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THE PROTEIN CONTENT AND MICROCHEMICAL TESTS OF THE SEEDS OF SOME COMMON IOWA WEEDS.

L. H. PAMMEL AND ARTHUR W. DOX.

Weed seeds are recognized as an important factor in the dietary of our useful birds. Other things being equal, those seeds having the highest nutritive value might be expected to figure more prominently in this regard than seeds less nutritious. In animal feeding, the protein content of the feed is taken as the measure of its nutritive value, and the cost of the feed is determined largely by the protein content as ascertained in the chemical laboratory. Hence the protein content of weed seeds is of some economical importance as related both to the maintenance of our native birds and to the control of the weeds themselves.

The list of species, the analyses of the seeds of which are here reported, comprise but a small part of the weed flora of the state. It is hoped, however, that the writers may have opportunity to extend the list during the coming season. The seed samples were collected in the vicinity of the Iowa State College during the late summer and early fall of 1916. All chaff, hulls, appendages, etc., were removed by rubbing in a cloth, screening, and winnowing, until the seeds were practically clean. The samples thus obtained were spread out on watch glasses in a dust-proof cupboard for several weeks until they were air-dry. The determinations here recorded are all on the air-dry basis. As a matter of additional interest the weight of fifty seeds was determined in each case, and from this value the approximate number of seeds per gram was computed. Nitrogen was determined by the well known Kjeldahl-Gunning method and the value thus obtained was multiplied by the factor 6.25 to convert it into protein.

For the purpose of ascertaining the microscopic characters of the weed seed investigation made chemically by Doctor Dox, a micro-chemical test also was made to determine the presence of starch, protein and fat. Microscopic tests have been made of the seeds of a great many weeds. A brief reference to some of the papers will not be amiss in this connection. One of us made a study of the anatomical characters of the seeds of Leguminosæ,

chiefly genera of Gray's Manual¹, on the seed coats of the genus *Euphorbia*², on the seeds and testa of some Cruciferae³, on the structure of the testa of several leguminous seeds,⁴ on some methods in the study of mature seeds,⁵ on the seed coats of *Crotalaria sagittalis* and *Astragalus mollissimus*⁶, on the histology of the caryopsis and endosperm of some grasses⁷, and on the characters of weed seeds⁸. P. II. Rolfs has reported on the seed coats of Malvaceae⁹, and the seeds of Berberidaceae have been studied by Pammel, Burnip and Thomas.¹⁰ Winton and Moeller¹¹ discussed the microscopy of vegetable foods. Hanausek, Winton and Barber¹² have a similar discussion in *The Microscopy of Technical Products*; A. J. Pieters and V. K. Charles¹³ have reported on the seed coats of certain species of the genus *Brassica*, while Winton¹⁴ has discussed the anatomy of weed seeds. Emma Sirrine¹⁵ has worked on the structure of the seed coats of Polygonaceae. Kramer's *Pharmacognosy*¹⁶ is another textbook covering this subject.

Three of the most important European treatises on the subject are Harz, *Landwirtschaftliche Samenkunde*; Tschirch, A., and Oesterle, *Anatomischer Atlas der Pharmakognosie und Nahrungsmittel*; Wiesner, *Die Rohstoffe des Pflanzenreiches*.

¹L. H. Pammel, *Trans. Acad. Sci. St. Louis*, 9, 90-273, *pl.* 7-35. This paper gives an extensive literature.

²*Trans. Acad. Sci. St. Louis*, 5, 543-568, *pl.* 12-14.

³*Am. Mo. Mic. Jour.*, 18, 205, 269, 312, 2 *pl.*, 2 *figs.*, *Bull. Ia. Agrl. Exp. Sta.*

⁴*Bull. Torrey Bot. Club*, 13, 17-24, *pl.* 52-53.

⁵*Jour. Appl. Micro.*, 1, 37-39, 6 *figs.*

⁶*The Biennial Rep. Ia. State College and Farm*, 13, 47-48.

⁷*Trans. Acad. Sci., St. Louis*, 8, 199-220, *pl.* 17-19. See also *Bull. Iowa Geol. Survey*, 1, 525.

⁸Charlotte M. King and L. H. Pammel, *Weed Flora of Iowa. Bull. Ia. Geol. Survey*, 4, 505-587, *figs.* 383-442. This paper contains a bibliography.

⁹*Bot. Gazette*, 17, 33-39, *pl.* 3.

¹⁰*Proc. Ia. Acad. Sci.*, 5, 209-223, *pl.* 12-16.

¹¹English translation of Josef Moeller, *Mikroskopie der Nahrungs u. Genussmittel aus dem Pflanzenreiche*.

¹²John Wiley and Sons, New York, 1907.

¹³*Bull. U. S. Dept. Agrl. (Bur. Pl. Ind.)*, 29, 19.

