NOTE.—Since the writing of this paper the work of Sebelien, Brynildsen and Haavardsholm (*Chem.-Ztg.*, **33**, 795 (1909)) has come to our notice. These investigators report the very satisfactory results obtained by the aeration procedure applied to total nitrogen determination, but they do not give data upon the nitrogen in organic materials.

Conclusions.

1. The Kober aeration process for the total nitrogen determination in organic materials can be successfully used, except in cases where the elements magnesium and phosphorus are present together in relatively large amounts.

2. Materials which contain relatively large amounts of both magnesium and phosphorus can be correctly analyzed for the total nitrogen by the Kober method when it is so modified as to keep the aerating solutions in the Kjeldahl flasks warm for the entire period of aeration.

3. The Kober aeration procedure has many advantages over the official distillation procedure and the results are as accurate except as mentioned above.

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THE DISAPPEARANCE OF PENTOSANS FROM THE DIGESTIVE TRACT OF THE COW.

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Received September 18, 1909.

Within recent years a great deal of energy has been devoted to the study of the physiology of the pentosans and their derivatives, the pentose sugars.[1]

The pentosans make up a large part of the "nitrogen-free extract" of the hays and coarse fodders used in animal feeding, and the degree in which they contribute to the maintenance of the animal is a matter of the utmost importance. The present paper is a report of a preliminary series of experiments which is being supplemented by further work on special phases of this subject.

It has been repeatedly confirmed that the pentosans of the food disappear from the digestive tract in rabbits and sheep to the extent of 40–80 per cent.[2] It seems also demonstrated that the pentose sugars, when absorbed by the animal, are utilized for energy production, and may lead to glycogen formation.[3]

[1] C. Neuberg, *Ergebnisse der Physiologie*, Bd. 3, 1, p. 373 (1904), gives an excellent résumé of the work in this field and makes reference to individual papers unnecessary.

[2] Slotzoff, *Z. physiol. Chem.*, **34**, 181 (1901–2). Stone, *Ber.*, **25**, 563 (1902). Weiske, *Z. physiol. Chem.*, **20**, 489 (1895). Stone and Jones, *Agric. Science*, **7**, 6–20 (1893). Lindsay, *Mass. Exp. Sta. Report* (1894), p. 175, 12th annual Rept.

[3] Ebstein, *Virchow's Archiv.*, **129**, 401 (1892); **134**, 361 (1893). Voit, *Deut*

The cow is one of the largest consumers of coarse feeding stuffs, and since it is also one of the most efficient of all animals in the transformation and utilization of foodstuffs it is an excellent subject for the study of the utilization of the pentosans.

Kellner,[1] McDowell[2] and Weiser[3] have studied the digestion of pentosans in mixed rations. McDowell also studied the disappearance of pentosans when clover hay alone and timothy hay alone was fed to steers. In these experiments he found a disappearance of 60.75 and 57.18 per cent., respectively. With the exceptions just noted no other investigations seem to have been made to compare the relative ease with which the pentosans from different plant sources disappear from the digestive tract of an animal. Likewise nothing is known concerning the behavior of the methyl pentosans in the digestive tract, and very little concerning the distribution of these substances in our common feeding stuffs. Our object in the present series of experiments was to obtain evidence on these questions.

The cows used in these experiments were grade Durhams. They were purchased as calves and when their weights were about 350 lbs. each, individuals were placed upon rations derived each from a single plant source. The plants used were corn, wheat and oats. When the collections of excreta were made for analysis the animals had been on their respective rations for a period of about nine months. This gave abundant time for the development of special flora in their digestive tracts in case certain varieties of organisms found a more suitable food supply in one case than in another. While the second series of experiments was in progress a study was also made by the Department of Agricultural Bacteriology of the flora of the digestive tracts of the animals. Mr. Wright[4] concluded from his investigations that no special organisms developed to the exclusion of other forms in any individuals as a result of the character of the ration.

