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DIGESTION EXPERIMENTS

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BY G. S. FRAPS, CHEMIST.

These experiments were conducted jointly by the Division of Animal Husbandry and the Division of Chemistry of the Texas Experiment Station. The Division of Animal Husbandry was responsible for the care and feeding of the animals, and the collection of excrement. Professor F. R. Marshall and Mr. J. C. Burns, of the Division of Animal Husbandry, and Cadets Evans and McLeod took part in this work. The digestion coefficients were published in Bulletin No. 97 in connection with other work of the Division of Animal Husbandry, which they were intended to supplement.

The Division of Chemistry is responsible for the preparation of samples, the analyses, and the discussion which follows. Mr. N. C. Hamner is responsible for the work on the sugars, starch, and pentosans; all the other assistant chemists had some share in the other analyses.

The objects of the work published in this Bulletin are as follows:

First—To secure some information regarding the relative feeding values of kaffir corn, milo maize, and molasses by means of a determination of the quantity of these feeds which is digested by steers.

Second—To determine the percentages of sugar, starch, and pentosans digested by the animals from these feeding stuffs. Work of this kind gives information as to the value of the constituents of the nitrogen-free extract of plants.

Third—To determine the proportions of the phosphoric acid, potash and nitrogen in the food which are excreted in the solid excrement. This gives information in regard to the value of the manure secured from different feeding stuffs.

PART I.

DIGESTIBILITY OF KAFFIR CORN, MILO MAIZE, AND MOLASSES.

The object of a digestion experiment is to ascertain by actual tests upon animals, the proportions of the different nutrients which are digested, and thereby become of value to the animal. The difference between the quantity of nutrients in the food fed and the quantity in the corresponding solid excrement is supposed to represent the quantity of nutrients digested. The *coefficient of digestion* is secured by dividing the quantity of each nutrient digested by the quantity which is fed. Knowing the coefficient of digestion of the nutrients in a given feeding stuff and the composition of the feeding stuff, it is a simple matter to calculate the quantity of digestible nutrients contained in any desired amount of the feed.

When the digestibility of a concentrated feeding stuff is to be estimated, a basal ration is first fed and its digestibility determined. A known amount of the concentrated feed is then added, and the digestibility of the mixture determined. The quantity of nutrients digested from the mixed ration less the quantity digested from the basal ration, gives the quantity taken from the concentrated feeding stuff. It is obvious that the determination of the digestibility of the concentrated feeding stuff is affected by any circumstances which affect the digestibility of the basal ration, and this determination is subject to a greater error than that of the basal ration.

The nutrients which disappear during the passage of food through the animal are not entirely absorbed, since a portion of them are converted by fermentation into gases, chiefly carbon dioxide and marsh gas, which are of no service to the animal. This fermentation appears to be of advantage since it aids in the digestion of material which would otherwise be useless to the animal, but at the same time it involves a loss of material, which is apparently digested.

It also appears that digested nutrients from different classes of feeding stuff do not have equal values to the animal body. This is partly due to the difference in the work required in chewing and digesting different feeds and also to the difference in the character of the constituents which make up the feeding stuff. Rations which take account of the different nutritive values of the same digested nutrient in different feeding stuffs are obviously a step forward and more promising of results to the feeder than rations based upon the theory of equal values for the same nutrients digested from different feeding stuffs. We will return to the discussion of this later.

DEFINITION OF TERMS.

The constituents of feeding stuffs are divided into groups, each one of which, except water, consists of a number of different chemical compounds which vary in proportion and in character with different classes of feeding stuffs. These groups are as follows:

Protein is the constituent of the food which contains nitrogen, and which forms flesh, muscles, hair, and other nitrogenous portions of the animal body. It furnishes material for additional flesh and to replace the wear and tear of the animal tissue. It may also be burned in the animal to produce heat or serve as a source of fat. Heat and fat may, however, be secured from constituents of feeding stuffs cheaper than protein.

Fat or ether extract in concentrated feeding stuffs is composed mainly of fats and oils, but the ether extract of grasses and hays is often composed to a considerable extent of waxes, coloring matters, and other bodies not fat, and the ether extract, therefore, has less value than true fats. Fat is used in the animal body to build up animal fat and to furnish heat and energy. Fat is more valuable than carbohydrates or protein for these purposes, one pound of fat being equal to about 2.25 pounds carbohydrates, or protein, for the production of energy or of fat.

Crude fiber is the most resistant portion of the plant and is composed of woody materials. The more crude fiber a feeding stuff contains the less valuable it is, other things being equal.

Nitrogen-free extract is much more digestible and valuable than the crude fiber. In concentrated feeding stuffs, the nitrogen-free extract is composed chiefly of starch, sugars, and similar substances which are easily digested and have high nutritive values, but in hays and fodders it is composed of hemicelluloses and other material less easily digested and of lower value to the animal than the starches and sugars.

The term, *Carbohydrate,* strictly speaking, should be applied to substances containing hydrogen and oxygen in a proportion to form water, combined with carbon. This would include sugars, starches, pentosans, and cellulose.

The term, *Digestible Carbohydrates,* is often applied to the digestible nitrogen-free extract and crude fiber taken together. Other substances than carbohydrates are present in these two groups of nutrients, particularly in the case of hays, fodders, and straws.

METHOD OF EXPERIMENT.

Two steers were selected and placed in a stall provided with a galvanized iron box, adjusted to catch the droppings. The steers were fed on a basal ration of two pounds cotton seed meal and ten pounds cotton seed hulls per day for the entire period of experiment. A sufficient quantity of cotton seed meal and hulls had been secured for the work, and each had been thoroughly mixed before the experiment was begun.

At the beginning of each period the meal and hulls were weighed out separately in daily rations, in sufficient number to last through the entire period. The kaffir corn and milo maize were weighed out in the same way, four pounds being added each day to the basal ration. The molasses used was from a single barrel, and three samples of it were taken for analysis during the progress of the experiment.

Each period was divided into a preliminary period of ten days and a digestion period of eight days, the same quantity of feed being given each day of the entire time. During the last eight days the excrement was collected. The entire quantity each day was brought to the laboratory, weighed, mixed thoroughly and a portion taken for analysis and estimation of dry matter. At the end of each period the dry excrements were mixed in proportion to the quantity excreted each day.

Several accidents interfered with the progress of the work as planned. Steer No. 1 had to be replaced by another animal. Several of the experiments with Steer No. 3 were interrupted. In such instances the collection of excrement was continued for eight days from the time of interruption.

The digestibility of the ration during the short periods before the interruptions was estimated, but on account of the natural irregularity in the excretion of faeces, these determinations have much less value than those made with longer periods. It is important to emphasize the fact that the digestion period should not be too short. In period four with Steer No. 2 the dry matter excreted varied from 1974 to 2558 grams per day. With Steer No. 3 the variation was less, being from 1928 to 2360 grams per day. These differences were considerable. The average dry matter excreted for three or four consecutive days was in some instances nearly the same as the average for eight days, but sometimes there were wide variations. For example, the dry matter excreted on days five, six, and seven of period three by Steer No. 2 was 2474 grams, being about 8 per cent greater than the average for the period (2269 grams). It is evident that too short a period for the collection of the excrement is liable to lead to too high or too low a digestion coefficient.

DIGESTIBILITY OF BASAL RATION OF MEAL AND HULLS.

Table No. 1 shows the composition of the cottonseed meal and hulls used in this investigation and the coefficients of digestibility we secured from the four experiments as well as our average. We also give the average coefficients of digestibility for cottonseed meal and hulls as compiled in Bulletin No. 77, Office of Experiment Stations, United States Department of Agriculture.

TABLE 1.—COMPOSITION AND DIGESTIBILITY OF COTTONSEED MEAL AND HULLS.

