EVALUATION OF PROTEIN SUPPLEMENTS

by

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INTRODUCTION

Feeds have been classified by animal nutritionists into three main groups. They are roughages, concentrates, and roots. A part of the group known as concentrates are to be discussed in this paper. The concentrate feeds concerned are classified as high protein feeds or protein supplements. These protein supplements are soybean oil meal, linseed oil meal, cottonseed oil meal, and soybeans. A protein supplement has been defined as a feed which is added to the livestock ration for the sole purpose of adding the nutrient protein.

The problem facing the livestock feeder is the determination of which supplement is most economical to buy and feed. It has been shown that most farm rations need some supplementary protein to balance the ration. Under average conditions the farm livestock ration made up entirely of farm raised feeds does not contain sufficient protein for maximum growth or for economic production, therefore, to balance the ration most livestock feeders must purchase protein.

Protein supplements are normally much higher in price than roughages, roots, or grains. Because of this higher price, even though only small amounts are normally fed, they make up a rather sizable portion of the cost of the ration. Since protein supplement purchases amount to a fairly large expense to the feeder, it is important to select the most economical feed. Thus a need is shown for the development of a choice indicator since these feeds are not all of

equal feeding value and they seldom sell for the same price. Any one particular supplement may be worth more for one type of livestock than for another. The classification of these various protein supplements, according to their value for the different species of livestock, is an important problem which is to be discussed.

The general purpose of this thesis is to review a number of previously expounded methods of comparison in order to examine their value as guides to more economical feed buying.

A number of noted animal nutritionists have stated that the most accurate method of feed evaluation is one which uses actual results of experiments with the different types of livestock. Therefore the hypothesis which has been presented is: The use of actual experiments conducted by experiment stations provide us with a method of feed evaluation which is most accurate due to its closer relationship to actual farm feeding conditions. It distinguishes between the different classes of livestock, thus making it more specific than other methods.

Thus a more specific purpose is to determine the most accurate method of protein supplement evaluation and to propose relative feeding values in a simple form which can be used by livestock feeders in more economical feed buying.

Once the decision has been made as to which of the methods proposed is most accurate, it then becomes necessary to use this method in comparison with actual market prices to determine its accuracy for future use by livestock feeders. The relative feeding values proposed plus the relative prices

will then provide the tools necessary for decision making relative to which supplement is most economical at any particular time for any particular class of livestock.

The scope of this paper includes only the determination of the relative feeding value of the various feeds for ruminant animals. In particular those are dairy cows, fattening yearlings and two year old beef cattle, fattening beef calves, wintering beef cattle, and fattening sheep.

The protein supplements concerned are defined in the following manner:

Soybeans--the grain or seed harvested from the soybean plant.

Cottonseed meal--is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 percent of protein.[1]

Linseed oil meal--is the product obtained by finely grinding the cake, chips or flakes obtained, according to the purposes employed, in the production of linseed oil. It must be designated and sold according to its protein content and its name must include one of the terms "hydraulic", "expeller",

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[1]Official definitions from the Official Publication of the Association of American Feed Control Officials, Inc., 1954, L. E. Bopst, Executive Secretary, College Park, Maryland, pp. 23, 29 and 40.

or "solvent extracted" to specify the method of manufacture of the source material. The flakes, chips or cake are obtained by removal of most of the oil from flaxseed.[1]

Soybean oil meal--is designated by the method of oil removal and it is the product resulting from the grinding of chips, cake or flakes. It is the product obtained after removal of most of the oil from soybeans. After removal of the oil the product is cooked. It shall be designated and sold according to its protein content.[2]

METHODS OF PROTEIN SUPPLEMENT COMPARISON

Protein supplement evaluation cannot be made until it is known which of the various methods of evaluation is most accurate. Due to the fact that there is considerable disagreement among nutritionists, a considerable portion of this thesis is devoted to a discussion of these different methods.

Total Crude Protein Method

Comparison by this method constitutes the buying of protein supplements according to the least cost per pound of total protein contained in the feed. Thus two supplements which are priced the same in the market place but have different total protein contents would not be of equal value.

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[1] Ibid.

[2] Ibid.

It would, in this case, be most economical to buy the supplement with the greatest crude protein content.

