THE COMPOSITION AND PALATABILITY OF SOME COMMON GRASSES[1]

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INTRODUCTION

In 1928 a project was organized by the Chemistry Department of the Massachusetts Agricultural Experiment Station entitled, "Studies in the Chemistry of Pasture Grasses." One phase of this project involved a study of the chemical composition of different species of grasses at the grazing stage. This particular study was undertaken because a search of the literature had disclosed a scarcity of information on the chemical composition at the grazing stage of individual species of the grasses commonly grown in the northeastern part of the United States. The study was continued over a period of 7 years (1931–37 inclusive). One progress report (*1*)[2] giving results for the years 1931, 1932, and 1933 has already been published. This paper is the final report and sets forth the results for the entire 7-year period, the earlier published results for 1931, 1932, and 1933 having been combined with those for 1934 to 1937.

Although the chemical composition of grasses has been widely studied, one or more of three circumstances has rendered the findings inapplicable to the present work: (1) The species used differed from those included in this study; (2) the analyses were made when the grasses were too mature to be considered as typical of good grazing, generally at or near the blossom stage; or (3) the studies were made on mixed herbage. A report of a few analyses of *Poa pratensis* by Pammel, Weems, and Lamson-Scribner (*7*), and more recently the work of Grunder (*5*) on *Trifolium repens*, are all that seem to have a direct bearing on this study.

EXPERIMENTAL METHODS

Six species of grasses have been grown as pure or practically pure stands, and their chemical composition has been determined by monthly sampling and analysis throughout the growing season (May–September) of each of the years indicated. In addition, one other species of grass and two species of legumes have been similarly studied during several seasons of the period indicated. Vitamin A assays of the fresh grasses have been made in several seasons, and the palatability of the grasses to cows has been studied by means of actual grazing tests.

Two separate tracts of land were chosen for the investigation. Tract No. 1 was utilized from 1931 to 1936 inclusive for studies of composition, and in 1937 and 1938 for palatability tests. From 1931

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[2] Italic numbers in parentheses refer to Literature Cited, p. 347.

to 1934 inclusive the grasses were grown without fertilizer other than that residual in the soil. In 1934, 1935, and 1936 a complete 8–6–6 fertilizer was applied at the rate of 400 pounds per acre at the beginning of the growing season.

Tract No. 2 was seeded in 1933, but samples were not taken until 1935 because flooding and winter-killing had necessitated complete reseeding. The analytical studies were continued through 1935, 1936, and 1937, and in 1938 palatability tests were conducted. Fertilizer was not applied to this set of plots at any time during the investigation. Analyses of the soils of both tracts are given in table 1; the principal differences are the somewhat larger amount of fine material and the very much larger amounts of organic matter and nitrogen in the soil of tract 2.

TABLE 1.—*Analysis of the air-dry soils* [1]

Tract and soil profile	Fine soil (1 mm or less)	Organic and volatile matter	Total nitrogen	Total phosphorus	Total potassium	Total calcium	Available phosphorus	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Parts per million*	
Tract 1:								
Surface soil	92.17	5.05	0.14	0.18	2.01	1.43	154	6.05
Subsoil	99.33	2.63	.04	.03	1.85	1.44	7	5.50
Tract 2:								
Surface soil	98.50	12.87	.41	.12	1.86	1.17	73	5.52
Subsoil	90.90	2.89	.06	.03	2.35	1.44	11	5.65

[1] All determinations except available phosphorus were made by the methods of the Association of Official Agricultural Chemists (*2*). Available phosphorus was determined by Truog's method (*8*).

The grasses and legumes chosen for the investigation were: Kentucky bluegrass (*Poa pratensis*), also called Junegrass; orchard grass (*Dactylis glomerata*); redtop (*Agrostis alba*); Rhode Island bent (*Agrostis capillaris*), also called colonial bent; timothy (*Phleum pratense*), also called herd's grass; sheep fescue (*Festuca ovina*); sweet vernal grass (*Anthoxanthum odoratum*); white Dutch clover (*Trifolium repens*); and Ladino clover (*Trifolium repens*).

Each series of plots was replicated once, making a total of 16 plots in the first series and 18 in the second. Each plot was 3½ feet wide by 62 feet long, and had an area of approximately one two-hundredth of an acre. To prevent mixing of the species and to facilitate control of weeds, paths 1 foot wide were maintained between individual plots and a border of fallow soil 3 feet wide was left along the margins of each tract. Seed was sown in the late summer (except for a few cases of reseeding) without a nurse crop and the plots were kept free from weeds by hand labor. A reasonable degree of success was attained in keeping pure the stands of the individual species.