¹⁴*Rep. Conn. Agrl. Exp. Sta.*, 1902, 345-358.

¹⁵*Proc. Ia. Acad. Sci.*, 2, 128-134, *pl.* 7-9.

¹⁶A text book of botany and Pharmacognosy, Lippincott, 1907.

TESTS OF IOWA WEED SEEDS

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PROTEIN CONTENT CHEMICALLY CONSIDERED.

The samples thus far examined are given below in the order of their protein content.

Common Name	Botanical Name	Wt. of 50	No. seeds per gm.	Per cent nitrogen	Per cent protein
Sweet clover	Melilotus alba	.0882	567	5.61	35.05
Red clover	Trifolium pratense				
	Yellow seed	.0877	570	5.48	34.23
	Purple seed	.0834	600	5.37	33.54
Yellow sweet clover	Melilotus officinalis	.0832	601	5.35	33.44
Alsike clover	Trifolium hybridum	.0335	1490	5.24	32.72
Milkweed	Asclepias syriaca	.3214	156	5.00	31.25
White clover	Trifolium repens	.0270	1850	4.97	31.03
Greater ragweed	Ambrosia trifida	.8045	622	4.94	30.89
Black-eyed Susan	Rudbeckia hirta	.0085	5880	4.92	30.73
Wild lettuce	Lactuca canadensis	.0305	1640	2.72	29.45
Swamp milkweed	Asclepias incarnata	.0903	5540	4.69	29.33
Dandelion	Taraxacum officinale	.0160	3120	4.64	28.98
Dandelion	erythrospermum	.0138	3620		
Horse mint	Monarda punctata	.0241	2070	4.52	28.28
Vetch	Vicia faba	1.2174	41	4.46	27.87
Pepper grass	Lepidium virginicum	.0112	4460	4.27	26.70
Tumbling mustard	Sisymbrium altissimum	.0077	6490	4.01	25.03
Sand bur	Cenchrus tribuloides	.3619	138	3.86	24.14
Three-seeded mercury	Acalypha virginica	.0366	1370	3.85	24.07
Wild mustard	Brassica arvensis	.0963	552	3.80	23.72
Small ragweed	Ambrosia artemisiifolia	.2495	200	3.75	23.46
Five-finger	Potentilla arguta	.0665	7690	3.73	23.29
Wild four o'clock	Oxybaphus nyctagineus	.1262	396	3.64	22.77
Mallow	Malva rotundifolia	.0656	762	3.61	22.57
Hemp	Cannabis sativa	.4524	111	3.59	22.47
Prickly lettuce	Lactuca scariola	.0222	2250	3.49	21.80
Velvet leaf	Abutilon theophrasti	.5002	100	3.35	20.93
Sticktight	Bidens frondosa	.1740	287	3.25	20.30
Wild morning glory	Convolvulus sepium	1.4340	35	3.23	20.20
Dooryard plantain	Plantago major	.0107	4670	3.05	19.09
Burdock	Arcium lappa	.3270	153	3.05	19.06
Heal-all	Prunella vulgaris	.0334	1500	3.03	18.91
Catnip	Nepeta cataria	.0289	1850	3.00	18.75
Timothy	Phleum pratense	.0190	2630	2.89	18.04
Mullein	Verbascum thapsus	.0634	14700	2.86	17.56
Spurge	Euphorbia Preslii	.0266	1880	2.85	17.81
Green cone flower	Lepachys pinnata	.0343	1460	2.80	17.52
Evening primrose	Oenothera biennis	.0147	3400	2.72	16.99
Yellow foxtail	Setaria glauca	.0549	911	2.65	16.92
Simpson honey plant	Scrophularia marilandica	.0055	9090	2.55	15.93
Soap wort	Saponaria officinalis	.0836	598	2.55	15.92
Redroot	Amaranthus retroflexus	.0166	3010	2.49	15.59
Bull thistle	Cirsium lanceolatum	.0923	5420	2.48	15.48
Pigweed	Amaranthus graecizans	.0176	2840	2.32	14.52
Wild parsnip	Pastinaca sativa	.1080	463	2.30	14.36
Cinquefoil	Potentilla monspeliensis	.0648	10400	2.27	14.15
Knot grass	Polygonum aviculare	.0423	1180	2.21	13.85
Yellow dock	Rumex crispus	.0678	737	2.14	13.14
False groundwell	Lithospermum latifolium	.6885	73	1.93	12.04
Prostrate pigweed	Amaranthus blitoides	.0441	1130	1.88	11.75
White vervain	Verbena urticaefolia	.0176	2840	1.78	11.12
Germander	Teucrium canadense	.0544	919	1.76	11.03
Hoary vervain	Verbena stricta	.0331	1510	1.63	10.16
Wild buckwheat	Polygonum convolvulus	.2080	240	1.59	9.94
Erect knot weed	Polygonum erectum	.0580	862	1.49	9.28
Lady's thumb	Polygonum Persicaria	.0537	931	1.05	6.56
Smartweed	Polygonum Pennsylvani-				
	cum	.1561	320	.91	5.69
Horse gentian	Triosteum perfoliatum	2.3260	21	.88	5.51
Prairie rose	Rosa pratincola	.4825	104	.68	4.25
Sumach	Rhus glabra	.2199	277	.52	3.24

