Oregon Agricultural

EXPERIMENT STATION.

Bulletin No. 39. - December, 1895.

DEPARTMENT OF CHEMISTRY.

OAT STRAW.

Cheat.

ORCHARD GRASS.

TALL OAT GRASS.

RED CLOVER.

G. W. SHAW.

The Bulletins of this Station are sent free to all residents of Oregon who request them.

AGRICULTURAL COLLEGE PRINTING OFFICE.
H. R. CLARK, Printer.
CORVALLIS, OREGON:
1895.

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A STUDY IN THE ECONOMY OF CATTLE FOODS.

BY G. W. SHAW.

The subject of stock feeding is an important one to this State, and is destined to be more so in the near future. It is important not only to the producer of cattle for the butcher's block, but also to every farmer who has to do with stock of any kind, for it improves the chance of supplementing the articles at hand in an economical manner and to suit the varied conditions and desires. This is the more so in these times of close margins, when every business has to be reduced to the strictest economy. It is "penny wise and pound foolish" for us to pursue in these days the methods of twenty-five years ago, when there was scarcely anything known either of the composition or digestibility of cattle foods. If we would succeed in any business it behooves us to spend a portion of our time in reading the experience of others, and of the investigations that are being conducted along the lines in which our business interests lie. It is no more essential that the manufacturer should be abreast of the times in order to succeed, than that the farmer should be acquainted with the latest discoveries in his business.

There is today a veritable struggle for existence, and this becomes more intense year by year in all pursuits. Farming, once regarded as the simplest of all occupations, has become one of the most complex. The farmer who follows practices of years ago, when he had but to sow the seed and harvest the crop, to pitch out the hay to his cattle, letting them eat as much as they would and trample under foot any that remained, has little remuneration to-day for his toil. The new methods that have taken the place of the old hap-hazard ways always require considerable thought, and often very close study. As the result of this, the farmer must become a student as well as a thorough business man. As time advances it becomes more and more evident that "No department of natural science is incapable of yielding instruction to the tiller of the soil." We can no longer look with suspicion upon anything that smacks of science, for knowledge which comes to us through its channels has been obtained by the most careful observations and experiment.

The ultimate purpose of all agricultural investigation is how to produce more plants and animals upon the same area at a less expense. With reference to this question during the last ten years a great many important problems have been solved, and none has a more important bearing upon farm economy than that of rational stock feeding. We must admit that much still remains to be done in this field, yet the results so far obtained have put an entirely different aspect upon this branch of farm operations. The field is a vast one, and we might almost say that it is boundless; and the varied local conditions so modify the circumstances that there is need of special investigation in each locality. The solution of these problems demands long and carefully conducted experiments, for the questions that have to be met are not only the composition of the fodder articles, but also their relative digestibility under the existing circumstances and with the particular kind of animal in hand, and how much of the various nutrients each kind of animal needs to support life, and to do the desired work.

In the state of Oregon on January 1, 1893 there were the following animals.

Horses..........................	294,509,	Valued	at	$13,479,667
Mules..........................	4,755,	"	"	249,503
Milch Cows....................	107,183,	"	"	2,572,392
Oxen and other Cattle......	781,114,	"	"	12,238,890
Sheep	2,456,077,	"	"	5,903,182
Hogs..........................	204,609,	"	"	912,760

A saving of but ten cents per month would aggregate over four and one-half million dollars to the state per year. and such a saving by rational feeding alone would be a very conservative estimate. Then there are the wasteful methods of handling manure, which will demand attention at another time.

A writer has tersely put the question of farm management as requiring a knowledge of "1. What fodder crops to grow; 2. which will produce the most nutritive matter per acre at the lowest cost; 3. how to feed these in such a way as to get the benefit of all they contain; and 4. how to return to the soil as much as possible of the manurial matter removed with the crop."

It is the province of this bulletin to set forth the results of the analyses of some of the grasses commonly grown in this state, as well as some explanation of the methods used in calculating rations. It is the legitimate office of any bulletin to disseminate among the farmers of the state in which it is published, results that will be useful to them, wherever those results may have been obtained, of course giving proper credit for the source. Hence in this publication is given a table showing the average composition of many common feeding stuffs. It is deemed best to give this at this time since of late there has been considerable inquiry for such information. The results given in Table III. represent averages of a large number of analyses made in many places in this country.

As this is essentially the first bulletin issued from this Station bearing directly on this important question, it will not be out of place to explain some of the terms which are used in all discussions of a like nature. These it will be necessary to understand in order to intelligently comprehend not only this bulletin, but also the farm literature as it appears in the best agricultural papers.

COMPOSITION OF CATTLE-FOODS.

The following description is put in as simple terms as possible without sacrificing accuracy of statement, and in no sense pretends to be new matter. The composition of food-stuffs, whether plant or animal, may be graphically represented as follows:

- FOOD STUFFS.
  - WATER.
  - DRY MATTER.
    - Organic
      - Nitrogenous —Protein
        - Albuminoids.
        - Amides.
      - Non-Nitrogenous
        - Fats or Ether Ext.
        - Carbohydrates
          - Nitrogen-free Ext.
          - Crude Fibre.
    - Mineral—Ash

It will be noticed that in all cases water is present. In many instances this is very evident, as in grass, beets, turnips, etc.; while in other material it is not so evident, yet when they seem perfectly dry under ordinary conditions, there is from 5 to 10 per cent moisture present. This water has no more food value than that taken from wells or streams. It is, however, a necessary constituent of the animal body, of which it composes from 40 to 50 per cent. Moisture is determined in the laboratory by heating the material for a long time at the temperature of boiling water, and in feeding stuffs, for technical reasons, this is conducted in a current of dry hydrogen. After the moisture has been driven off there is left the *dry matter*, which is partly organic and partly mineral in its composition. The mineral matter of plants has already been discussed in a previous bulletin, No. 36. In fodder analyses this mineral part of the plant is expressed by the term *ash*. It is the residue left after burning to perfect whiteness.