The animals were placed successively in a stall and the urine and feces collected quantitatively for twenty-four-hour periods by two workmen, one serving during the day and the other at night. The feces and urine were weighed and sampled. A five-pound sample of feces was spread in a thin layer and dried in a current of air at 65°, placed in a paper bag and all samples were preserved thus until they had acquired an air-dry moisture content, when all samples were weighed at the same time,

Arch. klin. Med., **58**, 523 (1897). V. Jacksch, *Ibid.*, **63**, 612 (1899). Bergell, Festschrift zum 70 Geburtstag von E. Von Leyden, 2 (1902). Neuberg and Wohlgemut, *Ber.*, **34**, 1745 (1901) and *Z. physiol. Chem.*, **35**, 41 (1902).

[1] Kellner, *Landwirtschaftliche Versuchsstationen*, **53**, 72 (1900).

[2] McDowell, *Penn. Agric. Exp. Sta. Rept.*, **1906**, p. 94.

[3] Weiser, *Landwirtschaftliche Versuchsstationen*, **58**, 238 (1903).

[4] Thesis (1909), Mr. W. H. Wright, University of Wisconsin.

ground and further sampled for analysis. The urine was preserved with chloroform and toluene in Mason jars.

The pentosan content was determined by the method of the Association of Official Agricultural Chemists. This consists in converting the pentosans into furfural by distillation with 12 per cent. hydrochloric acid, precipitation of the furfural as phloroglucide and weighing. Methyl pentosans were determined by the method of Ellett and Tollens,[1] which consists in extracting the phloroglucide precipitate with 95 per cent. alcohol at 65° after weighing. Small portions of alcohol were used and five successive extractions were made. Methyl furfural phloroglucide is soluble in this solvent and the furfural phloroglucide is not. The analyses were calculated to pentoses by the method adopted by the Official Agricultural Chemists. The methyl pentoses were calculated to rhamnose.

The results of the first series of experiments made during 1908 were so striking that it was thought desirable to repeat the work. This was done one year later (1909). During the interim the animals were kept on the same rations. The same individuals were employed in both experiments.

The results of the two series of experiments are shown in the following tables:

TABLE I.—RATION OF THE CORN-FED CALF AND ITS CONTENT OF PENTOSES.

Ration.	Per cent of pentoses (air dry).	Weight of pentoses (moisture-free basis). Grams.
5 lbs. corn meal	5.90	133.8
7 lbs. corn stover	28.86	916.37
2 lbs. gluten feed (corn)	18.52	168.04
Total		1218.21

The feed was entirely consumed daily throughout the experiment.

TABLE II.—SHOWING THE DISAPPEARANCE OF PENTOSANS OF THE CORN PLANT FROM THE DIGESTIVE TRACT OF A YEAR-OLD CALF IN THE EXPERIMENT OF 1908.

Date.	Feed per day. Lbs.	Pentose content (moisture-free basis). Grams.	Weight of feces (moisture-free basis). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Feb. 14	14	1218.2	817.7	189.6	84.44
" 15	14	1218.2	1687.4	401.3	67.88
" 16	14	1218.2	1999.2	522.4	57.12
" 17	14	1218.2	1566.8	352.8	71.04
" 18	14	1218.2	1767.1	440.5	63.85
" 19	14	1218.2	1948.8	490.9	59.70
" 20	14	1218.2	1899.2	378.1	68.96
" 21	14	1218.2	1893.1	395.5	67.53
				Average.	67.56

[1] Ellett and Tollens, *J. Landwirtschaft*, **53**, 1 (1905).

TABLE III.—SHOWING THE DISAPPEARANCE OF PENTOSANS OF THE CORN PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Date.	Feed per day. Lbs.	Intake of pentoses. Grams.	Weight of feces (air dry). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Jan. 18.....	16	1392.0	2085.0	378.0	72.85
" 19.....	16	1392.0	2328.8	520.5	61.17
" 20.....	16	1392.0	2097.9	468.2	66.49
" 21.....	16	1392.0	2042.0	451.2	67.59
" 22.....	16	1392.0	1899.5	464.1	66.66
" 23.....	16	1392.0	2058.2	466.7	66.48
" 24.....	16	1392.0	2062.0	461.0	66.88
				Average,	66.87

A number of samples of urines were examined for furfural-yielding substances. To 100 cc. urine were added enough 37 per cent. hydrochloric acid to make a 12 per cent. solution, and the urine distilled according to the official method. These results are given in Table IV:

TABLE IV.—SHOWING THE CONTENT OF FURFURAL-YIELDING SUBSTANCES IN COW'S URINE WHEN THE RATION WAS DERIVED FROM DIFFERENT PLANT SOURCES.
(Results Calculated as Pentoses.)

