105·4° F. The animal was dull and drank a large quantity of water, and the fæces were very liquid and black in colour.

On 19th December, in the morning, the temperature was 104° F.; in the evening 105·2° F.; the animal was feeding again, but the diarrhœa continued.

On the 20th December, in the morning, the animal was found dead—four days after the first symptoms were noticed.

Post-mortem.—There were petechial hæmorrhages throughout the subcutaneous tissue and muscles, but no extensive extravasations as seen in previous cases. There were blood clots in the pericardial sac, and hæmorrhages throughout the mucous and serous membranes. Throughout the whole of the vessels of the carcase there was very little blood. It appeared that hæmorrhage was the immediate cause of death; probably most of the bleeding had been into the lumen of the bowel.

The animal, which was originally poor in condition, improved considerably at first after having been fed with the meal. This was the same animal as was fed during twenty-three days on 136 lbs. of extracted soya meal (*see* Experiment II.).

Experiment XIII.—Heifer 309.

A sample of meal was received from the same manufacturer. It was labelled No. 12. This sample was stated to contain 7.95 per cent. of oil. It had been extracted with trichlorethylene, but represented bad manufacture in the sense that the extraction was very incomplete.

From 25th November to 1st December Heifer 309 was fed daily with 5 lbs. of this meal, together with hay and crushed oats.

From 2nd to 18th December the daily ration of soya meal was increased to 8 lbs.; total amount fed, 171 lbs.

Throughout the period of the observation—twenty-four days—the temperature of the animal was normal, and it remained healthy.

The sample was exhausted, otherwise the feeding would have been continued.

The histological examination of the lesions has so far failed to furnish an explanation of the pathology of the disease. The most prominent alteration was diffusion of blood cells through the tissues.

A manufacturer whose output of soya residue was concerned was good enough to supply all the information he could on the subject of manufacture.

The principal points in this information were as follows:—

(*a*) That he had for years issued without accident soya extracted by naphtha.

(*b*) That the accidents described synchronised with the naphtha being replaced by trichlorethylene as the solvent.

(*c*) That he had used trichlorethylene on other oily grains, and that the residues had been fed to stock without accident. Discussions brought out, however, that these residues were not fed in the same quantity as soya.

(*d*) That, whether naphtha or trichlorethylene is used, steam at a temperature of about 400° F. is employed to remove the last traces of the solvent from the meal.

After working with trichlorethylene in the laboratory it seemed doubtful if this method was capable of driving off all the trichlorethylene, and, on the question being put to the firm, the opinion was expressed that it probably left a trace.

It transpired that trichlorethylene was suspected of being poisonous, and on the assumption that the trouble might be acute poisoning by this agent the firm had had it tested on cattle. These tests were carried out by giving one or two reasonably large doses to cattle, and the results were negative.

As the trouble had only appeared in animals which had been fed for a considerable time on extracted soya, it was thought possible that trichlorethylene, while not being poisonous in a single dose, might be so if it were administered for some time and in considerable quantity, and this possibility was put to the experimental test.

Experiment XIV.—Heifer 321.

This heifer, which was being fed on ordinary stall diet, received daily by the mouth 3 ozs. of trichlorethylene in 6 ozs. of linseed oil. It was necessary to mix the trichlorethylene with oil to avoid excessive irritation of the alimentary mucous membrane.

This treatment continued for a period of thirty-nine days, and in all the heifer received 117 ozs. of trichlorethylene, a much larger quantity, of course, than any animal could possibly have received in extracted soya. The result was negative.

Conclusions.

The following conclusions and considerations arise from the foregoing experiments and observations:—

1. The cases produced at the laboratory by feeding on extracted soya cake and meal are identical in symptoms and *post-mortem* lesions with the cases occurring in the field amongst cattle which were fed on similar material.

2. In both cases the animals were receiving other food-stuffs (some went out to grass). This discredits the possibility of the trouble being due to a deficiency in vital constituents, as in the scurvy type of disease.

3. In both cases the trouble sometimes did not show itself for one or two weeks after the extracted soya meal or cake had been discontinued and the animal had been turned out to grass. This is a curious feature, and points to the poison being one which takes some time to act, although a poisonous dose is present in the system. It might also mean that the actual poison is manufactured inside the animal by a slow process from extracted soya (*see also* 4).

4. The extracted soya in no case (practice or laboratory) produced a sudden effect; in all a considerable amount was consumed, and a considerable time elapsed before signs of illness appeared. The smallest amount consumed at the laboratory before disease began was 172 lbs. (thirty-six days); the shortest time in which disease appeared was twenty-nine days (201 lbs.).

5. No species other than cattle suffered from feeding on this meal or cake, either in practice or at the laboratory.

6. The very high temperature (106° to 109° F.) accompanying the illness seems to exclude the ordinary poisons, but does not exclude a poison of the ricin class. Specific bacterial infection was excluded by test inoculations, microscopical and bacteriological examinations, and by the fact that a sterilising temperature was used in the process of manufacture. No castor seeds could be traced in the meal.

7. From inquiry (very wide) whole soya bean is not poisonous.

8. From inquiry amongst manufacturers there is plenty of evidence that soya extracted with naphtha does not cause poisoning, and it would appear that trouble followed the use only of soya extracted with trichlorethylene.

9. Trichlorethylene itself, however, is not poisonous when given to cattle in comparatively large doses—1 to 3 ozs., and for long periods. It may be: (*a*) that the products from trichlorethylene obtained by heat are poisonous (this is doubtful); (*b*) that the trichlorethylene in contact with the soya and heat used to drive off the former forms a poison; or (*c*) that some of the trichlorethylene was impure and contained other bodies.

10. It would appear from what occurred in practice that all bovines are, at least, not badly affected by the poison. On nine premises upon which trouble occurred the percentage of visibly affected varied from 1 to 19 per cent.—average, 10 per cent. The farmers thought, however, that the other animals suffered also, though not visibly. It is not improbable, of course, that this was so (*see also* Experiment III.), and that it was only the very badly affected which were taken as being ill. Amongst the visibly affected the death-rate varied from 6 to 100 per cent.—average, 84 per cent. It is possible, having regard to the above, that the poison is one against which a certain amount of immunity can be acquired, as in the case of ricin, but such an immunity did not show itself in Heifer 313.

11. If it be that, in order to obtain a poisonous quantity of the active agent, some 200 lbs., or more, of the material must be extracted, it would hardly seem to be a process which could be undertaken in an ordinary laboratory, but would require a small manufacturing plant.

12. If it be that the active agent is elaborated from the extracted soya in the digestive organs of bovines the problem of isolation becomes still more difficult.

13. If 12 be assumed, the most promising method of search might be to produce cases experimentally, and then try to extract a poison from the organs.

14. Extracted soya meal constitutes an excellent auxiliary foodstuff for cattle, but it is inadvisable to use trichlorethylene as the extractor.

STUDIES IN FORAGE POISONING—III.

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In continuing studies related to forage poisoning, our attention has been called to various outbreaks of this disease wherein it seems that a variety of feed stuffs may incorporate the causative agent. Occasional reports are received of cattle dying subsequent to feeding silage, especially in the winter months, when large quantities of silage are fed to cattle and other live stock in Kentucky. The feeding of silage to horses has been abandoned in many localities owing to the frequent disastrous results. Some horsemen regard wholesome silage as a dangerous feed for this class of live stock.

During the latter part of December 1915 an outbreak of a disease resembling forage poisoning was reported to the Experiment Station