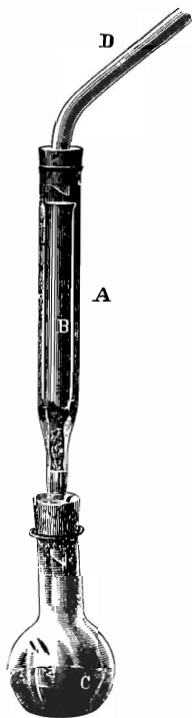


ART. XXII.—*Apparatus for quantitative Fat-extraction; On the Composition of the Sweet Potato; On the Composition of Maize Fodder*; by S. W. JOHNSON.—*Contributions from the Sheffield Laboratory of Yale College.** No. XLIII.

I. *Apparatus for quantitative Fat-extraction.*

THE apparatus consists of a glass tube A, of $\frac{3}{4}$ to $\frac{7}{8}$ in. bore and 6 to 7 in. long, narrowed at bottom to a bore of $\frac{1}{4}$ in., and there fitted by a cork to a flask C, of 80 c. c. capacity, and connected above by a cork with a reversed Liebig's condenser D.



Within A a similar but smaller tube B is maintained free from the sides of the larger tube, either by three knobs of glass fused upon it where it begins to narrow, by a support of platinum foil as in the figure, or by suspension with help of a wire looped around the upper part of B and a hook depending from the cork above it. B is closed below either by a plug of cotton or asbestos or else by a disk of filter paper supported by one of muslin tied over its narrow and slightly flanged end. The substance to be extracted is introduced into B, 50 c. c. of ether or other solvent are placed in the flask and heat is applied to boil the liquid. Its vapor passes into the condenser, and there liquefies; the liquid drops continuously upon, and percolates the contents of B, carrying into C any dissolved matters, whence it rises again as vapor to be again condensed and repeat the solvent action.

The cooling must be effectual and the heat applied to the flask just sufficient to maintain a regular circulation of the solvent. B may be weighed with its contents, after closing the end by means of corks or rubber caps. To dry its contents it may be connected at one end by means of a perforated stopper and tube to an apparatus for supplying pure hydrogen, at the other by a rubber tube several inches long and CaCl_2 tube to an aspirator, and may be heated by immersion in an inclined position in a bath of boiling water, while a slow stream of dry gas is transmitted. The loss in weight of B and its dried contents may in some cases give the amount of oil extracted more speedily and accurately than direct

* The substance of these papers was read at the Detroit meeting of the American Association for the Advancement of Science, in August, 1875.

weighing of the latter. For ordinary quantitative fat-estimations A and B may be made from stout test tubes.

This apparatus is not only easier to construct and to handle than those which have a separate interior or exterior tube to carry up the ether-vapors, but has the additional advantage that the substance to be extracted is kept warm by being constantly surrounded with hot vapor.

It is best to mount the apparatus so that it may be put into a somewhat inclined position if needful, as then by revolving the apparatus on the condenser tube D the stream of condensed solvent may be directed in succession on all parts of the contents of B and any channels that may form are easily broken up.

In milk-analyses I have followed the fat-extraction by similar treatment with 80 per cent alcohol for the separation of sugar.

II. On the Composition of the Sweet Potato.

The Sweet Potato (*Convolvulus batatas* or *Batatas edulis*) is an esculent of great value to the United States. It is not only at home in all the Southern States, but is produced in large quantities in Central New Jersey, and Central Illinois, latitude 40°; and has been successfully raised in gardens in nearly the coldest parts of New York, as well as in Maine and Southern Minnesota (St. Paul), in latitude 44° to 45°. It is probable that under northern cultivation varieties may originate more adapted to cold climates, so that were it needful its profitable cultivation might be extended several degrees of latitude northward, as is said to have happened in Europe with regard to maize, for which it is asserted that 46° north latitude was formerly the limit, whereas now it is cultivated nearly to 52°.

The Sweet Potato is known in many varieties which differ widely in quality. Naturally, the kinds which are propagated at the north are less sweet and less highly flavored than those produced in a warmer climate. The New Jersey and Delaware sweet potatoes which are marketed in New England, though palatable and largely consumed, are decidedly inferior to the produce of Virginia. I am informed that sweet potatoes of excellent quality are raised in Southern Illinois, lat. 37°–38°, while those produced in Central Illinois, lat. 40°, are “watery” and comparatively insipid.