Laboratory Number.		Water.	Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
867	Cottonseed hulls—percentage composition	8.52	4.70	0.94	48.91	3.33	33.60	91.48
868	Cottonseed meal—percentage composition	6.57	43 50	11.85	8.65	6 33	23.10	93.43
	Coefficient of digestion of meal and hulls (percentage digested):							
	Period 1, steer 1, 3 days	.....	55.9	93.9	54.6	41.7	69.0	60.4
	Period 1, steer 2, 6 days	.....	50.8	96.3	44.9	43.4	64.5	53.9
	Period 4, steer 2, 8 days	.....	49.5	93.9	52.1	41.2	65.2	57.1
	Period 4, steer 3, 8 days	.....	53.9	94.4	54.1	46.4	67.2	59.5
	Average	.....	52.5	94.6	51.2	43.2	66.5	57.7
	Average for cottonseed hulls* (A)	.....	.....	85.7	40.0	23.2	41.1	39.8
	Average for cottonseed meal* (B)	.....	88.4	88.6	55.5	23.7	60.6	73.7
	Coefficient of digestion of meal and hulls calculated from (A) and (B)	.....	.....	87.6	41.7	23.1	43.5	.....

*From Bulletin 77, Office of Experiment Station, U. S. Department of Agriculture.

We have also calculated the coefficient of digestibility of the mixture of meal and hulls used in our experiments from these average figures. The calculated value is appreciably less than that actually determined by us, and the difference is particularly great with the nitrogen-free extract. We found the nitrogen-free extract to be digested about 50 per cent more than it was calculated to be. This difference may be due to the fact that the average figures in the Bulletin referred to were secured from results varying considerably on some feeding stuff constituents, and in our work we may have approached nearer the maximum of digestibility than the above average.

It will be noted that the fat has a high digestibility. The protein is not as readily digested as that of some other feeding stuffs.

DIGESTIBILITY AND VALUE OF KAFFIR CORN.

Table No. 2 shows the composition of the cracked kaffir corn used in the digestion experiment, the average composition of kaffir corn, and the coefficients of digestion secured in these experiments and in experiments at other stations.

TABLE 2.—COMPOSITION AND DIGESTIBILITY OF KAFFIR CORN.

Laboratory Number.		Water.	Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
866	Kaffir corn (grain), percentage composition	12.41	8.15	2.20	2.73	1.59	72.92	87.59
	Average composition*	9.86	10.98	3.12	2.75	1.63	71.18	88.51
	Coefficient of digestion:							
	Period 2, steer 2, 9 days (A)	.....	62.9	81.0	61.2	99.0	82.4	80.2
	Period 2, steer 3, 3 days (B)	.....	71.5	83.4	100.0	100.0	83.0	85.2
	Period 2, steer 3, 8 days (C)	.....	64 9	75.2	.....	38.1	88.4	81.3
	Average of A and C	.....	63.9	78.1	.....	68.5	85.4	80.7
	By Oklahoma Station†	.....	43 6	44.8	45.4	63.9	40.8	41.7
	" " For kaffir meal	.....	53.3	46.1	.....	.....	75.9	64.2
	By Kansas Station‡ for meal.	.....	54.8	.....	.....	18.3	80.3	61.2

*Bulletin 95, Texas Experiment Station.
†Bulletin 35, Faeces contained some unmasticated grain.
‡Bulletin 103.

The kaffir corn used in our experiments contains smaller quantities of protein and fat than the average. In fact, it is considerably below the average in its content of protein. In our experiments the kaffir corn was digested much more nearly completely than in the experiments at the Oklahoma or Kansas Experiment Stations. The difference may be due to much more thorough mastication by our animals. It was noted at the Oklahoma Station that a certain proportion of the kaffir corn passed through the animal unchanged.

TABLE 3.—COEFFICIENTS OF DIGESTIBILITY (TEXAS EXPERIMENTS.)

	Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
Kaffir corn	63.9	78.1	.....	68.5	85.4	80.7
Milo maize	65.9	90.2	.....	.....	84.5	84.0
Molasses	49.0	.....	.....	104.4	104.6	93.5
Corn meal*	67.9	92.1	.....	.....	94.6	89.4
Wheat bran.*	77.8	68.0	28.6	.....	69.4	62.3
Cottonseed meal*	88.8	88.6	57.0	.....	77.6	78.7

*Average by other workers.

Table 3 shows the average coefficients of digestibility of kaffir corn, milo maize, and molasses secured in the experiments here reported and, for comparison, the average coefficient of digestibility of corn, wheat bran, and cottonseed meal secured by other workers. (For details of the experiments, see tables at end of this Bulletin.) It is noted that the fat and nitrogen-free extract of kaffir corn and milo maize are more completely digested than those in wheat bran and cottonseed meal, on an average, and somewhat less than those in corn meal. The protein of

kaffir corn and milo maize is less easily digested than that of corn meal, wheat bran, or cottonseed meal, though the difference from corn meal is slight, and more than compensated for by the larger content of protein in kaffir corn and milo maize.

Table 4 contains the digested nutrients in 100 pounds of kaffir corn, milo maize, molasses, and some other feeding stuffs, inserted for comparison. We would judge from these figures that corn meal has about 10 per cent greater value for feeding than kaffir or milo maize.

TABLE 4.—DIGESTIBLE NUTRIENTS* IN 100 POUNDS KAFFIR CORN, ETC.

	Protein, pounds.	Fat, pounds.	Crude Fiber, pounds.	Ash, pounds.	Nitrogen-Free Extract.	Fat Value.
Kaffir corn	7.0	2.4	.....	.....	60.7	18.1
Milo maize	7.1	2.5	.....	.....	61.0	18.5
Corn meal	6.5	3.6	.....	.....	67.8	20.6
Wheat bran	11.5	3.0	2.4	.....	41.9	16.3
Cottonseed meal	41.5	8.1	2.9	.....	19.2	20.1

*These figures are based on the average composition of Texas feeds given in Bulletin No. 95 of this Station.

DIGESTIBILITY AND VALUE OF MILO MAIZE.

Table 5 shows the composition of the milo maize used in these experiments, the average composition of milo maize as given in Bulletin No. 95 of this Station and the coefficient of digestibility of milo maize secured in these experiments.

The milo maize used in these experiments is somewhat below the average in protein and fat, but the difference is not as great as in the case of the kaffir corn.

TABLE 5.—COMPOSITION AND DIGESTIBILITY OF MILO MAIZE.

Laboratory Number.		Water.	Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
906	Milo maize (grain), percentage composition	10.27	9.45	2.23	2.72	1.74	73.69	87.99
	Average composition*	9.66	10.73	2.78	3.05	2.30	72.22	88.01
	Coefficient of digestion:							
	Period 3, steer 2, 8 days (A)	.....	70.8	86.7	100	100	85.9	90.7
	Period 3, steer 3, 4 days (B)	.....	40.2	84.4	.....	42.2	83.2	70.8
	Period 3, steer 3, 8 days (C)	.....	61.0	93.8	.....	83.5	83.1	77.2
	Average of A and C	.....	65.9	90.2	.....	.....	84.5	84.0

*Bulletin No. 95. Texas Experiment Station.

We have already given in Table 3 the coefficients of digestibility of milo maize. It is seen that in this respect milo maize compares favorably with corn.

We have also shown in Table 4 the average digestible nutrients in milo maize, with some other feeding stuffs for comparison. In this respect milo maize also compares favorably with corn. One hundred pounds milo maize or kaffir corn contains approximately one-half pound more digestible protein, 1.1 pounds less digestible fat, and 6.8 pounds less digestible nitrogen-free extract than corn. Since one pound fat is equal to 2.25 pounds nitrogen-free extract, the total difference is 8.8 pounds nitrogen-free extract when we deduct the protein. Corn appears to be about 7 per cent poorer in digestible protein, and 13 per cent richer in digestible carbohydrates, than kaffir corn or milo maize. We would thus say that the grain of kaffir corn and milo maize have about 10 per cent less feeding value than corn, and this conclusion appears to be in accord with feeding tests made at this and other stations and discussed in Bulletin No. 97 of this station.