Date.	Plant supplying ration.	Number of animal.	Volume of day's urine. cc.	Pentose content of day's urine. Grams.
Feb. 14 (1909)	Mixture { Oat, Wheat, Corn }	555	4907	1.1237
" 15 "	Corn	563	4509	1.2895
" 1 "	Oat	567	4564	1.7571
" 1 "	Oat	569	6999	2.4486
" 21 "	Corn	572	2650	0.8222
" 21 "	Corn	558	3219	1.2647
" 10	Wheat	565	2848	1.2106
" 10	Wheat	571	2627	0.9050
Mar. 18 (1908)	Corn	572	3016	1.3059
" 20 "	Oat	569	2979	1.8291
" 15 "	Wheat	565	5732	3.2400

The very small amount of furfural-yielding substances found in these urines is in accord with the observations of Weiske[1] and Lindsay[2] for other animals. Since substances other than pentoses, especially glycuronic acid and its combinations, which are normally present in urine, yield furfural on distillation, it is questionable whether any pentose sugars were present in these urines. It was thought permissible to disregard this factor.

[1] Weiske, *Z. physiol. Chem.*, **20**, 489 (1895).
[2] Lindsay, *Mass. Exp. Sta. Rept.*

TABLE V.—DISAPPEARANCE OF THE PENTOSANS OF THE WHEAT PLANT FROM THE DIGESTIVE TRACT OF THE COW.

Showing the Ration Used in this Experiment.

Ration.	Per cent. pentoses.	Weight of pentoses in ration. Grams.
7 lbs. wheat straw	23.09	733.24
6.7 lbs. whole wheat	11.73	356.52
0.3 lb. wheat gluten	1.33	18.06
Total		1107.82

The entire ration was consumed daily throughout the experiment.

TABLE VI.—SHOWING THE DISAPPEARANCE OF PENTOSANS OF THE WHEAT PLANT FROM THE DIGESTIVE TRACT OF A YEAR-OLD CALF IN THE EXPERIMENT OF 1908.

Date.	Feed per day. Lbs.	Content of pentoses. Grams.	Weight of feces (moisture-free). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Feb. 23	14	1107.8	2150.06	505.3	54.39
" 24	14	1107.8	2014.03	483.9	56.31
" 25	14	1107.8	2031.00	502.3	54.66
" 26	14	1107.8	1961.05	451.4	58.35
" 27	14	1107.8	2045.70	491.4	55.64
" 28	14	1107.8	1977.70	468.2	57.74
" 29	14	1107.8	2061.80	535.5	51.67
				Average,	55.55

TABLE VII.—SHOWING THE DISAPPEARANCE OF PENTOSES OF THE WHEAT PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Date.	Feed per day. Lbs.	Content of pentoses. Grams.	Weight of feces (air dry). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Jan. 10	16	1251.5	2700.8	683.3	45.19
" 11	16	1251.5	2783.0	682.9	45.44
" 12	16	1251.5	2364.7	613.5	50.90
" 13	16	1251.5	2992.8	756.0	39.60
" 14	16	1251.5	2512.5	629.0	49.75
				Average,	46.18

TABLE VIII.—DISAPPEARANCE OF THE PENTOSANS OF THE OAT PLANT FROM THE DIGESTIVE TRACT OF THE COW.

Showing the Ration Used in this Experiment.

Ration.	Per cent. of pentoses.	Weight of pentoses. Grams.
7 lbs. oat straw	27.99	879.9
7 lbs. rolled oats	7.07	203.9
	Total,	1083.8

TABLE IX.—SHOWING THE DISAPPEARANCE OF THE PENTOSANS OF THE OAT PLANT FROM THE DIGESTIVE TRACT OF A YEAR-OLD CALF IN THE EXPERIMENT OF 1908.