The sweet potato in highest repute at the north is the Nansemond, taking its name from the southeastern county of Virginia, where it is said to have originated. The “Nansemond Improved,” raised in Hanover Co., Va., is the finest variety of this esculent that has come under my notice. I am indebted to John Ott, Esq., of Richmond, Va., for abundant samples of this variety, the high quality of which has induced me to undertake its analysis.

The composition of the sweet potato has been studied by Proust, Einhof, Payen, Henry, Fromberg, and Antisell.

Their analyses were mostly made by methods less perfect than those we now possess, and they differ from each other to a degree not explained by the variations in quality of the sweet potato itself, and some of them are evidently incorrect. Since there is to my knowledge no printed summary of these older analyses I have thought it worth while to reproduce them.

As chemists are too well aware, no unexceptionable methods for separating or estimating some of the organic principles of our esculents have as yet been discovered. Since the tendency of newer researches points to the existence in plants of a series of isomeric bodies with the denser and maturer forms of cellulose at one extremity and dextrin at the other, with various celluloses, starches, amylo-dextrins and dextrins intermediate, which defy separation and have long resisted identification, the best that can be done in proximate analysis is to follow some method conventionally agreed upon, by which fairly comparable results may be reached. The analysis of the "Nansemond Improved" was made essentially according to the plan adopted by the German Agricultural Experiment Stations, and the results have been for the most part verified by repetition and critical examination of the educts. This analysis has regard only to the more important food-principles, without reference to traces of malic acid, etc., which have been reported in former examinations.

For analysis, about 600 grams of the tubers were thinly sliced (in December, 1874), air-dried in a warm room and then pulverized. In 5 grams of air-dry substance, water was estimated by three methods.

1. By drying at 100° C. in a flask exhausted by the Bunsen-Sprengel pump. This method, which leads speedily to the desired result in case of other vegetable matters, e. g., maize-meal, hay, etc., required several days for bringing sweet-potato flour to a constant weight.

2. By drying in air-bath at 125° C. This process speedily removes the water but occasioned browning of the substance.

3. By drying at 100° in a stream of hydrogen, a method somewhat tedious but less so than 1, and now adopted by many of the German Experiment Stations.

The three methods gave of loss on air-dry substance:

1	7.19 per cent.
2	{ 6.90 "
	{ 7.13 "
3	{ 7.54 "
	{ 7.19 "
Average =	7.19 "

The total loss of *water* experienced by the fresh substance = 73.39 per cent.

Fat was extracted from the dried-residue of the water-estimation, by treatment with carbon disulphide in the apparatus before described. The process required twelve hours for completion. Two trials yielded 0.26 and 0.31 of a soft yellow substance, appearing at first like a pure fat, but which to the feel and taste had more of the properties of wax than of the ordinary fats. It probably resides chiefly in the laticiferous tissue, whose yellow juice is evident on a fresh section of the sweet potato.

An aqueous extract of the sweet potato was obtained by digesting four grms. of finely-pulverized air dry substance with nearly half a liter of cold water for five hours and filtering. The residue was treated with a similar quantity of cold water for twelve hours more. Aliquot portions of the two extracts were separately evaporated in capsules and dried at 212° F. The first extraction was practically complete, as the second digestion took up but 3.5 mgr., or a little more than $\frac{1}{16}$ per cent of soluble matters. The total amount of solid aqueous extract, after deducting ash, was 7.94 per cent.

The aqueous extract was brown in color and perfectly clear. Boiled, it gave a very slight precipitate, acids made it turbid, and Millon's test gave a faint red tint to the liquid on heating. Iodine gave no coloration. Basic lead acetate gave a copious precipitate, separating in flocks on boiling, and in the filtrate Fehling's solution gave reddish-yellow precipitate on boiling. These reactions indicate presence of a trace of albuminoids, of gum* and of a glucose. They exclude starch, amylopectrin and dextrin.†

To effect proximate separation of gum and sugar, a portion of aqueous extract was evaporated to dryness, taken up in a very little water and treated with 80 per cent alcohol. Sugar was recovered by evaporation of the alcohol solution. As is known, this separation is a rough one. The sugar obtained gave on boiling with Fehling's solution, at once, a copious floccy-red precipitate. Set aside in concentrated solution it showed no signs of crystallization. It therefore largely consisted of a *glucose*. Its amount was 6.86 per cent. The substance remaining insoluble after a second treatment with alcohol, which was mostly *gum*, was 1.08 per cent of the fresh tuber.