DIGESTIBILITY OF MOLASSES.

Table 6 shows the composition of the molasses used in these experiments. The coefficients of digestibility secured in this work and at other stations have also been included in the table.

The digestion experiments with the molasses were not altogether satisfactory. It appears that the nitrogen-free extract of molasses is highly digestible.

TABLE 6.—COMPOSITION AND DIGESTIBILITY OF MOLASSES.

Laboratory Number.		Water.	Protein.	Reducing Sugar.	Sucrose.	Non-Sugar.	Nitrogen-free Extract.	Ash.
929	Percentage composition.....	24.33	4.00	19.11	39.66	8.40	.....	4.50
930	Percentage composition.....	23.50	4.06	19.08	39.46	9.29	.....	4.61
931	Percentage composition.....	25.92	4.06	19.13	39.48	6.81	.....	4.60
	Average.....	24.58	4.04	19.11	39.53	8.17	.....	4.57
	Coefficient of digestion.							
	Period 5, steer 2, 8 days...	.....	27.1	.....	.....	.....	103 0	91.0
	Period 5, steer 3, 8 days...	.....	86.2	.....	.....	.....	106.1	117.8
	Average.....	.....	56.7	.....	.....	.....	104.6	104.4
	Average of Kellner et al*	.....	49.0	.....	.....	.....	87.9	.....

*Experiment Station Record *13*, 776.

PRODUCTIVE VALUE OF FEEDS.

We have already stated that the digested nutrients of different feeding stuffs do not have the same value to the animal. Thus, one pound of digested nitrogen-free extract from corn is of more value to the animal

than one pound digested from cottonseed hulls. The difference may be due in part to the greater labor of chewing the cottonseed hulls than corn, in part to difference in the nature of the nitrogen-free extract, or to other causes.

The productive value of a feeding stuff may be different for animals which are just being maintained at a constant weight, and for those which are being fattened. (See Bulletin No. 84, Pennsylvania Experiment Station.)

The productive values of feeding stuffs and the nutrients which compose them have been measured in terms of fat by Kellner. The method of experiment consists in feeding the animal with a basal ration which is more than sufficient to maintain the fattening animal. The quantity of fat stored by the animal is then determined exactly, by methods which it would take too much space to describe. The feed to be tested is then fed, in addition to the basal ration, for a sufficient period, and the increase in fat again estimated. The difference gives the amount of fat produced from a known amount of feed. By this method, as we have said, the fat values of different feeding stuffs and nutrients have been determined. Whether or not the value of feeds for other uses of the animal are in the same proportion as the fat value, remains to be determined by actual experiment, but the use of the actual productive value of feeding stuff promises a great advance in the science of animal feeding.

We may define *fat value* as the quantity of fat produced by 100 pounds of the feed when added to a basal ration already sufficient for the needs of the animal body. We prefer the use of this term, *fat value,* because it does not involve any theory as to the value of the food for other purposes, and the fat production is actually determined in the experiments.

The content of digestible protein and the fat value of feeding stuffs afford a good basis of comparison. These two values vary in importance in different sections of the country, in some case the protein being more expensive, in others the fat value. As a rule, however, the protein is more expensive than the fat value.

Table 4 shows the fat values of kaffir corn, milo maize, and some other feeds for comparison.

EFFECT OF CRUDE FIBER ON VALUE.

In coarse feeding stuffs each gram of crude fiber in the food decreases the fat value of the digested constituents of the feed by about 0.14 gm. fat. In a concentrated feeding stuff, since each gram increase of crude fiber represents one gram decrease in nitrogen-free extract having a digestibility of about 80 per cent and a fat value of 0.20 grams fat, each gram of crude fiber represents a total decrease in the productive value of the feeding stuff of about 0.33 grams fat. This figure is probably below, rather than above the real decrease, since the crude fiber is accompanied by nitrogen-free extract having a lower value than the nitrogen-free extract of the feeding stuff proper.

WATER-SOLUBLE CONSTITUENTS OF EXCREMENTS.

The material dissolved by cold water was estimated in excrements from periods Nos. 1, 3, and 4. Something over 3 per cent of the excrement was soluble in water, of which approximately one-third was ash, something over one-third was protein, and less than one-third non-protein organic matter. About 10 per cent of the total protein, 20 per cent of the total ash, and 3 per cent of the nitrogen-free extract was soluble in water.

While the above facts are of some interest it was not considered of importance to pursue the investigation further.

PART II.

DIGESTIBILITY OF SUGARS, STARCH AND PENTOSANS.

The nitrogen-free extract of feeding stuffs is known to contain sugars, which are easily soluble in water; starch, which may be brought into solution by the action of ferments, and pentosans. The term pentosan properly includes a number of chemical compounds of different character, but which are all related to pentose sugars. As is well known, all the pentosans are not contained in the nitrogen-free extract, but a considerable proportion of them may be present in the crude fiber. This is especially true of materials rich in crude fiber and pentosans.

The nitrogen-free extract of concentrated feeding stuffs is largely made up of sugars and starches, which is perhaps one reason for their high feeding value. The nitrogen-free extract of hays and coarse feeding stuffs contains, as a rule, only small quantities of starch, although it may contain a *fair quantity* of sugars. It usually contains considerable quantities of pentosans. For example, the author found one hundred parts of the nitrogen-free extract of timothy hay to contain about ten parts sugar, and 35-40 parts pentosans. (Bulletin No. 172, N. C. Experiment Station.) The residue may contain some starch and probably consists to a considerable extent of substances related to pentosans, but derived from hexose sugars, which may, therefore, be termed hexosans. It is extremely desirable that investigations should be carried out on the composition of the nitrogen-free extract of coarse feeding stuffs.

In the work here reported our attention was confined chiefly to the study of the digestibility of the sugars, starches, and pentosans.

METHODS OF ANALYSIS.

The method used for estimating sugar was as follows: Mix 5 grams substance with 50 cc. water, stir well and filter into a 100-cc. flask containing 10 cc. concentrated hydrochloric acid; wash to nearly 100 cc. and heat to 87 degrees, taking fifteen minutes; cool and make up to volume. An aliquot portion is used for the determination of sugar.

We, therefore, include in our estimation of sugar both the reducing sugars and the compound sugars which are inverted by hydrochloric acid under these conditions.

Starch was determined by the diastase method and pentosans by the methods of the Association of Official Agricultural Chemists. For the estimation of pentosans in crude fiber three grams of material was boiled with acid and alkali and the crude fiber, which had been collected on asbestos, was distilled with hydrochloric acid according to the usual method.

DIGESTIBILITY OF SUGARS.

According to previous work by the author (Bulletin No. 172, N. C. Experiment Station), sugars are completely digested in most feeding stuffs. Small quantities of reducing substances appear to be present in the excrement, but apparently do not consist of sugars.

In the work here reported no attempt was made to eliminate the reducing substances from the solution. The chief subjects of study contain only small quantities of sugars and also quantities of starch. As the reducing substances could not be eliminated in the estimation of the starch, it was considered desirable to proceed in this work as if they were sugars.

Table 7 shows the digestibility of the sugars in the different materials excreted, assuming the reducing matter in the excrement to consist of sugars. With the exception of kaffir corn, the sugar in all the materials was digested to a greater extent than 90 per cent. The kaffir corn contained only 0.84 per cent of sugar, and it is evident that a small error of analysis would cause a great difference in the coefficient of digestibility calculated on this amount. This is apparent when we consider the digestibility of the sugars in milo maize, from which it would appear that more sugar was digested from the cottonseed meal and hulls than in previous periods. The sugar in molasses appears to be completely digested.

TABLE 7.—DIGESTIBILITY OF SUGARS.