Those persons who follow this method believe it to be a relatively simple one since the farmer can readily compute the cost of a pound of total protein when he has available the price of the feed and the protein content which is given on the feed tag. One follower of this method makes the following statement in a book on sheep science:

> Since there seems to be little difference in value in the proteins from various sources, the relative values of these materials are very close to their respective protein contents. Hence, in purchasing these materials, it seems that the best basis on which to purchase them is the cost per pound of protein rather than the cost per pound of meal.[1]

What do these men such as Prof. Kammlade base their decision upon? Do they use animal experiments to make such a statement or is it because they feel one unit of protein is the same whether it comes from soybean meal or linseed meal? That is, can they back up such statements, by quoting animal husbandry experiments or are they merely generalizing from the assumption that ruminant animals can utilize or digest protein of low quality as well as they can protein of good quality. This question is discussed further in a later section of this thesis.

Probably the most important disadvantage of this method is that crude protein content does not show the feeder how much

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[1] W. G. Kammlade, Sheep Science, p. 286.

of that protein is available to the animal. As only the digestible part of the protein can be utilized by the animal, it is this portion which determines the value of any protein supplement. Total protein, as Prof. Kammlade states, may in general reflect a feed's actual value but this is not always true. A protein supplement can be produced which has very low digestibility, yet according to the total protein content it could still have a relatively high value. Also, improper cooking of any of the protein meals, although they may have a high total protein content, may result in relatively low digestibility. Thus there is the possibility that this method of evaluation may not be as valuable as it is felt to be at the present time.

Total Digestible Protein Method

Comparison by this method constituted computing the cost per pound of digestible protein of the supplements and determining the lowest in cost. The feed with the lowest cost per pound of digestible protein would then be the most economical to buy.

Essentially a description of this method would be to find the total protein content of the different feeds and make use of a table such as Table I in Morrison's Feeds and Feeding.[1] This table contains the digestion coefficients for protein

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[1]Frank B. Morrison, Feeds and Feeding, p. 1086.

contained in soybean meal, linseed meal, cottonseed meal and soybeans. These digestion coefficients show the percentage of each nutrient contained in a particular feed which experiments have shown to be digested by animals. Computation of the digestible protein contained in a feed would then be found by multiplying the digestion coefficient by the amount of total protein in the feed. Division of the number of pounds of digestible protein contained in a ton of the feed into the cost per ton of feed would give the actual cost per pound of digestible protein in the feed. Digestible protein is what the animal can use, therefore, its cost seems more important that the cost of total protein.

The principal disadvantage of this method is the lack of knowledge of these digestion coefficients among the farmers and dairymen who use the feeds. If the digestion coefficients were made generally available, then this problem would be at least partially solved.

A method which could be used to present these coefficients to the feeder would need to be relatively simple and easily understood. A suggested method would be to devise a table showing the value of each of the feeds in relation to soybean meal as the base feed. Table 1 shows a proposed method of indicating the relative feeding value of the various feeds by use of average total protein content and the coefficients of digestibility.

Table 1. Relative feeding values, using digestion coefficients and the crude protein content of the different supplements.[a]

Feed	(A) Average protein content	(B) Digestion coefficient (percent)[b]	Dig. prot. (A x B)	Relative feeding value[b]
Soybean meal	41	84	34.44	100.00
Linseed meal	34	87	29.58	85.89
Cottonseed meal	41	83	34.03	98.81
Soybeans	37.9	89	33.73	97.94

[a]Source: F. B. Morrison, Feeds and Feeding, Appendix Table I.

[b]This shows the relative value of the amount of digestible protein in soybeans, cottonseed meal and linseed meal compared to soybean meal.

The principal disadvantage in the use of this particular table is that it does not show any difference between the feeding value of a supplement for the different classes of livestock.

Let us compare the digestible protein and crude protein methods of protein supplement evaluation and see what has occurred over the past 23 years.

In order to make a comparison of these two methods of feed evaluation a decision had to be made as to what prices and what protein content should be used for the different supplements. It was decided that cash prices on the Kansas City market would reflect Kansas conditions more accurately than any other set of prices. The reason for this is that Kansas City is the

central market for most of Kansas and prices in the local areas are a reflection of that market. The prices used in this tabulation are the calendar year prices averaged from the high and low daily cash price for soybean meal, cottonseed meal, and linseed meal. Soybean prices used were the average price received by Kansas farmers for number two soybeans. Soybean cash price was not used as we are concerned with the soybeans fed on the farm where they were raised. Only prices from January 1932 to December 1954 were used as it was felt that the last two decades would result in a more accurate evaluation of any future price trends than earlier years. The prices used are shown in Tables 7, 8, 9 and 10.