Cellulose was determined by alternate treatment of the powdered substance with dilute (2 per cent) sulphuric acid and caustic

* The term *gum* is used in a generic sense. The substance obtained appeared to have more nearly the characters of arabin than of pectin or other gummy body, being highly soluble in water.

† See Nägeli, Beiträge zur näheren Kenntnisse der Stärkegruppe, p. 103.

soda solution, in the usual manner. Combustion, with the mixture of equal bulks of sodium carbonate and slacked lime, gave 0.187 and 0.207 per cent of nitrogen, which multiplied by 6.25 leads to the content of *albuminoids*. Starch was estimated by difference. The summing up is as follows:

Water	73.39
Starch, by difference	15.06
Gum	1.08
Sugar (levulose?).....	6.86
Cellulose	0.98
Albuminoids	1.28
Fat and wax.....	0.28
Ash	1.07
	100.00

Table I includes all the analyses of the sweet potato that I have been able to find.

In the older analyses, 1 to 6, the figures for starch and cellulose are of no value because they were the results of an attempted mechanical separation. In fact these analyses are worthless for any purpose, except as regards the water and sugar estimations. Fromberg's figures for water are too exceptional to have any claim to accuracy.

As already mentioned, the figures in analyses 6 and 7 are so coincident in regard to several ingredients, and so plainly wrong in 6, as respects ash, that they must both be considered untrustworthy. Whether the low amounts of water in 8, and of sugar in 9, and the high percentages of sugar in 8 and of starch in 9, are analytical errors or characterize the sweet potato in its different varieties, remains to be established by future comparative investigations.

In the common potato (*Solanum tuberosum*) a range of water content from 68.3 to 82.1 per cent, and of starch-content from 15 to 26 per cent has been observed.

In nutritive values the Hanover sweet potato and the common potato on the average differ but little. Their comparative composition is as follows:

	Sweet potato.	Potato.
Water	73.4	74.6
Albuminoids	1.3	2.2
Fat and wax	0.3	0.2
Carbohydrates.....	23.0	21.2
Fiber.....	1.0	0.7
Ash.....	1.0	1.1
	100.0	100.0

The average composition of the common potato is that given by Dietrich and König in their *Zusammensetzung und Verdaulichkeit der Futterstoffe*.

TABLE I.

	1	2	3	4	5	6	7	8	9	10
	Proust, Malaga.	Einhof. ?	Henry, France ?	Fromberg, Barbadoes.	Payen, Neuilly ? White ?	Payen, France ?	Payen, France ? Yellow	Payen, France ? Red.	Antisell, N. Orleans,	Johnson, Hanover Co., Va. Yellow
	Gasparin, Cours d'Ag-riculture, t. ed., p. 58.	Ure's Diet. of Arts, Am. article, t. ed., p. 58.	Liebig's Handwörterbuch, 2d ed., 1 Bd., 1 Aeth., article Batate.	Johnston's Lect. on Ag-riculture, 2d ed., 1 Bd., 1 Aeth., article Batate.	Hamm's Landwirthschaft, Bd. 2, p. 165.	Payen et Richard, Precis d'Agriculture.	Deherain, Chimie Agricole, p. 159.	Chimie Agricole, 2d ed., t. vi, pp. 292-3.	Report of Dept. of Agriculture, 1869, p. 75.	Report of Nausemond
Water	72.0	74.3	73.1	59.31	71.25	74.00	79.64	67.50	73.00 ¹⁴	73.39
Starch	9.5	15.1	13.3	16.62	17.00	9.42	9.42 ¹³	16.05	19.16	15.06 ⁵
Cellulose	14.5 ¹	8.2	6.8	12.88 ⁴	8.55 ⁷	2.54	0.54	0.45	1.98	0.98
Gum	---	---	---	0.55 ⁵	---	1.30 ⁹	1.30 ⁹	1.10 ⁹	---	1.08
Cane Sugar	4.0 ²	---	3.3	7.99	3.20	1.45	3.50	10.20	4.35	---
Grape Sugar	---	---	---	2.66 ⁶	---	1.04	1.10	1.50	---	6.86
Albuminoids	---	0.8	0.9	---	---	1.10	0.25	0.30	0.35	1.28
Fat (wax)	---	---	1.1	---	---	0.89	3.25	2.90	0.24	0.28
Ash	---	---	---	---	---	13.69 ¹⁰	---	---	0.92	1.07
Total	100.00	98.4	99.3 ³	100.01	100.00	105.43 ¹¹	99.00	100.00	100.00	100.00