	Percentage Digested.
Cottonseed meal and hulls.	
Period 1, steer 1, 3 days.	95.4
Period 1, steer 2, 6 days.	92.0
Period 4, steer 2, 8 days.	95.7
Period 4, steer 3, 8 days.	96.4
Kaffir corn.	
Period 2, steer 2, 9 days.	86.2
steer 3, 3 days.	78.3
steer 3, 8 days.	86.2
Milo maize.	
Period 3, steer 2, 8 days.	116.3
steer 3, 4 days.	103.3
steer 3, 8 days.	93.7
Molasses.	
Period 5, steer 2.	100.4
steer 3.	100.6

Considering all these facts, including the previous work which has been done upon this subject, we feel justified in saying that even when the reducing substances in the excrement are considered to be sugars, the sugars present are digested to the extent of 90 to 100 per cent, and their digestibility approaches the higher rather than the lower figure.

STARCH.

Comparatively few determinations have been made of the digestibility of starch contained in feeding stuffs, in which the diastase method was used for the estimation of the starch. It is well known that if the starch is brought into solution by means of dilute acid, other carbohydrates also are dissolved.

Cottonseed meal does not contain starch. Cottonseed hulls, and the excrement from a ration of cottonseed hulls and meal, appear to contain starch according to the diastase method. The writer is inclined to believe, however, that true starch is not really present, but other substances go into solution under the action of the diastase and are converted into reducing bodies. This explanation is supported by the fact that the digestibility of this apparent starch in the cottonseed meal and hulls ration is only from 12 to 30 per cent, whereas the nitrogen-free extract was digested from 64.5 to 69 per cent and true starch should be digested as much as or more than the total nitrogen-free extract.

It would appear that either this apparent starch in cottonseed hulls is much less readily digested than the nitrogen-free extract, or else that some of the substance which goes into solution with diastase is produced by fermentation within the intestines of the animals. If either of these suppositions is true, it is evident that the apparent starch of cottonseed hulls is not starch at all, for we could not expect true starch either to be digested to a less extent than the nitrogen-free extract, or to be produced by any process within the animal's body.

The starch of kaffir corn and milo maize is digested from 96.6 to 99.8 per cent. It appears that the starch of concentrated feeding stuffs is almost completely digested when the food is thoroughly masticated.

TABLE 8.—DIGESTIBILITY OF STARCH.

	Percentage Digested.
Cottonseed meal and hulls.	
Period 1, steer 1, 3 days	29.8
steer 2, 6 days	12.3
Period 4, steer 2, 8 days	28.0
steer 3, 8 days	23.6
Kaffir corn.	
Period 2, steer 2, 9 days	98.0
steer 3, 3 days	96.6
steer 3, 8 days	97.4
Milo maize.	
Period 3, steer 2, 8 days	99.8
steer 3, 4 days	99.7
steer 3, 8 days	99.6

PENTOSANS.

Pentosans are derivatives of pentose sugars, and when distilled with concentrated hydrochloric acid they yield furfural. However, other bodies are found in plants which give rise to furfural when distilled with hydrochloric acid. Oxycelluloses and lignocelluloses yield furfural, but are not pentosans.

It is well known that a portion of the pentosans are found in the nitrogen-free extract and a portion in the crude fiber. About 20 per cent of the pentosans are found in the crude fiber. It is possible that the supposed pentosans in the crude fiber are really oxycelluloses and lignocelluloses.

The digestibility of the pentosans has been determined by W. E. Stone, Lindsay, Holland, the writer and others. (See Bulletin No. 172, N. C. Experiment Station.) They are sometimes more and sometimes less digestible than the nitrogen-free extract.

The digestibility of the total pentosans, the pentosans in the nitrogen-free extract, and in the crude fiber are determined in the experiments here reported. Since the quantity of the pentosans in the basal ration was very large and in the milo maize and kaffir corn very small, no digestive coefficients were secured for pentosans in these feeding stuffs.

About 25 per cent of the pentosans in cottonseed hulls and 20 per cent in cottonseed meal were contained in the crude fiber. The pentosans in the nitrogen-free extract were digested to greater extent than those in the crude fiber. In the basal ration of cottonseed hulls and meal the difference is considerable, being about 20 per cent. This is in accordance with previous experiments of the writer on timothy hay and green rape, although the difference was not so great. Crab grass hay is apparently an exception, the pentosans in the crude fiber being digested to a greater extent than those in the nitrogen-free extract. It is quite possible, however, that other experiments would not confirm this result with crab grass hay.

The distribution and digestibility of the pentosans is presented in Table 9.

TABLE 9.—DISTRIBUTION AND DIGESTIBILITY OF PENTOSANS.

Laboratory Number.		In 100 Parts Feeding Stuff.			Coefficient of Digestibility.		
		Total Pentosans.	Pentosans in Nitrogen-Free Extract.	Pentosans in Crude Fiber.	Total Pentosans.	Pentosans in Nitrogen-Free Extract.	Pentosans in Crude Fiber.
867	Cottonseed hulls	20.00	14.64	5.36	....	.....	.....
868	Cottonseed meal	5.26	4.27	0.99	.....	.....	.....
906	Milo maize	2.65	2.43	0.22	.....	.....	.....
866	Kaffir corn	1.60	1.32	0.28	.....	.....	.....
	Timothy hay, No. 1*	24.86	19.71	5.15	55.9	58.1	46.9
	Green rape, No. 1*	10.57	9.57	1.00	94.6	95.7	84.6
	Crab grass hay, No. 1*	26.25	21.90	4.35	63.1	61.0	69.9
	Cottonseed meal and hulls.						
	Period 1, steer 1, 3 days	.....	.....	.....	81.3	86.5	66.9
	steer 2, 6 days	.....	.....	.....	75.2	79.9	62.3
	Period 4, steer 2, 8 days	.....	.....	....	78.3	82.9	65.5
	Period 4, steer 3, 8 days	.....	.....	.....	79.2	83.4	68.6
	Average	.....	.....	.....	78.5	83.2	65.8

*Fraps, Bulletin 172, N. C. Experiment Station.

RESIDUAL NITROGEN-FREE EXTRACT.

We apply the term residual nitrogen-free extract to the residue left after subtracting sugars, starches and pentosans from the total quantity of nitrogen-free extract. A comparison of the quantities of constituents of nitrogen-free extract is given in Table 10.

Residual nitrogen-free extract makes up about 50 per cent of the total nitrogen-free extract in cottonseed hulls, about 25 per cent in cottonseed meal, something less than 10 per cent in milo maize, and 5 per cent in kaffir corn.

TABLE 10.—COMPOSITION OF NITROGEN-FREE EXTRACT IN PARTS PER 100 OF MATERIAL.

Laboratory Number.		Sugar.	Starch.	Pentosans.	Residue.	Total Nitrogen-Free Extract.
866	Kaffir corn	0.84	67.44	1.32	3.32	72.92
867	Cottonseed hulls	0.73	2.13	14.64	16.10	33.60
868	Cottonseed meal	11.35	1.03	4.27	6.45	23.10
906	Milo maize	1.49	63.00	2.43	6.77	73.69
931	Molasses	58.64	.....	.....	8.17	66.81
862	Excrement steer No. 1, period 1	0.29	3.41	4.36	16.65	24.71
863	Excrement steer No 2	0.43	3.66	5.56	14.57	24.22
898	Excrement steer No. 3, period 2, sample 1	0.34	5.07	5.57	21.89	32 87
899	Excrement steer No. 2, sample 2	0.39	4.00	5.85	20.88	31.12
900	Excrement steer No. 3, sample 3	0.28	4.50	5.87	18.15	28.80
903	Excrement steer No. 3, period 3, sample 1	0.19	3.23	7.31	19.39	30.12
904	Excrement steer No. 3, sample 2	0.26	3.40	7.04	20.76	31.46
905	Excrement steer No. 2, sample 1	0.16	3.48	7.02	21.35	32.01
916	Excrement steer No. 3, period 4	0.23	3.77	5.55	16 90	26.45
917	Excrement steer No. 2	0.26	3.36	5.30	17.68	26.60
952	Excrement steer No. 2, period 5	0.20	2.30	.....	.....	23.83
953	Excrement steer No. 3	0.12	2.20	.....	.....	24.63

Table 11 shows the digestibility of the different constituents of the nitrogen-free extract, with that of the crude fiber for comparison. Sugars and starches are both highly digested. Next come the pentosans, and the residue is digested to a less extent. We have already called attention to the fact that the apparent starch in cottonseed hulls is hardly true starch.