Samples were taken by means of a lawn mower with a grass catcher attached whenever the grass reached a height of 3 to 4 inches, so that intervals between samplings varied with species and season of the year. Whenever possible at least one sample a month was taken from each species; wherever rate of growth necessitated taking more than one sample in a month from any species, yield and moisture content were determined on the additional samples, and each sample was composited with the sample already taken from the same plot.

Analyses were made for moisture in the fresh grass, and for total nitrogen, crude fiber, ether extract, total ash, acid-soluble ash, calcium phosphorus, and magnesium in the dry matter. Potassium was determined in the samples for 1931, 1932, and 1933, but because of its minor significance in the nutrition of grazing animals, it was not determined from that time onward.

All analyses except those for calcium, phosphorus, and magnesium were made according to the official methods of the Association of Official Agricultural Chemists (*2*).[3] Calcium and magnesium were determined by a modification of McCrudden's method (*6*), and phosphorus by the method of Fiske and Subbarow (*4*). Vitamin A was determined by biological assay with white rats, on a much smaller number of samples (51) taken for the most part independently of the main investigation.

During May and June of 1937 and 1938 a series of tests of the palatability of seven of the species was conducted with mature Jersey and Guernsey cows in milk at the time. The entire tract of each series of plots was fenced off, the plots were conspicuously numbered, and a tub of water was placed at a convenient point within the enclosure. Two cows were used at a time. They were turned into the enclosure soon after 8 a. m. and taken out again shortly before noon. There was sufficient grass so that each trial extended over 2 such half days.

A complete record of the length of time spent by each cow in grazing each species was obtained by an attendant who noted the exact time that a cow started and stopped grazing on any particular plot. Lulls in grazing, after which the cow resumed grazing on the same plot, were recorded as carefully as shifts from plot to plot.

PRESENTATION OF RESULTS

CHEMICAL ANALYSES

A total of 300 samples of the several species was taken, but this number was reduced for analysis to 263 by the compositing of certain samples.

The results on the first six species listed in table 2 form the principal basis for discussion. Such information as was obtained on the last three species has been appended as a supplement to the more complete report on the first six. There are two reasons for this procedure: (1) The much larger number of samples from individual species in the first group, and (2) each and every year and a majority of months are represented in the data from the first group, whereas for unforeseen or unavoidable reasons this was not true for any of the three species in the second group.

In this study there were representatives of two great classes of herbage, the so-called top and bottom grasses, or more specifically those grasses more suitable for hay as contrasted with those more suitable for grazing. Some interesting differences are apparent in the composition of the species in these two classes. The top grasses were decidedly more succulent than the bottom grasses; they averaged about 2.5 percent less fiber and contained larger amounts of

[3] Grateful acknowledgment is made of the services of J. W. Kuzmeski and A. F. Spelman, who made the determinations of crude fiber and ether extract under the direction of Philip H. Smith, chief chemist of the feed control laboratory of this station.

ether extract, soluble ash, calcium, magnesium, and vitamin A (carotene). These differences probably are due in considerable measure to differences in stage of maturity and relative leaf area of the two classes of grass at a given height; they have a bearing on grazing practice that should not be lost sight of.

TABLE 2.—*Composition of 7 species of grass and 2 legumes, seasons of 1931–37*

Species	Samples	Moisture in the fresh grass	Composition of dry matter								Vitamin A equivalent per pound of dry matter
			Nitrogen[1]	Crude fiber	Ether extract	Total ash	Acid-soluble ash	Calcium	Phosphorus	Magnesium	
											International units
Top grasses:	*No.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	
Orchard grass	34	76.2	2.9	23.0	4.5	12.7	8.4	0.63	0.58	0.32	152,000
Redtop	36	74.0	3.0	21.9	4.2	10.6	6.8	.68	.39	.27	133,000
Timothy	36	74.2	2.9	20.6	3.9	9.5	6.3	.59	.40	.25	162,000
Bottom grasses:											
Kentucky bluegrass	39	69.6	3.0	23.6	3.4	9.0	5.8	.51	.42	.23	101,000
Rhode Island bent	37	70.6	3.1	21.7	3.7	10.3	6.2	.64	.40	.23	132,000
Sheep fescue	39	67.1	2.7	26.8	3.3	8.4	5.0	.43	.36	.16	85,000
Sweet vernal grass	14	77.9	3.2	17.6	4.7	10.0	6.8	.64	.38	.27	118,000
White Dutch clover	20	82.6	4.6	14.4	3.1	12.3	9.9	1.61	.45	.29	[2]
Ladino clover	8	83.7	4.3	13.7	2.5	13.5	8.8	1.90	.37	.42	[2]

