

pH VALUES OF THE CONTENTS OF THE GASTRO-INTESTINAL TRACTS OF SOME FARM ANIMALS¹

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Bradley, Eppson, and Beath² have demonstrated recently that plants of high nitrate nitrogen content are toxic to cattle. They found that the nitrate nitrogen in the plants is in part converted to nitrite nitrogen in the rumen of the cow, the nitrite causing methemoglobinemia which results in anoxemia and subsequent death.

Sheep and horses apparently are not poisoned by these plants of high nitrate content, probably because the nitrates are not reduced to nitrites in their gastro-intestinal tracts. *In vitro* studies on the reduction of nitrates to nitrites (unpublished data, this laboratory) indicated that the difference in the reaction of cattle and that of sheep and horses to these plants of high nitrate content may result from the difference in the pH of their respective gastro-intestinal tracts. In view of this fact a study of the pH values of the ingesta of cattle and sheep was begun. pH values for the ingesta of hogs is also included in this paper, since samples could be obtained for very little added expense and time.

A considerable amount of work has been done on the pH of the contents of the bovine rumen. Dukes³ reports the average pH of the rumen contents of the ox as 8.89 (Gabriel). Kick et. al⁴ found that, depending upon the ration which was being fed, the pH of the rumen contents of cattle varied between 5.5 and 7.7. Monroe and Perkins⁵ worked with cattle fitted with rumen fistulas. They found the pH of the ingesta to vary with various feeds, with different times of sampling,

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²Bradley, W. B., Eppson, H. F., and Beath, O. A. Nitrate as the cause of oat hay poisoning. *J. A. V. M. A.* 94:541-542 (1939)

³Dukes, H. H. Recent advances in the physiology of digestion. *J. A. V. M. A.* 77:225-228 (1930).

⁴Kick, C. H., Gerlaugh, Paul, Schalk, H. F., and Silver, E. A. *Ohio Agri. Expt. Sta. Bull.* 592:105 (1938).

⁵Monroe, C. F. and Perkins, A. E. A study of the pH values of the ingesta of the bovine rumen. *J. Dairy Sci.* 22:983-991 (1939).

and with different locations of sampling within the rumen. They reported pH values of from 5.79 to 7.36 in their various studies

Dukes⁶ quotes several authors in reporting the following pH values for the contents of the various parts of the digestive tracts of different farm animals:

TABLE I

pH Values of the Contents of the Gastro-Intestinal Tracts of Some Farm Animals. (Dukes)

	Contents of	pH Value	Authority*
Cattle	Omasum	7.2	Schwarz and Sremnitzer
	Abomasum	2-4.1	Schwarz and Kaplan
	Duodenum	6.68	Danninger, Pfranger, & Schultes
	Jejunum	8.42	Danninger, Pfranger, & Schultes
	Ileum	8.21	Danninger, Pfranger, & Schultes
	Cecum	8.22	Danninger, Pfranger, & Schultes
Horses	Duodenum	6.72	Danninger, Pfranger, & Schultes
	Ileum	7.09	Danninger, Pfranger, & Schultes
	Cecum	8.12	Danninger, Pfranger, & Schultes
Hogs, Sheep & Calves	Small In- Intestine	6.39-8.05	Long and Fenger

*As quoted by Dukes⁶

⁶Op. cit.

Methods

In this study samples were collected from animals slaughtered by the animal husbandry department.⁷ Samples were taken from the top of the rumen, the bottom of the reticulum, and the centers of the omasum and abomasum in the case of cattle and sheep. In hogs, as much liquid as possible was removed from the stomach for the pH determinations. Composite samples of the contents of the small intestines of sheep and hogs were collected by opening the intestines at six places. Large intestine samples were taken just beyond the junction with the small intestine. In some cases it was necessary to add distilled water to the ingesta in order to get enough liquid to make the pH determination. In preliminary studies it was found that diluting the liquid from the rumen of cattle with an equal amount of water caused only insignificant changes in pH values. When samples other than the omasum samples were diluted an equal amount of water was added to the ingesta, and the values obtained in these cases are probably very close to the actual pH of the ingesta. However, the omasum samples were very dry in most cases and the solution necessary to obtain enough liquid for the pH determination may have been great enough to significantly affect the pH.

The samples were collected as soon as possible after the animals had been killed. pH determinations were made, on unfiltered liquid from the ingesta, with a Cameron potentiometer fitted with a glass electrode and calomel half cell.

Results and Discussion

The results of the work with cattle are given in table 2.

⁷The author is indebted to Professor Forest U. Fenn, Assistant Professor of Animal Husbandry, for his cooperation in the collection of samples used in this study.