The organic matter embraces two well marked classes, viz., those containing the element nitrogen, *nitrogenous;* and those which lack nitrogen, *non-nitrogenous*. Of all the material composing a food-stuff, the nitrogenous matter is the most important. It embraces both albuminoids and amides, which, however, are not usually separated, but classed together as *Crude Protein*. The albuminoids compose much the larger part, and are the more important. They contain about 16 per cent of nitrogen, and are determined by an estimation of this element in the food-stuff. The part which these bodies play in the animal economy is the very important one of producing or renewing flesh (muscle or lean meat.) Their office is two-fold for they also furnish material from which the animal is able to elaborate a certain amount of fat. Yet by feeding the animal protein alone he cannot be kept alive for any length of time. Experiment has conclusively demonstrated that only by feeding all three ingredients can this be done without sacrificing health or flesh. The relative amount of protein, and its digestibility, determines in a large measure the commercial value of a food-stuff.

Nearly all food-stuffs contain more or less fat. This term is not used here in as definite a sense as in ordinary language, but rather refers to a class of bodies which have a similar composition, and since they are determined by extraction with ether, many chemists prefer to use the name *Ether Extract.* It really denotes more than fat, including in the case of grasses, clovers and other green food-stuffs, the coloring matter and certain gums. But in grain the extract is nearly all fats and oils. These do not differ in any essential particular from the animal fats and oils, which all belong to a class of bodies known as glycerides. As intimated above an animal has power to form fats in its own body, hence does not rely solely on the supply from the food-stuff. The function of this class of bodies is to keep up the animal heat. It seems to make no difference as to the source of the fat, for even in the butter from milch cows that had been fed on cotton-seed meal, thereby affecting the milk, Babcock failed to find any trace of the foreign fat, and pronounced it all butter fat.* As a heat producer the value of the fat of a food-stuff is 2½ times that of the other carbohydrates.

The CARBOHYDRATES are usually separated into *Crude Fibre*, and another class called *Nitrogen-free Extract.* The former is the woody tissue of the plant, which remains after successive boilings with a weak acid and a weak alkali. Carefully conducted experiments show that even this woody fibre has a nutritive value, a small quantity usually being digested. Still the value of food-stuffs usually varies inversely as the amount of crude fibre present. The *Nitrogen-free Extract* is composed of a number of substances, as starch, sugar, dextrin, and gums, grouped together because similar in composition. The entire group of carbohydrates is used to keep up the vital heat of the body, and produce fat to be stored up in the animal tissues for reserve fuel.

So far as known all changes of whatever kind occur in nature in accordance with fixed methods. "Like causes produce like results." This is as true in the process of animal digestion as elsewhere. The processes of nutrition are carried on according to well fixed laws, and it has been one of the objects of scientific research to arrive at a better understanding of these laws in order that they may be applied in feeding animals. The history of investigations to ascertain just what is the correct

*6th Annual Report of N. Y. Exp. Station.

proportions of nutrients to feed animals to produce different results, and that the most economically, covers a period of about thirty years, the earliest experiments being made by Bischoff and Voit, in Munich, Slohmann and Hennebey, in Weende, and Wolff, in Hohenheim. The results of these investigations, and later ones in America, have resulted in such intelligent tabulations as to enable us to get better results and more profit than with the old hap-hazard, guess-work method.

That a food-stuff may be of the greatest value, it must have a certain proportion existing between the nutrients, and these must be accompanied by a certain amount of non-nutritive matter. All the material of a food-stuff is not digestible. The per cent of digestible matter, then, is not the actual amount of nutritive matter present as shown in the analysis of the fodder. But a chemical analysis is the first step to render the results of feeding experiments intelligible, and is absolutely essential to an understanding of the material we are using in rations. *It is the foundation upon which the whole question of rational system of feeding rests. By chemical analysis it has been possible to determine not only the amount of nutritive matter in a great many fodders but also what percent of each class of nutrients is digestible.* So it is possible to measure the nutritive value of most of the common food-stuffs.

Before animals could be fed intelligently it was necessary to know their demands for the production of certain results. For instance, what was the proportion of nutrients demanded by an ox to simply maintain life and health, and what did he demand when at hard labor, and what should be the proportion to produce the quickest returns when he was intended for the block? This was a difficult question to solve, but the Germans, with their accustomed persistency, went at the problem, and as a result have been able to formulate a table of feeding standards, which gives the needs of various animals under different conditions. The ones obtained by Prof. Emil Wolff are the ones which are almost universally adopted by both German and American feeders. These results represent the average of a large number of experiments, as do the other tables here given.

TABLE I. · FEEDING STANDARDS.

Pounds per Day per 1,000 Pounds Live Weight.