[1] Reported as nitrogen rather than as protein because not all the nitrogen is in the form of protein; the amount of nonprotein nitrogen is small—10 percent or less.
[2] Not determined.

Nitrogen differences between species were small for the most part, and the same was true of phosphorus. The high value for phosphorus in orchard grass noted in the earlier report (*1*), while still persisting in the samples grown on soil of tract 1, was not noted in the samples from soil of tract 2. This may be due to the fact that there was about twice as much available phosphorus in the soil of tract 1 as in that of tract 2 (see table 1). It has been suggested that possibly the ability to utilize additional phosphorus may be a characteristic peculiar to to this species of grass.

There seems to be a rather definite relation between the amount of fiber in the several species and their breaking strength. Beaumont, Stitt, and Snell (*3*), of this station, have reported breaking strength for four of the six species represented here. Their values, arranged in order of increasing strength, are compared with those for fiber content in table 3. Except that the timothy had a little less fiber than the

TABLE 3.—*Breaking strength compared with fiber content of four of the species of grasses included in the test*

Species	Breaking strength[1]	Fiber content
	Grams	*Percent*
Redtop	52.9	21.9
Timothy	58.6	20.6
Kentucky bluegrass	92.6	23.6
Sheep fescue	147.9	26.8

[1] Grams per millimeter of perimeter; average of 50 determinations.

redtop, the two sets of values are in the same order; i. e., the higher the content of fiber the higher the breaking strength, which is what would naturally be expected.

The proportion of soluble ash to total ash was rather constant (table 2) the variation being only from 66.2 percent in orchard grass to 59.4 percent in sheep fescue; although there were some exceptions, in general the higher the percentage of soluble ash the greater the proportion of the total ash it constituted. As in the earlier trials (*1*), the two members of the bent family (redtop and Rhode Island bent) had the highest calcium values of the group, but contrary to earlier results, the value for redtop was higher than that for Rhode Island bent.

In general, the constitutents that varied significantly from one species to another were: Moisture, in the fresh grass; and, in the dry matter, crude fiber, ether extract, soluble ash, calcium, and magnesium. With minor exceptions phosphorus and nitrogen did not vary significantly.

In addition to the six species just discussed, three other species—one grass and two legumes—were studied, but in less detail, as already noted. The data are too incomplete to warrant statistical analysis, but they are given at the bottom of table 2 for such information as they may furnish.

In the limited number of samples available sweet vernal grass averaged higher in moisture, nitrogen, and ether extract, and lower in crude fiber than any of the other six species of grass. It was also quite high in soluble ash and magnesium, and was in a class with redtop and Rhode Island bent in its content of calcium.

White Dutch clover was decidedly more succulent than any of the grasses, its nitrogen (protein) content, like that of all legumes, was high (equivalent to 27 percent of protein in the dry substance); its fiber content was about 7 percent less than that of timothy, the best grass in this respect; its soluble-ash content of almost 10 percent was approached only by that of orchard grass; its calcium content was nearly 2½ times as much as that of redtop, the grass with the highest calcium value; its phosphorus content was exceeded only by that of orchard grass, and the same was true for magnesium. Only in ether extract was it lower than the grasses, containing less than sheep fescue, the lowest grass in this respect.

The small number of samples of Ladino clover (a giant variety of *Trifolium repens*) show its composition to be very similar in most respects to that of the dwarf white Dutch variety.

STATISTICAL ANALYSES

In the course of the statistical studies some interesting correlations were observed; those of special significance were between:

Moisture and nitrogen	$r=0.59\pm0.03$
Ether extract and soluble ash	$r=.55\pm.03$
Soluble ash and phosphorus	$r=.74\pm.20$
Calcium and magnesium	$r=.70\pm.02$

There was one significantly negative correlation, that between nitrogen and crude fiber, $r=0.62\pm0.03$.