The residual nitrogen-free extract in cottonseed meal and hulls is digested to approximately the same extent as the crude fiber. In timothy hay this is also true, but with crab grass hay there is considerable difference.

TABLE 11.—DIGESTIBILITY OF NITROGEN-FREE EXTRACT AND CRUDE FIBER.

Percentage digested from:	Sugar.	Starch.	Pentosans.	Residue.	Total.	Crude Fiber.
Cottonseed hulls and meal.						
Period 1, steer 1, 3 days	95.4	29.8	86.5	54.0	69.0	54.6
steer 2, 6 days	92.0	12.3	71.9	53.1	64.5	44.9
Period 4, steer 2, 8 days	95.7	28.0	82.9	49.2	65.2	52.1
steer 3, 8 days	96.4	23.6	83.4	54.0	67.2	54.1
Kaffir corn.						
Period 2, steer 2, 9 days	86.2	98.0	.....	*	82.4	.....
steer 3, 3 days	78.3	96.6	.....	*	85.2	.....
steer 3, 8 days	86.2	97.4	.....	*	81.3	.....
Milo maize.						
Period 3, steer 2, 8 days	116.3	99.8	.....	*	85.9	.....
steer 3, 4 days	103.3	99.7	.....	*	83.2	.....
steer 3, 8 days	93.7	99.6	.....	*	83.1	.....
Timothy hay No. 1†	100.0	.....	58.1	50.1‡	60.0	52.3
Timothy hay No. 2†	100 0	.....	57.0	46.0‡	56.0	53.8
Crab grass hay†	100.0	.....	61.0	32.7‡	50.0	67.3

*The quantity of residue digested was less than the quantity digested from the basal ration.
†Fraps, Bulletin 172, N. C. Experiment Station.
‡Any starch present included.

The addition of kaffir corn or milo maize appeared to decrease the digestibility of the nitrogen-free extract of cottonseed hulls and meal, especially of the residual nitrogen-free extract. For this reason we find more residual nitrogen-free extract when kaffir corn and milo maize were fed than there was present in these feeding stuffs. We also find that, although the sugars and starch of milo maize and kaffir corn exhibit a high percentage of digestibility, the total nitrogen-free extract has apparently a much lower digestibility, although only a small proportion of the nitrogen-free extract of these feeding stuffs is other than sugars and starch. It thus appears possible that the digestibility of the nitrogen-free extract of starchy concentrated feeds is really greater than it is supposed to be.

DIGESTIBILITY OF CRUDE FIBER.

In many hays the crude fiber is digested to a greater extent than nitrogen-free extract. In Table 12 we present the digestion coefficients of all hays of cereal grasses on which more than one experiment was made, which are published in Bulletin No. 77, Office of Experiment Station, U. S. Department of Agriculture. On an average the crude fiber appears to be digested 1 per cent more than the nitrogen-free extract. Considering the fact that the nitrogen-free extract of these hays contains some sugars and probably a small proportion of starch, we find that the residual nitrogen-free extract digested to a less extent than the crude fiber.

We are inclined to believe that this fact is due to changes in the crude fiber in the intestines of the animal, which renders it soluble in acid or alkali and, therefore, apparently a portion of the nitrogen-free extract, thus making the digestibility of the crude fiber greater than it should be and that of the nitrogen-free extract less so. This view has been put forward by the author in Bulletin No. 172 of the North Carolina Experiment Station.

TABLE 12.—DIGESTION COEFFICIENT OF HAYS OF CEREAL GRASSES.

	Nitrogen-Free Extract.	Crude Fiber.
Blue joint, average of 2	55.9	54.5
Crab grass, average of 2	54.5	59.1
Johnson grass, average of 2	56.9	65.7
Orchard grass, average of 2	55 4	60.4
Redtop, average of 2	61.9	61.3
Timothy, average of 17	62.5	52.5
Wild oat grass, average of 2	65.5	67.9
Witch grass, average of 2	65.6	62.8
Mixed grasses, average of 5	58.7	59.7
Pasture grass, average of 2	74.2	76.1
Rowen hay, average of 2	66.2	66.6
Average excess for crude fiber		0.9

PART III.

PLANT FOOD.

A feeding stuff possesses both a feeding value and a fertilizing value. If it is used as a feeding stuff and the animal excrement is lost, advantage is secured only by the feeding value of material. If it is used as a fertilizer, as is very often the case with cottonseed meal, no advantage is secured from the feeding value.

The constituents of the food fed to animals undergo a change in the animal body, but there is no loss of fertilizing material. The entire quantity of nitrogen, phosphoric acid, and potash in the food fed is either stored up in the body or excreted in the urine, in the solid excrement, or in case the animal is giving milk, a portion of it passes in the milk. The quantity of the fertilizing constituents of feeding stuff retained by a fattening animal is comparatively small. Young and growing animals retain larger proportions and milk cows use a certain amount in their milk, but a considerable part of the fertilizing value of the feed still passes into the excrement. In Table 14 is presented the plant food contained in the feeds used in this experiment and in the excrement secured therefrom. The figures for the excrement refer to the dried material containing the quantity of water shown in the table. The fresh excrement contains on an average about 70 per cent of water, so that the figures for the fresh material should be 30 per cent, respectively, of each of the ingredients.

The valuation per ton for the constituents of the feeding stuff is figured on the same valuation as is used in this State for commercial fertilizers during this season, namely, phosphoric acid 6 cents per pound, potash 6 cents per pound, and nitrogen 17 cents per pound. Table 13 shows the amount of plant food fed and excreted. These figures are calculated from the average composition and quantity of the excrements. We have not considered it advisable to carry out our calculations for each individual experiment.

We find that on an average 40 per cent of the phosphoric acid, 25 per cent of the potash and 48 per cent of the nitrogen, being 42 per cent of the fertilizing value of the feeding stuff, is excreted in the solid excrement. Since the animals used in the experiment were fattening animals, it is hardly likely that more than 5 per cent of each fertilizing constituent was retained in the body. Accordingly we find that approximately 55 per cent of the phosphoric acid, 70 per cent of the potash, and 47 per cent of the nitrogen is excreted in the urine, or about 53 per cent of the total valuation of the feeding stuff.

TABLE 13.—PLANT FOOD FED AND EXCRETED, IN GRAMS.

	Phosphoric Acid.	Potash.	Nitrogen.	Valuation.
In 4356 grams hulls	25.2	52.7	32.7	
In 907 grams meal	25.4	18.8	63.1	
Total fed per day	50.6	71.5	95.8	
Excreted in solid excrement per day	18.8	22.5	48.3	
Per cent in solid excrement	37.1	31.4	50.4	45.2
In hulls and meal	50.6	71.5	95.8	
In 1815 grams kaffir corn	10.5	5.8	23.6	
Total fed	61.1	77.3	119.4	
Excreted in solid excrement per day	21.9	18.1	57.6	
Per cent in solid excrement	37.5	23.4	48.2	42.7
In hulls and meal	50.6	71.5	95.8	
In 1815 grams milo maize	14.1	7.8	27.4	
Total fed	64.7	79.3	123.2	
Excreted per day	24.1	24.6	54.1	
Per cent in solid excrement	39.0	31.0	43.9	40.9
In hulls and meal	50.6	71.5	95.8	
In 1361 grams molasses	3.4	44.4	8.8	
Total fed	54.0	115.9	104.6	
Excreted per day	25.6	15.2	50.2	
Per cent in solid excrement	47.4	13.1	48.0	39.1
Average per cent in solid excrement	40.3	24.7	47.6	42.0

Accordingly, if the solid excrement is saved, there is a saving of about 42 per cent of the fertilizing value of the feeding stuff. If the urine is saved in addition, there is a saving of about 95 per cent of the fertilizing value. These figures have no reference to the loss of nitrogen by fermentation or of fertilizing material due to leaching of the excrement by rain.