As might be expected, the legumes stand at the head of the list. The oil-bearing seeds, also, contain considerable amounts of protein. On the other hand, those that contain notable quantities of starch, as the Polygonaceæ, are much lower in protein. Those at the end of the list represent seeds with a thick woody coat sufficient in amount to reduce greatly the protein percentage. On the whole, there is rather a close agreement in composition between related species of the same genus. The list, however, is as yet too incomplete to warrant discussion in greater detail.

In the paper on the anatomy of the Leguminosæ attention is called to the presence of fat when the carbohydrates are wanting. In such cases fat is present usually in greater amounts than where the starch occurs. The reserve food not only varies in the tribes but in related genera. In the Viciæ and Phaseolæ the reserve food consists largely of carbohydrates in the form of starch and proteins, the latter in the form of aleurone grains. In the Caesalpinicæ e. g., honey locust, the reserve food occurs in the form of proteins and fat. In the soy bean (*Soja hispida*) it occurs largely as fat and proteins, in clover as starch, protein and fat.

The microchemical tests recorded in this paper consisted of the usual test for starch, namely, iodine in potassium iodide, iodine for protein, Sudan III for fat, ferric chloride for tannin. Many of the testa or pericarps have some tannin. Tannin was not, however, found in the endosperm of many seeds and for this reason the test is omitted from the table. The pericarps of many seeds, as well as the testa, contain some tannic acid, although the amount with some exceptions is very small. Most of the tests given in the table were made by us. Where the tests were made by others, they have been starred. Most of the starred tests were taken from Harz, Winton and Moeller.

MICROCHEMICAL TESTS FOR STARCH, PROTEIN AND FAT.

Name	Starch	Protein	Fat
Gramineæ			
Agropyron repens -----	abundant	some	little
Aristida ramosissima -----	compound grain abundant	some	little
Bromus ciliatus var. purgans -----	simple		
	abundant	some	little
*Bromus secalinus -----	simple grains	some	little
Digitaria humifusa -----	abundant small polygonal simple	some	little

MICROCHEMICAL TESTS FOR STARCH, PROTEIN AND FAT—Continued

Name	Starch	Protein	Fat
<i>Cenchrus tribuloides</i> -----	large and small abundant	some	little
<i>Echinochloa crus-galli</i> -----	abundant small polygonal simple	some	little
<i>Elymus canadensis</i> -----	simple abundant	some	little
<i>Hordeum jubatum</i> -----	simple abundant	some	little
* <i>Lolium temulentum</i> -----	small simple	some	little
<i>Setaria glauca</i> -----	abundant small polygonal simple	some	little
<i>Setaria viridis</i> -----	abundant small polygonal simple	some	little
<i>Setaria Italica</i> -----	abundant small polygonal simple	some	little
Urticaceæ			
<i>Cannabis sativa</i> -----	none	abundant	abundant
<i>Urtica gracilis</i> -----	none	abundant	abundant
Amaranthaceæ			
<i>Amaranthus blitoides</i> -----	very small grain abundant	some	little
<i>Amaranthus graecizans</i> -----	very small grain abundant	some	little
<i>Amaranthus retroflexus</i> -----	very small grain abundant	some	little
Polygonaceæ			
<i>Polygonum aviculare</i> -----	small starch grain abundant	small	little
<i>Polygonum convolvulus</i> -----	grains variable in size	small	little
<i>Polygonum erectum</i> -----	grains abundant	small	little
<i>Polygonum Persicaria</i> -----	apparently simple abundant	small	little
<i>Polygonum Pennsylvanicum</i> -----	compound and abundant	small	little
<i>Rumex acetosella</i> -----	abundant simple	some	little
<i>Rumex crispus</i> -----	abundant simple	some	little
Nyctaginaceæ			
<i>Oxybaphus nyctagineus</i> -----	abundant simple	abundant	some
Carvovhyllaceæ			
<i>Saponaria officinalis</i> -----	compound abundant	some	little
<i>Silene antirrhina</i> -----	small	some	little
<i>Silene virginica</i> -----	small	some	little
<i>Agrostemma githago</i> -----	small	some	little
Ranunculaceæ			
* <i>Ranunculus arvensis</i> -----	none	abundant	some
* <i>Ranunculus abortivus</i> -----	none	abundant	some
Berberidaceæ			
<i>Berberis vulgaris</i> -----	none	abundant	some
Chenopodiaceæ			
<i>Salsola Kali var. tenuifolia</i> -----	none	abundant	some
<i>Chenopodium album</i> -----	abundant small	some	little
Crucifere			
<i>Brassica arvensis</i> -----	none	abundant	abundant
<i>Brassica nigra</i> -----	none	abundant	abundant
<i>Barbarea vulgaris</i> -----	none	abundant	abundant
<i>Camelina sativa</i> -----	none	abundant	abundant
<i>Capsella Bursa-pastoris</i> -----	none	abundant	abundant
<i>Lepidium apetalum</i> -----	none	abundant	abundant
<i>Lepidium virginicum</i> -----	none	abundant	abundant
<i>Sisymbrium officinale</i> -----	none	abundant	abundant
<i>Sisymbrium altissimum</i> -----	none	abundant	abundant
Compositæ			
<i>Ambrosia artemisiifolia</i> -----	none	abundant	abundant
<i>Ambrosia trifida</i> -----	none	abundant	some
<i>Arcium major</i> -----	none	abundant	some
* <i>Centaurea Cyanus</i> -----	none	abundant	some
<i>Cirsium lanceolatum</i> -----	none	some	little
<i>Lactuca canadensis</i> -----	none	some	little
<i>Lactuca scariola</i> -----	none	some	little
<i>Rudbeckia hirta</i> -----	none	some	little
<i>Taraxacum officinale</i> -----	none	some	little
Scrophulariaceæ			
<i>Scrophularia marilandica</i> -----	none	abundant	some
<i>Verbascum Thapsus</i> -----	none	abundant	some