PALATABILITY TRIALS

Palatability trials with five cows extended over 105 hours of potential grazing time and 54 hours of actual grazing time. A summary of the results of these trials, classified according to individual preference for the several species of grass, as well as the average preference for the entire series of trials, is presented in table 4. The cows showed a decided preference for timothy. In order of preference orchard grass, redtop, Rhode Island bent, and sweet vernal grass ranked so close together (16 to 17.5 percent) that probably the small differences between them were not significant. Bluegrass, however, was grazed less than 10 percent of the time, and sheep fescue was practically untouched.

Separation of the results into groups for first and second day, for first, second, and third trials, and for the two series of plots shows that the trends of preference noted for the results as a whole persisted remarkably all through these smaller groups.

Some variation in individual preference was noted, but the general trend was unmistakable, especially as to the best-liked and least-liked species. In palatability timothy was at or near the top; redtop was near the top; bluegrass was near the bottom—not higher than fifth place in any case—and fescue was consistently in last place.

TABLE 4.—*Summary of results of the grazing trials classified according to individual preference for the several species*

Cow No.	Total grazing time	Kentucky bluegrass		Orchard grass		Redtop		Rhode Island bent		Sheep fescue		Sweet vernal grass		Timothy	
		Grazing time	Proportion of total	Grazing time	Proportion of total	Grazing time	Proportion of total	Grazing time	Proportion of total	Grazing time	Proportion of total	Grazing time	Proportion of total	Grazing time	Proportion of total
	Min.	*Min.*	*Pct.*	*Min.*	*Pct.*	*Min.*	*Pct.*	*Min.*	*Pct.*	*Min.*	*Pct.*	*Min.*	*Pct.*	*Min.*	*Pct.*
760	787	90	11.4	142	18.0	151	19.2	147	18.7	3	0.4	80	10.2	174	22.1
806	442	38	8.6	78	17.7	98	22.2	65	14.7	1	.2	83	18.8	79	17.9
607	198	15	7.6	46	23.2	25	12.6	21	10.6	0	----	49	24.8	42	21.2
665	863	28	3.2	105	12.2	112	13.0	131	15.2	15	1.7	217	25.1	255	29.6
687	950	145	15.3	196	20.6	166	17.5	159	16.7	7	.7	89	9.4	188	19.8
Total	3,240	316	----	567	-----	552	-----	523	-----	26	----	518	-----	738	-----
Weighted average	------	------	9.8	------	17.5	------	17.0	------	16.1	------	.8	------	16.0	------	22.8

On the basis of the preference shown by the cows as a group the rating of the grasses is without exception in the order of their vitamin A (carotene) content, and with one exception in the order of their succulence (moisture content). In general also the cows preferred those with a relatively high content of ether extract, soluble ash, and magnesium, and with a low content of fiber. Nitrogen (protein) content of the grasses apparently had little if any relation to their palatability.

The observation of some investigators that redtop lacks palatability does not agree with the rating it received in these tests. The discrepancy probably is due to the fact that in these trials it never reached the stage where it developed woody stolons.

SUMMARY

This is the final report of a 7-year investigation into the chemical composition and palatability to cows of certain grasses and legumes grown as practically pure stands. The species studied were: Kentucky bluegrass, orchard grass, redtop, Rhode Island bent, sheep fescue, timothy, sweet vernal grass, white Dutch clover, and Ladino clover.

In the main investigation 300 samples, reduced by compositing to 263, were analyzed. In addition, 51 biological assays were made for vitamin A, and palatability tests with 5 cows extended over 105 hours of potential grazing time and 54 hours of actual grazing time.

Considerable species differences were noted in the several constituents except nitrogen and phosphorus [4]; these differences for the most part were more obvious between the two groups of grasses (top and bottom) than between the individuals within a group. Relatively the greatest group differences were in vitamin A (carotene), magnesium, soluble ash, and ether extract, a reflection probably of greater leaf area in the top grasses. The composition of the two legumes was in rather sharp contrast to that of the grasses. Highly significant correlations were noted between certain of the constituents.

Cows used in palatability tests showed a definite preference for species high in moisture and carotene and low in fiber. The nitrogen (protein) content of the grasses apparently had little if any relation to their palatability.

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[4] One species (orchard grass) had a much higher phosphorus content than the others under certain circumstances.