In other words, if a ton of cottonseed meal is fed, having a fertilizing valuation of $29.50, the portion of its fertility which goes into the solid excrement has a valuation of $12.39. That portion of its fertility which goes into the urine has a valuation of about $15.

The other feeding stuffs which we are considering have a much lower fertilizing value per ton than cottonseed meal, but it amounts to a considerable sum.

If a farmer feeds cottonseed meal and other feeding stuffs in such a manner that the fertility in the solid and liquid excrement enters his soil, and gets enough for his cattle to pay for the food, feeding and original cost of cattle, he still makes considerable profit. He is getting

a profit of $20 to $30 in plant food for each ton of cottonseed meal he has fed.

TABLE 14.—PERCENTAGE OF PLANT FOOD IN FEEDS AND IN DRY SOLID EXCREMENTS.

Laboratory Number.		Phosphoric Acid.	Potash.	Nitrogen.	Water.	Valuation per ton.
866	Kaffir corn	0.58	0.32	1.30	.....	$ 5.50
867	Cotton seed hulls	.58	1.21	0.75	.....	4.70
868	Cottonseed meal	2.80	2.07	6.96	.....	29.50
906	Milo maize	0.78	0.43	1.51	.....	6.59
930	Molasses	0.25	3.26	.65	.....	6.12
	Excrement from cottonseed meal and hulls					
862	Steer 1, 3 days	1.08	1.16	.....	9.18	
863	Steer 2, 6 days	.60	.90	.....	9.25	
917	Steer 2, 8 days	.83	.94	.....	5.87	
916	Steer 3, 8 days	.66	.81	.....	5.59	
	2378 grams average, per cent	0.79	0.95	2.03	7.47	$ 8.98
	Excrement from milo maize, hulls and meal.					
899	Steer 2, 9 days	.83	.83	.....	6.44	
898	Steer 3, 3 days	.88	1.03	.....	6.26	
900	Steer 3, 8 days	1.15	1.05	.....	7.43	
	Average	.95	.97	2.13	6.71	$ 9.54
	Excrement from kaffir corn, hulls and meal					
905	Steer 2, 8 days	.75	.55	.....	4.62	
903	Steer 3, 4 days	.95	.75	.....	5.27	
904	Steer 3, 8 days	.88	.73	.....	5.25	
	Average	.86	.71	2.26	5.05	$ 9.56
	Excrement from molasses, hulls and meal					
952	Steer 2, 8 days	1.05	.76	.....	6.58	
953	Steer 3, 8 days	1.20	.57	.....	6.23	
	Average	1.13	.67	2.22	6.40	$ 9.73
	Average for the fresh dung	0.28	.25	.65	.....	2.84

SUMMARY AND CONCLUSIONS.

1. The ration of cottonseed meal and hulls fed in this experiment was digested to a much greater extent than the calculated digestion from average figures.

2. The nutrients of the grain of kaffir corn and milo maize are somewhat less digestible than the corresponding nutrients in Indian corn.

3. Indian corn has about 10 per cent greater value for feeding than kaffir corn or milo maize.

4. The nitrogen-free extract of molasses is highly digestible.

5. The productive value of different classes of feeds as measured by the fat produced, is not in proportion to their digestible constituents.

6. Increase in crude fiber in a feed means a decrease in productive value.

7. Sugars are digested 92 to 100 per cent, even when the reducing materials in the excrement are considered to be sugars.

8. The apparent starch of cottonseed hulls, which can not be true starch, though dissolved by diastase, has a low digestibility.

9. The starch of kaffir corn and milo maize is almost completely digested.

10. The digestibility of the pentosans is discussed.

11. Although the nitrogen-free extract of milo maize and kaffir corn is composed almost entirely of starch, the nitrogen-free extract was digested to a much less extent than the starch. This difference is probably due to a depression of digestibility of the nitrogen-free extract of the meal and hulls. It appears possible that the nitrogen-free extract of starchy feeds is digested to a greater extent than is shown by digestion coefficients.

12. It appears possible that crude fiber undergoes changes within the animal which render it soluble in acid or alkali and therefore a portion of the nitrogen-free extract.

13. Forty per cent of the phosphoric acid, 25 per cent of the potash, and 48 per cent of the nitrogen, being 42 per cent of the fertilizing value of the feeding stuff, was excreted in the solid excrement.

14. About 53 per cent of the total fertilizer value of these feeding stuffs passes into the urine.

15. In feeding a ton of cottonseed meal having a fertilizer valuation of $29.50 to fattening animals, that portion of its fertility which passes into the solid excrement has a valuation of about $12.40, and that which passes into the urine of about $15.

TABLE 15.—PERCENTAGE COMPOSITION OF FEEDING STUFFS AND EXCREMENTS.

Laboratory Number.		Water.	Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
866	Kaffir corn	12.41	8.15	2.20	2.73	1.59	72.92	87.59
867	Cottonseed hulls	8.52	4.70	.94	48.91	3.33	33.60	91.48
868	Cottonseed meal	6.57	43.50	11.85	8.65	6.33	23.10	93.43
906	Milo maize	10.27	9.45	2.23	2.72	1.74	73.69	87.99
929	Molasses, sample No. 1	24.33	4.00	.....	.....	4.50	8.40	75.67
930	Molasses, sample No. 2	23.50	4.06	.....	.....	4.61	9.29	76.50
931	Molasses, sample No. 3	25.92	4.06	.....	.....	4.60	6.81	75.08
	Average for molasses	24.58	4.04	.....	.....	4.57	8.17	75.42
862	Excrement, steer No. 1, period No. 1	9.18	12.31	0.42	47.81	5.57	24.71	90.82
863	Excrement, steer No. 2, period No. 1	9.25	11.78	0.22	49.89	4.64	24.22	90.75
898	Excrement, steer No. 3, period No. 2	6.44	13.37	0.62	42.10	4.60	32.87	93.56
899	Excrement, steer No. 2, period No. 2	6.26	13.22	0.55	44.43	4.42	31.12	93.74
900	Excrement, steer No. 3, period No. 2, sample 2	7.43	13.25	0.73	44.61	5.18	28.80	92.57
903	Excrement, steer No. 3, period No. 3	5.25	14.53	0.52	44.66	4.92	30.12	94.75
904	Excrement, steer No. 3, period No. 3, sample 2	5.27	13.75	0.43	44.49	4.60	31.46	94.73
905	Excrement, steer No. 2, period No. 3	4.62	14.18	0.51	44.61	4.07	32.01	95.38
916	Excrement, steer No. 3, period No. 4	5.87	13.06	0.39	49.02	5.21	26.45	94.13
917	Excrement, steer No. 2, period No. 4	5.59	13.53	0.40	48.48	5.40	26.60	94.41
952	Excrement, steer No. 2, period No. 5	6.58	14.00	0.31	50.15	5.13	23.83	93.42
953	Excrement, steer No. 3, period No. 5	6.23	13.82	0.30	50.17	4.85	24.63	93.77

TABLE 16.—PERCENTAGE OF STARCH, ETC., IN FEEDING STUFFS.