	Total Organic Matter.	Fat.	Protein.	Nitrogen-Free Extract.	Total Nutritive Substance.	Nutritive Ratio.
Horse at light work	21.0	0.40	1.5	9.5	11.40	1:7.0
Horse at average work	22.5	0.60	1.8	11.2	13.60	1:7.0
Horse at hard work	25.5	0.80	2.8	13.4	17.0	1:5.5
Oxen at rest in stall	17.5	0.15	0.7	8.0	8.85	1:12.
Oxen at ordinary work	24.0	0.30	1.6	11.3	13.2	1:7.5
Oxen at hard work	26.0	0.50	2.4	13.2	16.10	1:6.0
Oxen fattening—first period	27.0	0.50	2.5	15.0	18.0	1:6.5
Oxen fattening—second period	26.0	0.70	3.0	14.8	18.5	1;5.5
Oxen fattening—third period	25.0	0.60	2.7	14.8	18.1	1:6.0
Milch Cows	24.0	0.40	2.5	12.5	15.4	1:5.4
Sheep—wool producing (coarse breed)	20.0	0.20	1.2	10.3	11.7	1:9.0
Sheep—wool producing (fine breed)	22.5	0.25	1.5	11.4	13.15	1:8.0
Sheep—fattening, first period	26.0	0.50	3.0	15.2	18.7	1:5.5
Sheep—fattening, second period	25.0	0.60	3.5	14.4	18.5	1:4.5
Swine—fattening, first period	36.0	......	5.9	27.5	32.5	1:5.5
Swine—fattening, second period	31.0	......	4.9	24.0	28.9	1:6.0
Swine—fattening, third period	23.5	......	2.7	17.5	20.2	1:6.5

In place of the standard as above given for milch cows, Dr. Babcock* suggests the one given below as better adapted to this country:

Total organic matter	25.0 lbs.
Digestible protein	2.2 "
Digestible carbohydrates	13.1 "
Digestible fat	.7 "
Total digestible matter	16.0 "
Nutritive Ratio	1:6.8

NUTRITIVE RATIO AND FUEL VALUE.

It is found that under different conditions animals demand different ratios of the flesh-forming nutrients (protein) to the heat-producing nutrients (carbohydrates.) For instance, if the carbohydrates are disproportionately increased and the proteins correspondingly decreased the result will be a loss of flesh and strength. Since this is true it can readily be seen that it is a matter of importance for any feeder to understand thoroughly the feeding material with which he has to deal. He should understand not only its composition, but also its digestibility.

The ratio existing between the protein and the carbohydrates is known as the "*Nutritive Ratio*", and is an extremely important index to the quality of the food, as found by actual di-

*9th Annual Report of Wisconsin Exp. Station.

gestion experiments. The term shows not only the relative amount of food constituents in the material, but also indicates on what side the food should be supplemented to produce the desired results at the least cost. To illustrate how the nutritive value, or nutritive ratio, is determined, let us take a chance illustration.

There is in Red Top hay

Digestible Protein	4.13	per cent.
Digestible Nitrogen-free Extract	30.35	"
Digestible Fibre	17.28	"
Digestible Fat ....72 × 2½=	1.80	"

4.13) 49.43

11.9 or 1:11.9

which expresses the nutritive ratio. The fat is multiplied by 2½ since experiments shows that pound for pound it supplies 2½ times as much heat as the carbohydrates. Provided there is much protein matter the ratio is said to be close; and wide when there is a small amount of protein as compared with the carbohydrates. If we examine the table of feeding standards on page 37 we shall see that in the case of fattening cattle, we have a much closer ration in the second period than in either the first or third periods.

The heat producing power of foods is also an important element. This is expressed in terms of "Potential Energy," the unit of which is the *calorie of heat*, or the amount of heat required to raise one pound of water 4 degrees Fahrenheit. The heat giving power is best expressed in *calories per pound of food consumed.* Calculated in this manner the following general estimate may be made of the average potential energy in one pound of food nutrients.

	Calories per pound.
Protein	1860
Fat, or Ether Extract	4220
Carbo hydrates	1860

It is doubtless true that these figures are not absolutely correct, but they represent the best of modern research, and are certainly within a very small limit of error.

DIGESTIBILITY OF FOOD-STUFFS.

The chemical analysis of a fodder does not represent its food value. A part of the food eaten by an animal is indigestible. The relative amount of digestible and indigestible matter varies with different food-stuffs and the higher or lower degree of digestibility very materially affects its nutritive value. Different stages of growth also influence the digestibility of the food-stuff, and therefore its food value. The amount of digestible matter for most of the common cattle-foods has been determined by feeding animals for a stated period upon food whose composition has been previously determined by analysis. The material so used is weighed, and the excreta of the animal very carefully collected, weighed and analyzed. The excreta is supposed to closely represent the indigestible matter, and from its analysis and that of the food eaten can be calculated the amount digested. The per cents of the various nutrients that can be digested by an animal are called the *Digestion Co-efficients.*

The amount of digestible matter, then, can be computed, when we know the digestion co-efficients, as follows: Suppose we know the composition of alfalfa to be as follows:

Protein...............................	5.91	×	78	=	4.61	Digestible
Fat	1.15	×	42	=	0.48	"
Nitrogen-free Extract............	12.02	×	70	=	8.41	"
Crude Fibre	10.57	×	42	=	4.44	"

The digestion co-efficients of a number of the common food-stuffs, as determined by various experimenters, is given in table II below, that the figures may be accessible to the farmers of this state. The figures will be subject to change as more extended experiments are conducted in this country. Such figures, on account of the time required for digestion experiments are not subject to rapid change, and they will serve as a fair index of the digestibility for some time.

The chemical department of the Station is now at work determining the composition of Oregon grasses, forage plants, grains and mill products and will issue bulletins relative to each as often as it seems best to do so. These analyses will be followed as far as possible, by digestion experiments with animals in order to further demonstrate the value of the various foods. In the present bulletin we wish to set forth the composition of a few Oregon grasses as determined in the laboratory of the Station. The writer is well aware that the results show a condition of things contrary to the popular idea in some portions of the state. Yet this is just the reasons for publishing the results. The results are in harmony, however, with the recognized facts as found in other states.