Date.	Feed per day. Lbs.	Content of pentoses. Grams.	Weight of feces (moisture-free). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Mar. 2.....	14	1083.8	1875.7	423.6	60.91
" 3.....	14	1083.8	2591.9	585.5	45.96
" 4.....	14	1083.8	2240.3	508.6	53.07
" 5.....	14	1083.8	2265.7	529.9	52.11
" 6.....	14	1083.8	2391.8	533.3	50.79
" 7.....	14	1083.8	2084.7	454.9	58.02
" 8.....	14	1083.8	1931.0	463.4	57.24
				Average,	53.87

TABLE X.—SHOWING THE DISAPPEARANCE OF THE PENTOSANS OF THE OAT PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Date.	Feed per day. Lbs.	Content of pentoses. Grams.	Weight of feces (air dry). Grams.	Pentoses in feces. Grams.	Per cent. of pentoses disappearing from digestive tract.
Jan. 26.....	14	1103.2	2497.1	505.1	54.37
" 27.....	14	1103.2	1907.6	422.3	61.73
" 28.....	14	1103.2	2587.9	546.1	50.49
" 29.....	14	1103.2	2197.3	465.1	57.85
" 30.....	14	1103.2	2017.0	444.5	57.09
" 31.....	14	1103.2	2230.8	518.0	53.05
Feb. 1.....	14	1103.2	2206.3	506.3	54.11
				Average,	55.52

TABLE XI.—DISAPPEARANCE OF METHYL PENTOSANS OF THE CORN PLANT FROM THE DIGESTIVE TRACT OF THE CALF IN THE EXPERIMENT OF 1908.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1.....	216.5	117.02	45.95
2.....	216.5	82.16	62.06
3.....	216.5	84.16	61.13
		Average,	56.38

TABLE XII.—DISAPPEARANCE OF METHYL PENTOSANS OF THE CORN PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1.....	247.36	56.08	77.33
2.....	247.36	55.63	77.52
3.....	247.36	57.90	76.60
4.....	247.36	75.14	69.63
5.....	247.36	30.44	87.70
6.....	247.36	43.01	82.62
7.....	247.36	57.32	76.83
		Average,	78.31

TABLE XIII.—DISAPPEARANCE OF METHYL PENTOSANS OF THE WHEAT PLANT FROM THE DIGESTIVE TRACT OF A ONE-YEAR-OLD CALF IN THE EXPERIMENT OF 1908.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1	207	31.99	60.39
2	207	44.99	78.27
3	207	44.88	78.32
		Average,	72.33

TABLE XIV.—DISAPPEARANCE OF METHYL PENTOSANS OF THE WHEAT PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1	238.7	0	100.0
2	238.7	0	100.0
3	238.7	93.37	60.81
4	238.7	75.87	68.13
		Average,	82.23

TABLE XV.—DISAPPEARANCE OF METHYL PENTOSANS OF THE OAT PLANT FROM THE DIGESTIVE TRACT OF A YEAR-OLD CALF IN THE EXPERIMENT OF 1908.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1	147.3	57.66	60.85
2	147.3	57.01	61.29
3	147.3	62.10	57.84
4	147.3	62.23	57.25
		Average,	59.31

TABLE XVI.—DISAPPEARANCE OF METHYL PENTOSANS OF THE OAT PLANT FROM THE DIGESTIVE TRACT OF A TWO-YEAR-OLD COW IN THE EXPERIMENT OF 1909.

Day.	Rhamnose in ration. Grams.	Rhamnose in feces. Grams.	Per cent. disappearing from digestive tract.
1	147.3	86.05	41.58
2	147.3	44.43	70.81
3	147.3	65.42	57.00
4	147.3	54.09	64.46
5	147.3	45.66	70.00
		Average,	61.05

The data obtained in these experiments show that the furfural-yielding substances contained in the corn plant regularly disappear from the digestive tract of the cow to a much greater extent than do the corresponding bodies in the wheat and oat plants.

The nutritive ratios of all these rations were the same, and the calorific values of the rations were nearly equivalent. It would seem that as

far as possible the influence of varying amounts of protein on the digestion of the nitrogen-free extract of the ration was eliminated. The pentosans of the corn plant are present in a form which is less resistant than are those of wheat and oats.

The methyl pentosans disappear in greater amount in every case than do the simple pentosans. Various observers[1] have shown that the enzymes secreted by the digestive tract do not affect the pentosans.