Laboratory Number.		Sugar.	Starch.	Pentosans.	Pentosans in Crude Fiber.	Pentosans in Nitrogen-Free Extract.
866	Kaffir corn	0 84	67.44	1.60	0.28	1.32
867	Cottonseed hulls	0.73	2.13	20.00	5.36	14.64
868	Cottonseed meal	11.35	1.03	5.26	.99	4.27
906	Milo maize	1.49	63.00	2.65	0.22	2.43
929	Molasses, sample No. 1	.....	.....	.....	.....	.....
930	Molasses, sample No. 2	.....	.....	.....	.....	.....
931	Molasses, sample No. 3	.....	.....	.....	.....	.....
862	Excrement, steer No. 1, period 1, hulls and meal	0.29	3.41	8.19	3.83	4.36
863	Excrement, steer No. 2	0.43	3.66	9.31	3.75	5.56
898	Excrement, steer No. 3, period 2, sample 1	0.34	5 07	9.26	3.69	5.57
899	Excrement, steer No. 2, sample 2	0.39	4.00	9.05	3.22	5.83
900	Excrement, steer No. 3, sample 3	0.28	4.50	9.20	3.43	5.87
903	Excrement, steer No. 3, period 3, sample 1	0.19	3.23	10.82	3.51	7.31
904	Excrement, steer No 3, sample 2	0.26	3.40	10.41	3.37	7.04
905	Excrement, steer No. 2, sample 1	0.16	3.48	10.83	3.81	7.02
916	Excrement, steer No. 3, period 4	0.23	3.77	9.24	3.49	5.55
917	Excrement, steer No. 2	0.26	3.36	9.13	3.78	5.45
952	Excrement, steer No. 2, period 5	0.20	2.30	.....	3.83	.....
953	Excrement, steer No. 3	0.12	2.20	.....	4.11	.....

TABLE 17.—NUTRIENTS FED, EXCRETED AND DIGESTED.

Period 1.

		Protein.	Fat.	Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
Steer 1 3 days	Fed in 4536 gm. hulls, No. 867.	213.2	42.6	2218.5	151.0	1524.1	4149.5
	In 907 gm. cottonseed meal, No. 868	394.5	107.5	78.5	57.4	209.5	847.5
	Total fed per day	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Excreted 2179 gm., No. 862	268.2	9.2	1041.8	121.4	538.4	1978.8
	Digested, grams	339.5	140.9	1255.2	87.0	1195.2	3018.0
	Percentage digested	55.9	93.9	54.6	41.7	69.0	60.4
Steer 2 6 days	Fed per day in hulls and meal	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Excreted 2540 gm., No. 863	299.2	5.6	1267.1	117.9	615.1	2305.0
	Digested, grams	308.5	144.5	1029.9	90.5	1118.5	2691.8
	Percentage digested	50.8	96.3	44.9	43.4	64.5	53.9

TABLE 17.—NUTRIENTS FED, EXCRETED AND DIGESTED—continued.

Period 2.

		Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
Steer 2 9 days	Fed in hulls and meal	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Fed in 1815 gm., kaffir corn, No. 866	147.9	39.9	49.5	28.9	1323.5	1589.7
	Total fed per day	755.6	190.0	2346.5	237.3	3057.1	6586.5
	Excreted 2707 gm., No. 899	357.9	14.9	1202.7	119.6	842.4	2537.5
	Digested	397.6	175.1	1143.8	116.7	2214.7	4049.0
	Digested from hulls and meal (Average Steer 2)	304.6	142.8	1113.5	88.2	1124.3	2773.3
	Digested from kaffir	93.0	32.3	30.3	28.5	1090.4	1275.7
	Percentage digested	62.9	81.0	61.2	99.0	82.4	80.2
Steer 3 3 days	Fed, total per day	755.6	190.0	2346.5	237.3	3057.1	6586.5
	Excreted in 2412 gm., No. 898	322.5	15.0	1015.2	111.0	792.8	2256.3
	Digested	433.1	175.0	1331.3	126.3	2264.3	4330.2
	Digested from hulls and meal	327.3	141.7	1244.5	96.6	1165.7	2975.8
	Digested from kaffir	105.8	33.3	86.8	29.7	1098.6	1354.4
	Percentage digested from kaffir	71.5	83.4	.....	100.0	83.0	85.2
Steer 3 8 days	Fed, total per day	755.6	190.0	2346.5	237.3	3057.1	6586.5
	Excreted in 2505 gm., No. 900	331.9	18.3	1117.5	129.7	721.4	2318.8
	Digested	423.7	171.7	1229.0	107.6	2335.7	4267.7
	Digested from hulls and meal	327.3	141.7	1244.5	96.6	1165.7	2975.8
	Digested from kaffir	96.4	30.0	.....	11.0	1170.0	1291.9
	Percentage digested from kaffir	64.9	75.2	.....	38.1	88.4	81.3
	Average coefficient of digestion for kaffir	63.9	78.1	.....	.....	85.4	80.7

Period 3.

Steer 2 8 days	Fed in hulls and meal	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Fed in milo maize 1815 gm., No. 906	171.5	40.5	49.4	31.5	1337.4	1628.5
	Total fed per day	779.2	190.6	2346.4	239.9	3071.0	6625.3
	Excreted 2490 gm., No. 905	353.1	12.7	1110.8	101.0	797.0	2375.0
	Digested	426.1	177.9	1235.6	138.9	2274.0	4250.3
	Digested from hulls and meal	304.6	142 8	1113.5	88.2	1124.3	2773.3
	Digested from milo	121.5	35.1	122.1	150.7	1149.7	1477.0
	Percentage digested	70.8	86.7	100	100	85.9	90.7

TABLE 17.—NUTRIENTS FED, EXCRETED AND DIGESTED—continued.

Period 3.—continued.

		Protein.	Fat.	Crude Fiber.	Ash.	Nitrogen-Free Extract.	Dry Matter.
Steer 3 4 days	Total fed	779.2	190.6	2346.4	239.9	3071.0	6625.3
	Excreted in 2636 gm., No. 903	383.0	13.7	1177.2	130.0	794.0	2497.5
	Digested	396.2	176.9	1169.2	109.9	2277 0	4127.8
	Digested from hulls and meal	327.3	141.7	1244.5	96.6	1165 7	2975.8
	Digested from milo	68.9	34.2	.....	13.3	1111.3	1152.0
	Percentage digested	40.2	84.4	0?	42.2	83.2	70.8
Steer 3 8 days	Total fed	779.2	190 6	2346.4	239.9	3071.0	6625.3
	Excreted in 2526 gm., No. 904	347.3	10.9	1123.8	116.0	794.6	2392.8
	Digested	431.9	179.7	1222.6	123.9	2276.4	4232.5
	Digested from hulls and meal	327.3	141.7	1244.5	96.6	1165.7	2975.8
	Digested from milo	104 6	38.0	.....	26.3	1110.7	1256.7
	Percentage digested	61.0	93.8	0?	83.5	83.1	77.2
	Average	65.9	90.2	.....	.....	84.5	84.0
	Period 4.						
Steer 2 8 days	Fed in hulls and meal per day	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Excreted in 2269 gm., No. 917	307.0	9.1	1100.0	122.5	603.6	2142.0
	Digested, grams	300.7	141.0	1197.0	85.9	1130.0	2854.8
	Percentage digested	49.5	93.9	52.1	41.2	65.2	57.1
Steer 3 8 days	Fed in hulls and meal	607.7	150.1	2297 0	208.4	1733.6	4996.8
	Excreted in 2147 gm., No. 619	280.4	8.4	1052.5	111.8	567.9	2021.0
	Digested, grams	327.3	141.7	1244.5	96.6	1165.7	2975.8
	Percentage digested	53.9	94.4	54.1	46.4	67.2	59.5
	Period 5.						
Steer 2 8 days	Fed in hulls and meal per day	607.7	150.1	2297.0	208.4	1733.6	4996.8
	Fed in molasses 1361 gm., Nos. 929, 930, 931	55.0	.....	.....	62.2	909.2	1026.2
	Total fed per day	662.7	150.1	2297.0	270.6	2642.8	6023.0
	Excreted. 2451.1 gm., No. 952	343.2	7.6	1225.8	125.8	584.2	2289.5
	Digested	319.5	142.5	1071.2	144.8	2058.6	3733.5
	Digested from hulls and meal	304.6	142.8	1113.5	88.2	1124.3	2773 3
	Digested from molasses	14.9	—.3	—42.3	56.6	934.3	960.2
	Percentage digested	27.1	.....	.....	91.0	103.0	93.5
Steer 3 8 days	Fed per day	662.7	150.1	2297.0	270.6	2642.8	6023.0
	Excreted 2077.1 gm., No. 953	287.0	6.2	1042.0	100.7	511.5	1947.0
	Digested	375.7	143.9	1255.0	169.9	2131.3	4076.0
	Digested from hulls and meal	327.3	141.7	1244.5	96.6	1165.7	2975.8
	Digested from molasses	47.4	2.2	10.5	73.3	965.6	1100.5
	Percentage digested	86.2	.....	.....	117.8	106.1	107.3

TABLE 18.—SUGAR, ETC., FED, EXCRETED AND DIGESTED.