TABLE II.

Showing the Digestion Co-efficients as determined by American Experimenters.

FEEDING STUFFS.	Trials.	Organic Matter.	Protein.	Fat.	Nitrogen-Free Extract.	Fibre.
Grass, Rye, etc., green	6	....	74	67	73	83
Corn Fodder, green	3	....	74	69	73	74
Clover, Alfalfa, etc., green	2	....	67	64	78	53
Corn Silage	18	....	46	80	67	67
Sorghum	...	62	62	85	78	60
Hay of Grasses	47	....	54	54	63	55
Corn Fodder, dry	37	....	58	71	69	70
Corn Stalks	4	....	52	52	64	66
Mixed Hay, clover and timothy	3	....	42	54	57	49
Clover, Alfalfa, etc., hay	14	51	61	49	65	46
Oat Straw	2	....	40	37	52	57
Cow-pea hay	2	....	65	50	71	43
Vetch hay	...	....	76	60	66	54
Wheat Straw	...	....	17	36	39	56
Rye Straw	...	....	23	32	37	58
Potatoes	...	....	69	...	96	55
Roots	8	....	84	...	95	80
Milling and other material.						
Wheat Shorts	...	....	78	68	68†	...
Corn Meal	2	....	76*	82	92	87
Pea Meal	2	....	83	54	94	26
Wheat Bran and Middlings	6	68	78	76	72	33*
Linseed Meal	...	....	86	90	80	35
Cotton Seed Meal	2	....	89	100	68	33*
Oats	...	....	82	80	75	23
Gluten Meal	1	89	87	88	91	...

*European Experiment. †Includes fibre.

The materials which we propose to discuss are red clover, timothy, orchard grass, tall oat grass, cheat, and oat straw. The value of the articles given below is not intended to express more than the *relative* value. The actual value is governed by too varying circumstances to be expressed in any definite figures. The figures do tell us this, that if we pay $12.87 per ton for clover hay, we should be able to secure timothy at $11.73. If we pay less than the amount named above for the clover the proportion existing between the prices should be as 12.87 is to 11.73. In reckoning these values we have counted the digestible fat and protein as worth 4 1-3 cents per pound, and the digestible carbohydrates at 9-10 of a cent per pound.

A FEW OREGON FODDER PLANTS.

RED CLOVER. *Trifolium pratense*, L.

The sample was cut when in full bloom in the summer of 1894, and hung in the laboratory till the spring of 1895, when it was analyzed. The composition was as follows:

	Percentage Composition	Calculated to Dry Substance.	Digestible Matter in 100 lbs.
Water	9.39	- -	- -
Dry Matter	90.61	- -	- -
Ash	7.71	8.58	- -
Protein	8.26	9.11	5.04
Crude Fibre	28.45	31.40	13.09
Nitrogin-free Extract	43.76	48.29	28.44
Ether Extract	2.43	2.69	1.19

Nutritive ratio 1:8. 8. Heat units in 1 pound 916.42. Relative value $12.87 per ton.

This excellent forage plant is so well known that a description here would be superfluous, however, a few words as to its production may not be out of place. There is no doubt but that the farmers of the Willamette valley could profitably pay more attention to the preduction of clover. There are three reasons for this statement, first, that clover is king of all forage plants; second, owing to its power to gather nitrogen from the air, it is a great enricher of the soil, and therefore would tend to preserve the soil fertility; third, the conditions, as shown by careful trials, are in many cases favorable to its production. As the question of soil fertility is forced upon the attention of the farmers, as it is bound to in the not far distant future, the merits of clover will become better known, and we shall see it taking a regular place in farm crops. As to its adaptibility to the Willamette valley, and the method of seeding to secure a good stand, we refer the reader to Bulletin No. 35, by Prof. H. T. French, of this Station. There are many soils in this valley adapted to its production, and at the Station success has attended its seeding even on the "white lands." There is a popular belief that the soils of the Willamette valley are deficient in lime and therefore unsuited to the growing of clover. But analysis does not show this to be the case, in fact the soils in nearly all cases carry a fair amount of lime—on an average about 0.4 per cent—while east of the mountains this amount is nearly doubled. There is certainly a sufficient supply of lime to meet the demands of clover, which, while it is said to do the best on a calcareous soil, will do well even if the lime content is comparatively small.

TIMOTHY. *Phleum pratense*, L.

This is an average sample, and was gathered when in early bloom.

	Percentage Composition	Calculated to Dry Matter	Digestible Matter in 100 lbs.
Water	11.19	- -	- -
Dry Matter	88.81	- -	- -
Ash	3.98	4.48	- -
Protein	6.02	6.77	3.25
Crude Fibre	30.35	34.15	16.69
Nitrogen-free Extract	46.25	52.13	29.14
Ether Extract	2.20	2.47	1.19

Nutritive Ratio 1:14.8. Heat units in 1 pound 963.11. Relative value $11.42 per ton.

The grass is a perenial, and adapted to moist heavy soils, but since it roots shallowly it is quite easily affected by drouth. While popular judgement places this grass at the head of the list, yet a large number of chemical analyses and digestion experiments fail to support this idea. Timothy is successfully grown throughout the valleys of the state, and in some localities grows as high as 7 to 8 feet. While this grass sells better than most other grasses, yet for feeding purposes it is not equal to some others, as will be seen by comparing the figures above given with the following.

ORCHARD GRASS *Dactylis glomerata*, L.