Brown[2] has found in the digestive tract of herbivora, enzymes which convert the cell walls of grains into soluble products with remarkable rapidity and holds the view that these are derived from the grains themselves. To these enzymes he attributes the chief action in the solution of the resistant carbohydrates and holds that the rôle of bacteria in these processes is of secondary importance.

In order to determine the action of the bacteria of the intestinal tract of the cow on the disappearance of pentosans, a series of fermentations were carried on during 14 days with corn fodder, wheat and oat straw, respectively. The fodder and straws were ground to a powder and one gram of material was weighed into Erlenmeyer flasks. A quantity of fresh cow feces was then introduced into a flask and agitated with a nutrient salt solution prepared according to the directions of Omelianski.[3]

TABLE XVII.—SHOWING THE DECREASE IN PENTOSAN CONTENT OF FEEDS DURING INCUBATION WITH FECAL BACTERIA.

Material. 1 gram.	Atmosphere.	Original content of pentoses. Gram.	After 14 days' incubation. Gram.	Per cent. disappearing.
Corn fodder	Carbon dioxide	0.2924	0.1435	50.93
	" "	0.2924	0.1405	52.64
	Hydrogen	0.2924	0.0738	74.76
	"	0.2924	0.0658	77.50
Wheat straw	Carbon dioxide	0.2309	0.1655	28.33
	" "	0.2309	0.1666	27.85
	Hydrogen	0.2309	0.1450	37.21
	"	0.2309		38.77
Oat straw	Carbon dioxide	0.2799	0.1849	33.95
	" "	0.2799	0.2033	27.37
	Hydrogen	0.2799	0.1459	48.90
	"	0.2799	0.1422	59.10

The solution was then filtered with suction through a layer of paper pulp, and fifty cc. of the filtrate were added to each Erlenmeyer flask containing the samples of feeds. The flasks were closed with double-hole rubber stoppers and connected in series by short glass tubing doubly

[1] Slotzoff, *Z. physiol. Chem.*, **34**, 161 and 181.

[2] Brown, *J. Chem. Soc.*, **61**, 352 (1892).

[3] Omelianski, *Centralbl. Bakteriologie*, 2 Abt., **8**, 193 (1902).

bent at right angles. After passing hydrogen through the flasks for half an hour the inlet was closed with a pinchcock and the outlet with a mercury trap. The flasks were then incubated at 40°. In one series carbon dioxide was employed to expel the air from the flasks instead of hydrogen.

After two weeks the contents of each flask were used for a furfural distillation in the usual manner. The results are shown in Table XVII.

From these results it is apparent that the intestinal bacteria destroy pentosans under anaerobic conditions, and here again the degree in which these are destroyed varies with the plant and in the same order as was observed in the feeding experiment.

These experiments warrant the conclusions:

1. That the pentosans of the corn plant are more easily attacked and disappear from the digestive tract of the cow in a greater degree than do those of the wheat and oat plants.

2. That the methyl pentosans of these three plants are less resistant to the agencies operating in the digestive tract than are the simple pentosans.

3. That in the artificial cultures of fecal bacteria from the cow the behavior of the pentosans from corn, wheat and oats is the same as is observed in feeding experiments, *viz.*, those of the corn plant are less resistant than those of the oat, and those of the oat less resistant than those of the wheat.

NEW BOOKS.

Experimental Dairy Bacteriology. H. L. RUSSELL AND E. G. HASTINGS. Boston: Ginn & Co.

This little work of 146 pages is designed solely for students in practical Dairy Bacteriology. Although it gives brief statements as to the significance of some of the facts presented, its aim is to simply give a guide for experimental work, rather than any instruction in the general subject of dairy bacteriology. The subjects covered are those which would be naturally included in such a laboratory course. The structure and use of a microscope, the preparation of media for bacteriological work, the isolation of bacteria, the purification of cultures, etc., as well as the application of these various facts to the problems of the dairy. An appendix gives the bacteriological chart of the American Bacteriolocial Society and a glossary of terms used, as well as tables for converting the centigrade to the Fahrenheit scale and the metric into the English scale of weights and measures. The book is neatly printed and cannot fail to prove useful to laboratory students in this increasingly important subject. H. W. CONN.