¹ With starch, "parenchyme amidonne."
² "Matter soluble in water."
³ Including "1.4% malic acid."
⁴ "With a little oil and coagulated albumin."
⁵ "Dextrin."
⁶ "Impure caseine." By estimation of nitrogen, Fromberg calculated 2.97% albuminoids.
⁷ Given as "fibrine" obviously a mistake for "fibre."
⁸ Nitrogen is given at 0.199%, equal to 1.25% albuminoids.
⁹ "Pectic acid with organic matter."
¹⁰ Includes 6.48% salts and 7.00% malates of potash and ammonia, as quoted by Gasparin, Cours d'Agriculture, p. 59. Sacc, Cours de Chim. Agricole, gives water 7.3% and salts and malates 9.26.
¹¹ The total is given by Payen and Richard as 103.43.
¹² Deherain gives this as an analysis of the "Batate (Convolvulus batatas)," Pelouze and Fremy as an analysis of the yellow yam, "Igneame jaune."
¹³ The correspondence of the figures for starch, gum, albuminoids and cellulose between this and the preceding analysis, and the excess of 5.43% in 6, indicate some confusion which I cannot unravel.
¹⁴ Antisell analyzed "sweet potato flour" containing 7.95% water. He calculated the composition of the sweet potato flesh, assuming 65.96% water. I have calculated the results of his analysis on 73% water, for the sake of better comparison.
¹⁵ Estimated by difference.

The sweet potato is possibly more easily digestible than the common potato, because of containing nearly 7 per cent of soluble sugar in place of a similar amount of starch. Its sweet taste is mentioned by European writers as a reason why it does not enter more largely into the produce of southern France, and probably for most inhabitants of temperate regions it does not relish so well in constant use as does the common potato, which, like bread, appears daily and twice daily on the tables of the Middle and New England States, as well as on those of England, Germany and France. The sweet potato is, however, in its best varieties a most inviting esculent, and perhaps "wears" better than any other vegetable save the common potato. Its juices are so rich in sugar that the tuber keeps poorly, for wherever the cuticle is broken, the common omnipresent fungi take root, under favorable conditions of temperature and moisture, and rapidly penetrate the tissues, producing discoloration and dry or wet rot. French authorities report that the potato-fungus, *Peronospora infestans*, attacks the sweet potato as vigorously as the common.

III. On the Composition of Maize Fodder.

The use of maize as a fodder plant is very extensively practiced in this country as well as in South Germany and Austria. In the latter countries maize fodder appears to be uniformly regarded as a valuable resource to the farmer. In the United States, however, some excellent farmers have denounced it for various reasons; some because of the difficulty of securing the crop, and others because of its supposed innutritious quality. In fact, chemical analysis has been employed to show that maize is a comparatively worthless fodder crop.

These considerations induced me to undertake its investigation, and I have been fortunate in finding highly suitable material on the farm of J. J. Webb, Esq., near New Haven, Conn., as well as the most hearty assistance in preparing the fodder for analysis at the hands of that gentleman. Two samples, raised from separate plantings and on separate fields, were placed at my disposal. The variety of maize was the Southern or Norfolk White; the seed was obtained from Long Island. No. 1 was raised on long tilled ground and inverted sod, with help of stable manure. No. 2 was taken from new ground, which had borne two rye crops, was seeded, had been in pasture for five years, was then plowed and had carried two successive crops of corn fodder, of which it was of course the last. To the soil that yielded No. 2 no stable manure had ever been applied. No. 2 was sown 10 to 15 days earlier than No. 1, and was more mature at the time of cutting the samples, Sept. 1st, 1874.

The further examination consisted in extracting the pulverized fodder with water, evaporating the solution, to determine total quantity of soluble matters, redissolving in a little water and treating with 80 per cent alcohol to throw down gum.

This treatment was carried out both with cold and hot water. The results were as follows, calculated on dry substance:

	1		2	
	Cold.	Hot.	Cold.	Hot.
Total extract	1.49	22.27	2.01	26.54
Ash .....	.47	5.21	.31	4.41
Soluble in alcohol, starch, sugar, fat, etc., .....	.80	10.87	1.48	21.51
Insoluble in alcohol, gum .....	.22	6.16	.22	.62

The water extract gave a reaction with Fehling's solution, showing the presence of a little sugar. The alcohol precipitate when redissolved in water gave no reaction with Fehling's solution but contained a trace of albuminoid.