The sample was cut while in bloom. Its composition was as follows:

	Percentage Composition	Calculated to Dry Matter	Digestible Matter in 100 lbs.
Water	11.80	- -	- -
Dry Matter	88.20	- -	- -
Ash	5.90	6.60	- -
Protein	8.17	9.26	4.41
Crude Fibre	38.33	43.46	21.08
Nitrogen-free Extract	33.54	38.12	21.13
Ether Extract	2.26	2.56	1.22

Nutritive Ratio 1:7.2. Heat units in 1 pound 918.81. Relative value $11.73 per ton.

This grass has been tried on the Station farm and of it Prof. French says:

"There is no state in the Union where orchard grass does better than in Oregon. It makes good pasturage, and when cut early it can not be easily excelled for hay. It does well on the level lands of the Willamette valley, and on the red hill land it grows with great vigor. In most parts of Oregon it is desirable to get a grass which will mature early so that it can make its growth before the dry season begins. This grass meets these requirements completely. It begins to head in April, and is often ready to cut in May. It continues its growth through the winter, furnishing a good growth for pasturage. If sown alone it should be sown thick; but the best results are obtained when sown with clover or some other grass. In spring this grass will furnish a bite two weeks earlier than most other grasses. When grazed down it soon recovers its vigor of growth."

In England the grass is considered better than timothy, and many feeders in this country who have tried it side by side with other grasses give it the preference. Of it Mr. I. A. Cole says: "After twenty years experience I have settled down on orchard grass as posessing greater merits than any other for both the pasture and meadow for fattening animals or for the dairy stock. When cut for hay just before its bloom, and cured with as little sun as possible, it will make more milk than any other variety known to me."

Its superiority is also borne out by chemical analyses. To obtain the greatest food value the grass should be cut while in early bloom.

TALL OAT GRASS *Arrhenatherum avenaceum*, Beauv.

	Composition of Air Dry Substance	Calculated to Dry Matter	Digestible Matter in 100 lbs.
Water	14.30	- -	- -
Dry Matter	85.70	- -	- -
Ash	7.23	8.43	- -
Protein	10.88	12.69	13.14
Crude Fibre	24.36	28.42	26.97
Nitrogen-free Extract	42.82	52.34	26.97
Ether Extract	2.41	2.80	1.20

Nutritive ratio 1:7.2. Heat units in 1 pound 912.56. Relative value $12.39 per ton.

The trials made with this grass in Oregon have met with marked success. It is a deep feeder, and consequently will withstand very dry weather and produce an excellent crop. An examination of its analysis as stated above will show it to have a high feeding value, indeed to have the highest of any of the grasses here treated. It is best used together with some clover as the cattle eat it more readily when thus mixed.

CHEAT, OR CHESS. *Bromus secalinus*, L.

	Composition Air Dry Substance	Calculated to Dry Matter	Digestible Matter in 100 lbs
Water	8.56	- -	- -
Dry Matter	91.44	- -	- -
Ash	9.19	10.05	- -
Protein	3.61	3.94	1.95
Crude Fibre	31.90	33.79	17.55
Nitrogen-free Extract	44.99	50.30	28.44
Ether Extract	1.75	1.92	.95

Nutritive ratio 1:24.5. Heat units in 1 pounds 941.77. Relative value $10.79 per ton.

In some portions of the state this grass is grown considerably. For hay it does not compare with any of the grasses named above. The samples used for analysis were of average quality, and while if cut a little earlier they would have made a little better showing, yet experience elsewhere conclusively has shown that this is a poor grass so far as food value is concerned. Our farmers would do better to use either tall oat grass or orchard grass. Foods are pretty fairly measured by the amount of protein they contain. In cheat we find this constituent low. The fact of its low feeding value is so well established that it is rarely used elsewhere as an agricultural grass. Our analysis simply adds strength to other analyses, and the sooner the farmers of certain portions of the state recognize the limited value of the grass the better. To more fully test the grass in this state the writer, in connection with the agriculturist of the Station, will shortly enter upon a feeding experiment with the hay of cheat. But the results given in the above table may be taken as fairly representing its relative value.

The reasons for it being a poor grass may be set forth as follows. As stated above, experiments show that animals require a certain amount of each nutrient for the maintainance of life, health and strength. Of these ingredients protein is the most important, and of this cheat contains a relatively small amount. Hence in order to obtain the requisite amount of flesh-forming matter (protein,) the animal has to eat an excessive amount of other ingredients, which is a waste, and tends to injure the digestive system of the animal. To use cheat alone would be much the same as to attempt to feed a person altogether on potatoes. A correct ratio with this hay should contain a more liberal supply of nitrogenous grains than most other hays. It will be noted that cheat contains but little more protein, or flesh-forming material, than the sample of oat straw analyzed, which was an excellent sample. Less cheat and more clover would, indeed, be a boon to the state.

There is also another reason why cheat is considered inferior. It is an annual, necessitating the preparation of ground and seeding each year which is no small expense. This of course increases very materially the cost of the crop over that of either oat or orchard grass which are perennials. In calculating the feeding value of course this has not been taken into account, but in counting the actual agricultural value of the grass this would form a very important item, and make this grass still less valuable. In fact cheat comes much nearer to oat straw in value than it does to either of the other grasses mentioned.

Oat Straw.

The sample of oat straw may be considered a good one, as the grain was not over-ripe when cut, and therefore shows a little closer nutritive ratio than is usual.

	Composition Air Dry Substance	Calculated to Dry Matter	Digestible Matter in 100 lbs
Water	9.62	- -	- -
Dry Matter	90.38	- -	- -
Ash	5.20	5.62	- -
Protein	3.51	3.78	1.40
Crude Fibre	43.37	46.94	24.82
Nitrogen-free Extract	36.02	41.63	18.73
Ether Extract	2.21	2.39	.44

Nutritive ratio 1:27.8. Heat units in 1 pound 853.62. Relative value $9.43 per ton.