TABLE II
pH Values of the Ingesta from the Stomachs of Beef Cattle

Animal No.	Date	Time Between Killing and Determining pH	pH of contents of the				Remarks
			Rumen	Reticulum	Omasum	Abomasum	
1	1-9-40	2½	6.35	6.75	6.3*	3.1*	Yearling
2	1-9-40	2	6.3	6.85	6.1*	4.3	Yearling
3	1-9-40	1	6.7	7.15	6.3	2.95	Yearling
4	1-9-40	¼	6.1	6.95*	7.0*	2.5	Yearling
5	2-28-40	2½	5.8	6.5	6.1*	4.85	Hereford heifer
6	2-28-40	2	6.3	6.75	6.2*	2.0	Hereford heifer
7	2-28-40	1¼	5.9	6.75	5.55*	4.45	Hereford heifer
8	3-12-40	2	6.5	6.9	5.7*	6.3	Shorthorn steer (yearling)
9	3-12-40	1½	5.3	5.75	4.9*	3.6	Shorthorn steer (yearling)
Averages			6.14	6.70	6.01	3.78	

*Samples diluted for determination.

The pH values for the contents of the rumen range between 5.3 and 6.7, averaging 6.14. These values are in general lower than those reported by Monroe and Perkins⁸. The contents of the reticulum were found in every case to be less acid than the rumen contents, their pH values ranging between 5.75 and 7.15, with an average value of 6.70. Since most of the omasum samples had to have a considerable amount of water added to them before the pH determinations could be made, the significance of the results is somewhat limited. However, it appears that the pH of the contents of the omasum is usually considerably lower than that of the reticulum and somewhat lower than that of the rumen. The pH values of the contents of the abomasum are far more variable than those for the contents of the other three stomachs, ranging from 2.0 to 6.3. The abomasum contents were found to be usually much more acid than the ingesta from the other three stomachs.

The pH values of the ingesta from the various stomachs of the sheep were found to compare quite well with those for cattle (see table 3). The omasum and abomasum contents of sheep are possibly a little less acid than those of cattle. Apparently some factor other than the pH of the rumen contents is responsible for the difference of reaction of sheep and cattle to ingested plant material of high nitrate content.

The small and large intestine contents of sheep apparently are just slightly acid to neutral.

⁸Op. cit.

TABLE III
pH Values of the Ingesta of Sheep

Animal No.	Date	Time between killing and determining pH	pH of the contents of						
			Rumen	Reticulum	Omasum	Abomasum	Intestine Small	Intestine Large	
1	3-6-40	4	6.6	6.65	7.0*	4.9	7.1	7.0*	Ewe
2	3-6-40	4	6.3	6.9*	6.3*	5.45	6.8	7.0*	Ewe
3	3-6-40	4	5.5	6.15	5.6*	3.3*	6.4	6.9*	Lamb (male)
4	3-12-40	4	6.25	6.75*	7.05*	4.05*	-----	-----	
5	3-12-40	4	5.75	6.4*	6.05*	4.50*	-----	-----	
6	3-12-40	4	6.25	6.5*	6.65*	3.85	-----	-----	
	Averages		6.11	6.56	6.44	4.34	6.77	6.97	

*Samples diluted for determination.

TABLE IV
pH Values of the Ingesta of Hogs

Animal No.	Date	Time between killing and determining pH	pH of the contents of the			Remarks
			Stomach	Small Intestine	Large Intestine	
1	1-16-40	2	3.95	6.25	5.7*	Poland China barrow
2	1-16-40	2	3.7	6.5	5.4	Chester White barrow
3	1-16-40	2	4.45	6.45	5.4*	Chester White barrow
4	3-13-40	2½	4.0*	6.0*	5.75*	Duroc Jersey barrow
5	3-13-40	2½	4.1*	6.4*	5.5	Duroc Jersey barrow
6	3-13-40	2½	3.35*	6.1	5.8*	Duroc Jersey barrow
Averages			3.93	6.28	5.59	

*Samples for determination.

pH values of from 3.35 to 4.45 were found for the ingesta from the hog's stomachs, the average value being 3.93 (see table 4). Although this range in values is smaller, the average compares well with the averages for the abomasums of sheep and cattle. The large intestine of the hog was found to be somewhat more acid than the small intestine, the average pH values being 5.59 and 6.28 respectively.

Summary

pH values for the stomach contents of cattle and the stomach and intestine contents of sheep and hogs were determined on the ingesta of slaughtered animals.

The four stomachs of sheep and cattle were found to be quite similar as concerns the pH of their contents.

The pH of the hog's stomach is apparently about the same as that for the abomasum of sheep and cattle.

The contents of the intestines of sheep were found to be neutral to slightly acid. The average pH value for the small intestine of the hog was found to be 6.28. For the large intestine it was 5.59.