Starch is carried into solution by boiling with water, and soluble gum is more completely extracted by the hot maceration of the imperfectly pulverized material.

These laborious trials were not duplicated, and it is not fully established whether the absence of gum in 2 is the result of a possible error in analysis or the consequence of maturer development of stalks. The larger quantity of hot water extract in 2 is not improbably due to the presence of seed kernels with abundant starch.

The results agree fairly with the average of a number of analyses made of late years in Germany and Austria, which, however, doubtless refer usually to a much smaller plant and crop.

The subjoined statement gives: A, the average of my two analyses; B, the average of the German analyses as given by Wolff, Fütterungslehre, 1874; C, the average given by Dietrich and König, 1874. All refer to the fresh fodder.

	A.	B.	C.
Water	86.1	82.2	85.0
Ash	0.8	1.1	1.0
Albuminoid	0.8	1.2	1.8
Ether extract (fat and wax)	0.3	0.5	0.6
Cellulose	4.8	4.7	4.4
Carbohydrates, etc.	7.2	10.3	7.2
	100.00	100.00	100.00

Total Yield.—The following figures give the gross produce of the two crops upon an area of 100 square feet as ascertained by Mr. Webb's weighings, and also the produce, per acre, (found by multiplying these weighings by $\frac{4\frac{1}{2}\frac{5}{10}}{1.0}$) as well as the quantities of water and dry matter in the fodder at the several times of weighing.

	Crop 1.			Crop 2.		
	100 sq. ft.	1 Acre.		100 sq. ft.	1 Acre.	
	lbs. oz.	lbs.	tons.	lbs. oz.	lbs.	tons.
Fresh cut, Sept. 1	124-4	54,123	27	117-4	51,074	25 5-10
Containing water	108-5*	47,184	23 1-2	99-11*	43,413	21 7-10
Field-cured, Nov. 11	22	9,583	4 8-10	24	10,454	5 2-10
Water	6-1*	2,244	3 3-10	6-7*	2,793	1 4-10
In barn, Feb. 8	34-7	15,028	7 1-2	38-15	16,988	8 5-10
Water	18-3*	8,089	4	21-6*	9,327	4 7-10
Dry	15-15†	6,939	3 1-2	17-9‡	7,661	3 8-10

Werner, Handbuch des Futterbaues, p. 602, gives the yield of uncured maize fodder in Germany and Austria in four instances, as follows: 50,000, 72,000, 72,000 and 52,800, or an average of 60,000 kilos. per hectare. This average equals 53,440 lbs. per acre. One of the crops of 72,000 kilos. equal to 64,129 lbs. per acre, made 14,000 kilos. of cured fodder, "maize hay," equal to 12,470 lbs. per acre. The loss of water in curing was $80\frac{1}{2}$ per cent of the fresh cut maize. This indicates that the crop was thickly sown, probably on very rich ground, and was cut in a quite immature and watery state.

It is noticeable that the less mature crop 1, weighed fresh $1\frac{1}{2}$ tons more than 2, but when field-cured 2 was 870 lbs. heavier than 1. Crop 2, field-cured, contained $1\frac{1}{2}$ per cent more water and also 3 per cent more carbohydrates, etc., than 1. The autumn weather during which the fodder stood in the field was exceptionally fine and dry. After storing, the weather of the winter was very rainy and damp, and for that reason the loosely packed fodder gathered moisture, so that the average 5 tons of fodder as it was stored Nov. 11, became 8 tons as it lay in the barn Feb. 8, after exposure for three months to the damp winter air. This gain of water was greatest with 2, amounting to more than $3\frac{1}{4}$ tons for the produce of an acre, and being one-half as much water as the green fodder lost in field-curing, and as much as the field-cured fodder contained at the time of storing. Such variability in the water content of a harvested crop appears to be unexampled.

The objection urged against corn fodder that it is innutritious does not apply in respect to the *total yield* of dry matter, for to obtain $3\frac{5}{16}$ (average of $3\frac{1}{2}$ and $3\frac{5}{16}$) tons per acre of dry matter from other forage, would require a crop of 4 tons of meadow hay, and $4\frac{1}{4}$ tons of clover hay, admitting these to contain 8 and 12 per cent of water respectively.