By comparing the analysis of straw with the other as here given it will be seen that it is deficient in feeding qualities, particularly in albuminoids and fats, yet by a proper balancing by means of succulent foods, as roots or silage, and materials rich in albuminoids and fats, as oil meal, a considerable amount of straw can be fed to animals at a profit, especially if the animals are properly housed. Oil meal can now be had as cheaply on this coast as it can in the east, and indeed it is even cheaper than quoted in Chicago. It is an extremely valuable food to be fed in connection with the coarser foods, and it is safe to say that if it does not cost more than $25 per ton it can in most cases be used with profit. At present it is quoted at a much lower figure than this. A too large proportion of straw should not be used as it will tend to constipate the animal, but with a proper balancing the succulent food and roots will furnish the necessary laxative matter to counterbalance the above tendency, and the straw will serve as an excellent source of income on the farm. The ill repute which it has obtained comes largely from trying to economize by feeding it without combining the proper amount of protein and fats.

We have not spoken of the manurial value of any of these substances, which of itself is an important item. While it is not our intention to speak at length of this side of the matter at this time, it may be said that an animal averages to take out of a fodder about 20 per cent of its value, the balance being contained in the excreta which in all instances should be saved and returned to the land. There is not as much attention paid to this saving as there ought to be, but in the not far distant future its necessity will be forced upon us. In the calculation of the quality of any food-stuff for farm use, the manurial value should also receive attention and be added to the food value, thus giving the total value of the fodder to the farm.

CALCULATING RATIONS FROM THE TABLES.

While it is not our purpose to dwell at length on the question of cattle rations, yet it is desirable to introduce the subject in this bulletin in order to explain the use of the tables, and to pave the way for future publications treating of feeding experiments.

Having discussed the various terms applied to fodder analysis, we can come directly to the use of the tables. In the computation of rations it is evident that only the digestible part of a food need be considered. An examination of Table II, page 39, will show that some fodders may be considered as *concentrated*, while others are *coarse*. Among the concentrated foods we would place such substances as wheat, oats, oil meal, pea meal, etc.; while the latter class would include the hays, grasses, and many waste products. In the compounding of rations we attempt to make such a combination of the two classes as will give the best results. Let us illustrate, suppose we have on hand red clover hay, oat hay, cut in the milk stage, wheat bran, and coarsely ground wheat, and that we are desirous of compounding a suitable ration for milch cows, the average weight of which is 1000 pounds. Find in Table I, or rather the American standard below the table. the *nutritive ratio* required under the circumstances, and also the amount of the various nutrients. There we find that the nutritive ratio should be about 1: 6. 8, that the animal should have about 25 pounds of dry matter composed as follows:

Protein	2.20
Carbohydrates	13.10
Fat	.70
Total Nutritive Matter	16.00

In making up the ration the tables should not be followed too rigidly for no two lots of food material will have exactly the same composition. They do, however, represent a very close approximation to the true composition of the substances given. After a careful examination of the table, suppose we decide to form a *trial ration* of 10 pounds clover hay, 15 pounds oat hay, and 5 pounds wheat bran. In Table II, page 39, we find that in 100 pounds clover hay there are 6.74 pounds digestible matter, or .0674 in one pound. In 10 pounds then, there would be .0674 × 10, or .674 as in the table below. In like manner the other nutrients are calculated.

	Protein.	Carbohydrates.	Fat.
10 lbs. Clover hay	0.67	3.76	0.16
15 lbs. Oat hay	0.75	6.61	0.20
5 lbs. Wheat bran	0.57	2.19	0.12
Total Digestible Nutrients	1.99	12.56	0.48

Comparing these nutrients with the standard they will all be found too low. To remedy this let us use 15 pounds clover and 10 pounds oat hay. Calculating in the same manner as above, the ration will stand as follows:

15 lbs. Clover hay	1.01	5.64	0.24
10 lbs. Oat hay	.50	4.45	0.13
5 lbs. Wheat bran	57	2.19	0.12
Total Digestible Nutrients	2.08.	12.28	0.49

Still the nutrients are too low. For a third trial let us use 11 pounds of Oat hay. and add 1 pound of the ground wheat, which will give the following ration:

15 lbs. Clover hay	1.01	5.64	0.24
11 lbs. Oat hay	.55	4.89	0.14
5 lbs. Wheat bran	.57	2.19	0.12
1 lb. Wheat	.10	.71	0.02
Total Digestive Nutrients	2.23	13.43	0.52.

Calculating the nutritive ratio as before explained we shall find it to be 1: 6. 6 which is close to our standard. The fat is lower than the standard, but the carbohydrates are higher, and will to some extent compensate for the lack of fat since the two classes have the same office in animal economy. While a small departure from the standard is allowable, a broad one should always be avoided. If these tables are even approximately followed there will be a decided saving in the feeding of animals. The tables are in no wise speculative, but are the result of laborious and painstaking experiment conducted by many trained specialists, and so far as experience has gone there is no reason to doubt their accuracy. They are not, however, inflexible rules, but rather guides, to be followed as good sense and judgement may direct, bearing in mind that a wide deviation will always be at the expense of the desired results.