Period 1.

		Sugar.	Starch.	Pentosans.	Residue.	Total Pentosans.	Pentosans in Crude Fibre.	Crude Fibre less Pentosans.
Steer 1 3 days	Fed in 4536 gm. hulls, No. 867.....	33.1	96.6	664.1	730.4	907.3	243.2	1975.5
	907 gm. cottonseed meal, No. 868.....	103.0	9.3	38.7	58.5	47.7	9.0	69.5
	Total fed per day.....	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	Excreted 2179 gm. dry matter, No. 862..	6.3	74.3	95.0	362.8	178.5	83.5	958.4
	Digested.....	129.8	31.6	607.8	426.1	776.5	186.7	1086.6
	Percentage digested.....	95.4	29.8	86.5	54.0	81.3	66.9	53.1
Steer 2 6 days	Fed per day in hulls and meal, Nos. 867, 868.....	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	Excreted 2540 gm. dry matter, No. 863.....	10.9	92.9	141 2	370.0	236.5	95 2	1172.0
	Digested.....	125.2	13.0	561.6	418.9	718.5	157.0	873.0
	Percentage digested.....	92.0	12.3	79.9	53.1	75.2	62.3	42.70

Period 2

Steer 2 9 days	Fed in hulls and meal, Nos. 867, 868.....	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	1815 gm. kaffir corn, No. 866	15.2	1224.0	23.9	60.2	29.0	5.1	44.5
	Total fed per day.....	151.3	1329.9	726.7	848.7	984.0	257.3	2089.5
	Excreted 2707 gm. dry matter, No. 899.....	10.5	108.3	158.4	565.3	245.0	87.2	1115.5
	Digested.....	140.8	1221.6	568.3	283.4	739.0	170.1	974.0
	Digested from hulls and meal (average Steer 2)..	127.7	21.3	572.0	403.3	733.1	161.1	952.4
	Digested from kaffir	13.1	1200.3	—3.7	—19.9	5.9	9.0	21.6
	Percentage digested from kaffir.	86.2	98.0	.....	.....	20.3	176.5	48.5
Steer 3 3 days	Fed, total per day.....	151.3	1329.9	726.7	848.7	984.0	257.3	2089.5
	Excreted in 2412 gm. dry matter, No. 898	8.2	122.3	134.3	528.0	223.3	89.0	926.4
	Digested.....	143.1	1207.6	592.4	320.7	760.7	168.3	1163.1
	Digested from hulls and meal.....	131.2	25.0	583.6	426.0	756.6	173.0	1071.7
	Digested from kaffir	11.9	1182.6	8.8	--105.3	4.1	—4.7	—8.6
	Percentage digested from kaffir	78.3	96.6	36.8	.....	14.1	... .	.....

TABLE 18.—SUGAR, ETC., FED, EXCRETED AND DIGESTED—continued.

Period 2—continued.

		Sugar.	Starch.	Pentosans.	Residue.	Total Pentosans.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans.
Steer 3 8 days	Fed, total per day.	151.3	1329.9	726.7	848.7	984.0	257.3	2089.5
	Excreted in 2505 gm. dry matter, No. 900	7.0	112.9	147.0	454.7	230.5	85.9	1031.6
	Digested	144.3	1217.0	579.7	394.0	753.5	171.4	1057.9
	Digested from hulls and meal	131.2	25.0	583.6	426.0	756.6	173.0	1071.7
	Digested from kaffir	13.1	1192.0	—3.9	—32.0	—3.1	—1.6	—13.8
	Percentage digested from kaffir	86.2	97.4					
	Period 3.							
Steer 2 8 days	Fed in hulls and meal, Nos. 867, 868	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	Milo maize 1815 gm., No. 906	27.0	1143.6	44.1	122.9	48.1	4.0	45.4
	Total fed per day	163.1	1249.5	746.9	911.8	1003.1	256.2	2090.4
	Excreted 2490 gm. dry matter, No. 905	4.0	86.7	174.8	531.7	269.7	94.9	1016.0
	Digested	159.1	1162.8	572.1	380.1	733.4	161.3	1074.4
	Digested from hulls and meal	127.7	21.3	572.1	403.3	733.1	161.1	952.4
	Digested from milo maize	31.4	1141.5	0	—23.2	0.3	0.2	122.0
	Percentage digested from milo maize	116.3	99.8			0.6	5.0	268.7
Steer 3 4 days	Total fed.	163.1	1249.5	746.9	911.8	1003.1	256.2	2090.4
	Excreted in 2636 gm. (dry), No. 903	5.0	85.0	192.3	510.0	284.6	92.3	1085.3
	Digested	158.1	1164.5	554.6	401.8	718.5	163.9	1005.1
	Digested from hulls and meal	131.2	25.0	583.6	426.0	756.6	173.0	1071.7
	Digested from milo maize	27.9	1139.5	—29.0	—24.2	—38.1	—9.1	—66.6
	Percentage digested	103.3	99.7					
Steer 3 8 days	Total fed	163.1	1249.5	746.9	911.8	1003.1	256.2	2090.4
	Excreted in 2526 gm. (dry), No. 904	6.6	85.9	177.8	524.0	263.0	85.1	1038.6
	Digested	156.5	1163.6	569.1	387.8	740.1	171.1	1051.8
	Digested from hulls and meal	131.2	25.0	583.4	426.0	756.6	173.0	1071.7
	Digested from milo maize	25.3	1138.6	—14.3	—38.2	—16.5	—1.9	—19.9
	Percentage digested	93.7	99.6					

TABLE 18.—SUGAR, ETC., FED, EXCRETED AND DIGESTED—continued.

Period 4.

		Sugar.	Starch.	Pentosans.	Residue.	Total Pentosans.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans.
Steer 2 8 days	Fed in hulls and meal, Nos. 867, 868, per day..	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	Excreted in 2269 gm. dry matter, No. 917.....	5.9	76.2	120.3	401.2	207.2	86.9	1013.2
	Digested.....	130.2	29.7	582.5	387.7	747.8	165.3	1031.8
	Percentage digested.....	95.7	28.0	82.9	49.2	78.3	65.5	50.4
Steer 3 8 days	Fed in hulls and meal, Nos. 867, 868.....	136.1	105.9	702.8	788.9	955.0	252.2	2045.0
	Excreted in 2147 gm. dry matter, No. 916.....	4.9	80.9	119.2	362.9	198.4	79.2	973 3
	Digested.....	131.2	25.0	583.6	426.0	756.6	173.0	1071.7
	Percentage digested.....	96.4	23.6	83.4	54.0	79.2	68.6	52.4

	Period 5.	Sugar.
Steer 2	Fed in hulls and meal, per day, Nos. 867, 868.....	136.1
	Fed in molasses 1361 gm., Nos. 929, 930, 931.....	798.0
	Total per day.....	934.1
	Excreted 2451 gm. dry matter, No. 952.....	5.0
	Digested.....	929.1
	Digested from hulls and meal.....	127.7
	Digested from molasses.....	801.4
	Percentage digested.....	100.4
Steer 3	Fed per day.....	934.1
	Excreted 2077.1 gm. dry matter, No. 953.....	2.5
	Digested.....	931.6
	Digested from hulls and meal.....	131.2
	Digested from molasses.....	800.4
	Percentage digested.....	100.6