As respects nutritious *quality*, the corn fodder is very different from meadow or clover hay. To make the nature of the difference evident, I subjoin the average analyses of the dry matter of German hay and maize fodder,§ and an average of the two analyses of Mr. Webb's corn fodder.

* Nearly.

† More exactly $15\frac{9}{16}$ lbs.

‡ More exactly $17\frac{5}{16}$.

§ From Dietrich & König's *Zusammensetzung und Verdaulichkeit der Futterstoffe*.

	German.			Mr. Webb's.
	Meadow hay.	Red clover.	Maize fodder.	Maize fodder.
Ash	7.7	7.4	6.7	5.8
Albuminoids—so-called flesh-formers	11.8	16.6	12.4	6.0
Fat	2.7	2.7	3.7	1.8
Cellulose—woody fiber.....	29.9	30.1	29.3	34.3
Carbohydrates, starch, gum, sugar, etc.....	47.9	43.2	47.9	52.1

It is seen from the above figures that the German meadow hay and the German corn fodder are almost identical in composition. Clover hay differs from them in containing some four per cent more of albuminoid and four per cent less of carbohydrates. Mr. Webb's maize fodder contains but one-half as much albuminoids and fat as the German, while its cellulose and carbohydrates are each four to five per cent more. This difference between the two statements of maize fodder depends simply on the fact that most of the German analyses were made on less mature maize. Some of the German analyses give but 0.9 per cent of albuminoids in fresh fodder, the same result as in Mr. Webb's 1 (0.88).

How greatly age influences the content of albuminoids in forage plants is shown by the fact that meadow grass quite young as it is found in pasturage contains in its dry matter 24 per cent of albuminoids, cut just before bloom 12 per cent, and at end of blossoming but 8 per cent. In case of both maize fodder and meadow grass the inferior quality of the older vegetation is compensated by their superior quantity.

Such maize fodder as Mr. Webb produces is valuable when properly employed. Used as a substitute for meadow hay it would be pronounced, and deservedly so, poor cattle food, but as an ingredient of a properly compounded ration it has a high value. In New England, hay commands a high price in the cities and large towns, and is therefore adapted to sell off rather than to consume on the New England farm. The farmer can raise or buy Indian corn, cotton-seed meal, and other concentrated foods, and combine them with coarse fodder to make a cattle food equal or superior to the best of hay, at less cost than is involved in feeding the latter. To throw cured maize fodder out in the cattle yard or to feed it in the stall as hay is fed, is likely to be highly wasteful. To attempt to sustain cattle on it alone or to employ it as an adjunct to hay is also a mistake. To use it profitably it must be finely cut and well mixed or alternated with maize or cotton-seed meal, bran, or some similar material which serves at once to ensure its large consumption and the full economy of its nutritive qualities. Maize-meal and similar articles contain too much albuminoids, fat and starch, for healthy and economical cattle food. Maize fodder contains too little of these and too much coarse fiber. The

mixing of the two in proper proportions enhances their separate value and makes a more perfect nutriment, and under New England circumstances doubtless an economical cattle food.

The digestibility of cellulose in the alimentary apparatus of herbivorous animals has not only been amply established by numerous feeding trials in the agricultural experiment stations of Germany and Austria, but the relative digestibility of the cellulose and other food-elements of various kinds of cattle food has been the subject of repeated experiments. The method of these investigations consists in determining by chemical analysis the amount of cellulose, etc., contained in the ingested food and the amount that passes off in the solid excreta. The difference is the quantity digested. It has been found as the average of some 45 experiments on oxen, cows, goats and sheep, that 62 per cent of the cellulose of meadow hay is dissolved in the digestion of these animals and serves as food, while as the average of 18 trials but 46½ per cent of the cellulose of red-clover hay is digested. In a single trial Moser found that 72 per cent of the cellulose of maize fodder was digested by sheep. One result is not conclusive as to the comparative digestibility of maize fodder, because this quality is influenced by the maturing of the plant, and by the individuality of the animal, as well as by the proportion of food-elements in the ration; but it indicates a high nutritive power.

Moser's results in regard to the other ingredients of maize fodder show that the sample he worked with was in all respects more digestible than the average meadow or clover hay, except these are cut before blossom, and was, roundly speaking, twice as digestible as the straw of the cereal grains.

I am indebted to my friend and late assistant, E. H. Jenkins, M. A., for carrying out the details of the foregoing analyses.