TABLE III.—*Average Composition of American Feeding Stuffs.*

Feeding Stuffs.	No. of analyses.	Percentage Composition. Water.	Ash.	Crude protein.	Crude fibre.	Nitrogen-free Extract.	Ether extract.	Organic matter.	Per cent Digestible Matter. Crude protein.	Carbo hydrates	Ether extract.	Nutritive Ratio.
Green fodders and silage.												
Pasture grass	....	80.0	2.0	3.	4.0	9.7	.8	18.0	2.6	10.6	.5	4.5
Green fodder corn (maize)	126	79.3	1.2	1.8	5.0	12.2	.5	19.5	1.3	11.8	.4	9.8
Alfalfa (lucern)	23	71.8	2.7	4.8	7.4	12.3	1.0	25.5	3.6	11.4	.4	3.4
Green clover	43	70.8	2.1	4.4	8.1	13.5	1.1	27.1	2.9	14.1	.7	5.4
Alsike clover, in bloom	4	74.8	2.0	3.9	7.4	11.0	.9	23.2	2.7	13.1	.6	5.4
Rye fodder	7	76.6	1.8	.6	11.6	6.8	.6	21.6	2.1	14.1	.4	7.2
Oat fodder	5	65.2	2.5	3.4	11.2	19.3	1.4	35.3	2.7	22.7	1.0	9.3
Red top, in bloom	5	64.8	2.3	3.3	9.4	19.1	1.2	32.9	2.3	20.5	.7	9.6
Meadow fescue, in bloom	4	69.9	1.8	2.4	10.8	14.3	.8	28.3	1.7	17.8	.5	11.2
Timothy	56	61.6	2.1	3.1	11.8	20.2	1.2	36.3	2.2	23.0	.7	11.1
Blue grass	18	65.1	2.8	4.1	9.1	17.6	1.3	32.1	2.9	19.2	.8	7.3
Corn silage	99	79.1	1.4	1.7	6.0	11.1	.8	19.5	.8	11.6	.7	16.6
Clover silage	5	72.0	2.6	4.2	8.4	11.6	1.2	25.4	2.0	13.2	1.0	8.0
Hay and dry coarse fodders.												
Fodder corn (maize), field cured	35	42.2	2.7	4.5	4.3	34.7	1.6	55.1	2.6	33.3	1.1	13.8
Hay from red clover	38	15.3	6.2	12.3	24.8	38.1	3.3	78.5	6.5	34.6	1.6	5.9
Hay from mammoth clover	10	21.2	6.1	10.7	24.5	33.6	3.9	72.7	5.7	32.0	1.9	6.4
Hay from alfalfa (lucern)	21	8.4	7.4	14.3	25.0	42.7	2.2	84.2	7.6	37.8	1.3	5.4
Hay from alsike clover	9	9.7	8.3	12.8	25.6	40.7	2.9	82.0	6.8	36.8	1.4	5.8
Oat hay, seed in milk	....	9.2	6.5	8.9	28.1	44.7	2.7	84.3	5.0	44.0	1.3	9.4
Timothy hay	68	13.	4.4	5.9	29.0	45.0	2.5	82.4	3.0	43.9	1.2	15.6
Hay from mixed meadow grasses	11	16.0	4.6	6.4	29.9	41.0	2.1	79.4	3.6	42.7	1.0	12.5
Marsh hay	2	7.9	5.2	7.8	30.1	46.3	2.7	86.9	3.5	44.7	1.7	13.9
Oat straw	12	9.2	5.1	4.0	37.0	42.4	2.3	85.7	1.9	41.4	.7	27.1
Barley straw	97	14.2	5.7	3.5	36.0	36.0	1.5	80.1	.9	41.3	.6	47.5
Wheat straw	7	9.6	4.2	3.4	38.1	43.4	1.3	86.2	.8	37.9	.5	48.9
Rye straw	7	7.1	3.2	3.0	38.9	46.6	1.2	89.7	.8	42.7	.4	54.1
Buckwheat straw	3	9.9	5.5	5.2	43.0	35.1	1.3	84.6	2.3	37.7	.6	17.0
Pea vine	14	13.6	6.6	9.0	35.5	33.7	1.6	79.8	4.3	32.3	.8	7.9
Roots and Tubers.												
Potatoes	12	78.9	1.0	2.1	.6	17.3	.1	20.1	1.4	16.1	.1	11.6
Red beets	9	88.5	1.0	1.5	.9	8.0	.1	10.5	.9	7.6	.1	8.7
Sugar beets	19	86.5	.9	1.8	.9	9.8	.1	12.6	1.1	9.3	.1	8.6
Mangel-wurzels	9	90.9	1.1	1.4	.9	5.5	.2	8.0	1.1	4.8	.2	4.8
Rutabagas	4	88.6	1.2	1.2	1.3	7.5	.2	10.2	.9	7.1	.2	8.4
Turnips	3	90.5	.8	1.1	1.2	6.2	.2	8.7	.6	5.5	.2	10.0
Carrots	8	88.6	1.0	1.1	1.3	7.6	.4	10.4	1.0	7.1	.3	7.8
Grains and Mill Products.												
Corn (maize)	208	10.9	1.5	10.5	2.1	69.6	5.4	87.6	7.1	62.7	4.2	10.3
Corn and cob meal	7	15.1	1.5	8.5	6.6	64.8	3.5	83.4	6.5	56.3	2.9	9.7
Oats	30	11.0	3.0	11.8	9.5	59.7	5.0	86.0	9.1	44.7	4.1	6.0
Oat shorts	6	10.0	5.2	16.2	7.5	54.5	6.6	84.8	12.6	45.7	5.4	4.6
Barley	10	10.9	2.4	12.4	2.7	69.8	1.8	86.7	9.5	66.1	1.2	7.2
Wheat	310	10.5	1.8	11.9	1.8	71.9	2.1	87.7	9.2	64.9	1.4	7.4
Wheat bran—roller process	7	12.0	5.6	16.1	8.4	53.7	4.2	82.4	12.6	44.1	2.9	4.0
Wheat bran—old process	9	12.0	4.9	13.0	8.1	58.2	3.8	83.1	10.1	47.5	2.6	5.3
Wheat shorts	12	11.8	4.6	14.9	7.4	56.8	4.5	83.6	11.[illegible]	45.4	3.2	4.6
Wheat middlings	33	12.1	3.4	15.7	4.7	60.2	4.0	84.5	12.2	47.2	2.9	4.4
Rye	9	11.6	1.9	10.6	1.7	72.5	1.7	86.5	8.3	65.5	1.2	8.2
Rye bran	7	11.6	3.6	14.7	3.5	63.8	2.8	84.8	9.7	48.0	1.6	5.4
Rye shorts	1	9.3	4.9	18.0	5.1	59.9	2.8	85.8	11.9	45.1	1.6	4.1
Buckwheat	8	12.6	2.0	10.0	7	64.5	2.2	85.4	7.7	49.2	1.8	6.9
Buckwheat bran	2	10.5	3.0	12.4	31.9	38.8	3.3	86.5	7.4	30.4	1.0	4.7
Buckwheat shorts	2	11.1	5.1	27.1	8.3	40.8	7.6	83.8	21.1	33.5	5.5	2.2
Buckwheat middlings	6	12.7	5.1	28.2	4.2	42.3	7.5	82.2	22.0	33.4	5.4	2.0
Pea meal	2	10.5	2.6	20.2	14.4	51.1	1.2	86.9	18.0	56.0	.6	3.1
Cow pea	5	14.8	3.2	20.8	4.1	55.7	1.4	82.0	18.3	54.2	1.1	3.1
Miscellaneous Feeds.												
Linseed meal, old process	2	9.2	5.7	32.9	.9	35.4	7.9	85.1	28.3	32.8	7.1	1.1
Linseed meal, new process	14	10.1	5.8	32.2	9.5	38.5	3.0	84.1	27.2	32.9	2.7	1.0
Apples	36	84.8	.5	.4	1.5	12.5	.3	14.7	.3	12.8	.2	44.3
Apple pomace	7	76.7	.5	1.4	3.9	16.2	1.3	22.8	1.0	11.0	1.1	14.6
Skimmed milk	96	90.4	.7	3.3	....	4.7	.8	8.9	9.3	4.7	.8	2.1
Butter milk	85	90.1	.7	4.0	....	4.0	1.1	9.2	3.1	4.0	1.1	1.7
Whey	46	93.4	.7	.9	....	4.8	.3	5.9	.8	4.7	.3	6.9