MICROCHEMICAL TESTS FOR STARCH, PROTEIN AND FAT---Continued

Name	Starch	Protein	Fat
Plantaginaceæ			
Plantago major	very few	abundant	some
Caprifoliaceæ			
Triosteum perfoliatum	none	abundant	some
Labiatae			
Nepeta cataria	none	abundant	some
Monarda fistulosa	none	abundant	some
Prunella vulgaris	none	abundant	some
Teucrium canadense	none	abundant	some
Solanaceæ			
Datura Stramonium	none	abundant	some
Physalis pubescens	none	abundant	some
Solanum carolinense	none	abundant	some
Convolvulaceæ			
Convolvulus sepium	none	abundant	some
Cuscuta Epithymum	small grains	some	little
Boraginaceæ			
Cynoglossum virginianum	none	some	little
Lithospermum latifolium	abundant compound	some	little
*Melampyrum arvense	none	some	some
Verbenaceæ			
Verbena stricta	none	abundant	some
Verbena urticæifolia	none	abundant	some
Onagraceæ			
Oenothera biennis	none	abundant	some
Umbelliferae			
Daucus carota	none	abundant	some
Heracleum lanatum	none	abundant	some
Pastinaca sativa	none	abundant	some
Ericaceæ			
*Vaccinium Myrtillus	none	abundant	some
Asclepidaceæ			
Asclepias incarnata	none	abundant	abundant
Asclepias syriaca	none	abundant	abundant
Linaceæ			
Linum usitatissimum	none	abundant	some
Malvaceæ			
Abutilon Theophrasti	none	abundant	some
Gossypium herbaceum	none	abundant	some
Malva rotundifolia	none	abundant	some
Sida spinosa	none	abundant	some
Hibiscus Trionum	none	abundant	some
Leguminosææ			
Amorpha canescens	small grains	some	some
Amphicarpa monoica	none	abundant	some
Astragalus canadensis	none	abundant	some
Cassia Chamaecrista	none	abundant	some
Crotalaria sagittalis	none	abundant	some
Dalea alopecuroides	none	abundant	some
Desmodium canescens	none	abundant	some
Gleditsia triacanthos	none	abundant	some
Glycyrrhiza lepidota	none	abundant	some
Lathyrus venosus	some large grains	some	little
Lespedeza capitata	none	abundant	some
Medicago lupulina	none	abundant	some
Melilotus alba	small grains	some	little
Melilotus officinalis	small grains	some	little
Trifolium pratense	small grains	some	little
Trifolium repens	small grains	some	little
Vicia sativa	abundant	some	little
Euphorbiaceæ			
Acalypha virginica	none	abundant	abundant
Euphorbia corollata	none	abundant	abundant
Euphorbia maculata	none	abundant	abundant
Euphorbia preslii	none	abundant	abundant
Rosaceæ			
Potentilla arguta	present	abundant	some
Potentilla monspeliensis	present	abundant	some
Grossulariaceæ			
Ribes rubrum	none	abundant	some

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