RESUME.

In the State of Oregon on January 1, 1893, there were the following animals: horses, 204,509; mules, 4,755; milch cows, 107,183; oxen and other cattle, 781,114; sheep, 2,456,077; hogs, 504,609. A saving of but ten cents per month per head in the method of feeding would amount to over four and one-half million dollars annually. The question of rational feeding, then, is an important one, and demands the attention of every farmer.

It is the province of this bulletin to discuss this subject from the chemical standpoint, as well as to present analyses of some Oregon fodder plants.

The analysis of a food-stuff is expressed in the following terms: water, dry matter, ash, protein, ether extract, crude fibre, and nitrogen-free extract. The water has no more food value than that obtained from streams. The dry matter is what remains after all the water has been driven off. The ash is the mineral matter which remains after the organic matter has been burned away. The term protein is applied to the class of bodies containing nitrogen, which element composes about 16 per cent of the protein. The office of these nitrogenous bodies is that of flesh forming. The ether extract includes fats, oils, certain gums, and coloring matters. Crude fibre is the woody tissue of the plant or grain. The nitrogen free-extract embraces all other bodies than those named, among which are sugar, starch, dextrin and certain gums. The ether extract, crude fibre, and nitrogen-free extract together are called carbohydrates, the office of which is to furnish vital heat and produce fat, for which purpose the ether extract has 2½ times the value of the other carbohydrates.

All the material of a food-stuff is not digestible. To be of the greatest value there must be a certain ratio existing between the nutrients, and there must be a certain amount of non-nutritive matter. These conditions vary according to what is desired from the animal.

By chemical analysis, which is the foundation of rational feeding, it has been possible to determine not only the composition of the various food-stuffs, but also the digestibility of each nutrient, and what proportions of nutrients are needed by various classes of animals to produce desired results. (See Tables I, II, and III.)

The index to the quality of food is its "nutritive ratio," or the ratio existing between the digestible protein and the digestible carbohydrates.

The percents of the nutrients that can be digested are known as digestion co-efficients. Knowing these and the analysis of any fodder, it is possible to ascertain approximately the amount digestible. The digestion co-efficients for many materials have been determined, (See Table II) and also the composition of many food-stuffs. (Table III.)

Analysis and computation of the relative digestible matter in red clover, tall oat grass, orchard grass, timothy, cheat, and oat straw, show their relative value to be in the above order.

Clover can be successfully and profitably produced on soils of the Willamette Valley and in most parts of the State. Farmers should give more attention to this most excellent forage plant. Timothy is not so valuable a fodder plant as is popularly supposed. It is inferior to either orchard grass or tall oat grass. Cheat, or chess, is relatively a poor fodder plant, and should give way to either orchard grass, tall oat grass, or these mixed with clover. Oat straw may be made a greater source of revenue to the farmer by feeding it more than is now done, and using a greater quantity as litter, thereby securing a greater manurial value than by burning. It can well be fed when compounded with more concentrated foods.

In compounding rations it should be remembered that the standards here given are not inflexible rules, but rather guides from which there should not be a wide deviation.