The protein percentages used were represented in the price quotations. To determine digestible protein the digestion coefficients given in Morrison's Feeds and Feeding were multiplied by the protein composition given in the price quotations.

Table 2 is presented to show the average yearly cost per pound of total protein and per pound of digestible protein for the four feeds on the Kansas City cash market for the period 1932 to 1954. The source of the prices used was the Kansas City Grain Market Review and the Annual Farm Facts publications of the Kansas State Board of Agriculture.

Figure 1 was derived from Table 2. It shows the relationship between the four supplements when their average protein content and average yearly price are used to determine the cost per pound of total protein. This figure shows that, during

Table 2. Cost per pound of total protein and digestible protein in cottonseed meal, linseed meal, soybean meal, and soybeans, 1932-1954.[a]

Year	Total protein (percent)				Digestible protein (percent)			
	CSM 41[b]	LSM 34[c]	SBM 41[d]	Soybean 37.9[e]	CSM 34.03[b]	LSM 29.58[c]	SBM 34.44[d]	Soybean 33.7[e]
1932	.0244	.0402	.0275	.0260	.0294	.0463	.0327	.0293
1933	.0279	.0461	.0365	.0416	.0336	.0530	.0434	.0468
1934	.0425	.0583	.0451	.0548	.0511	.0670	.0537	.0616
1935	.0409	.0483	.0390	.0555	.0492	.0555	.0465	.0624
1936	.0403	.0590	.0420	.0590	.0486	.0678	.0500	.0664
1937	.0445	.0612	.0480	.0581	.0536	.0704	.0572	.0653
1938	.0341	.0651	.0342	.0442	.0411	.0749	.0407	.0497
1939	.0375	.0586	.0360	.0442	.0452	.0673	.0428	.0497
1940	.0407	.0477	.0354	.0455	.0490	.0548	.0422	.0512
1941	.0442	.0535	.0429	.0520	.0533	.0615	.0510	.0585
1942	.0514	.0633	.0541	.0727	.0620	.0728	.0644	.0818
1943	.0606	.0734	.0570	.0743	.0730	.0843	.0678	.0835
1944	.0671	.0742	.0653	.0841	.0808	.0852	.0777	.0946
1945	.0675	.0744	.0655	.0905	.0813	.0855	.0780	.1018
1946	.0920	.1112	.0874	.0995	.1108	.1279	.1041	.1119
1947	.1036	.1378	.1041	.1338	.1248	.1584	.1239	.1504
1948	.1038	.1221	.1042	.1365	.1251	.1404	.1240	.1535
1949	.0827	.1069	.0911	.0923	.0997	.1229	.1084	.1039
1950	.0911	.1098	.0916	.1024	.1097	.1262	.1091	.1151
1951	.1065	.1100	.0915	.1247	.1283	.1265	.1103	.1403
1952	.1174	.1292	.1044	.1192	.1414	.1485	.1242	.1341
1953	.0917	.1195	.0858	.1080	.1105	.1374	.1022	.1215
1954	.0959	.1225	.1019	.1252	.1155	.1408	.1213	.1408

[a]This table contains the cost per pound of total protein and the cost par pound for digestible protein for the four protein feeds. The prices used were the annual average price on the Kansas City market for soybean meal, linseed meal and cottonseed meal. The price used for soybeans was the annual average of the monthly price received by Kansas farmers. Digestion coefficients obtained from Table 1, column B.

[b]Price data was based on 41 percent total protein meal except for 1933 and 1934 which were based on 43 percent total protein meal.

[c]Price data was based on 34 percent total protein meal except for 1946, 1947, 1953 and 1954 which were based on 32 percent total protein meal.

Table 2. (continued)

[d]Price data was based on 41 percent total protein meal except for 1951 to 1954 which were based on 44 percent total protein meal.

[e]Price data for soybeans was based on the average total protein content from Morrison, Feeds and Feeding, Table I, p. 1086.

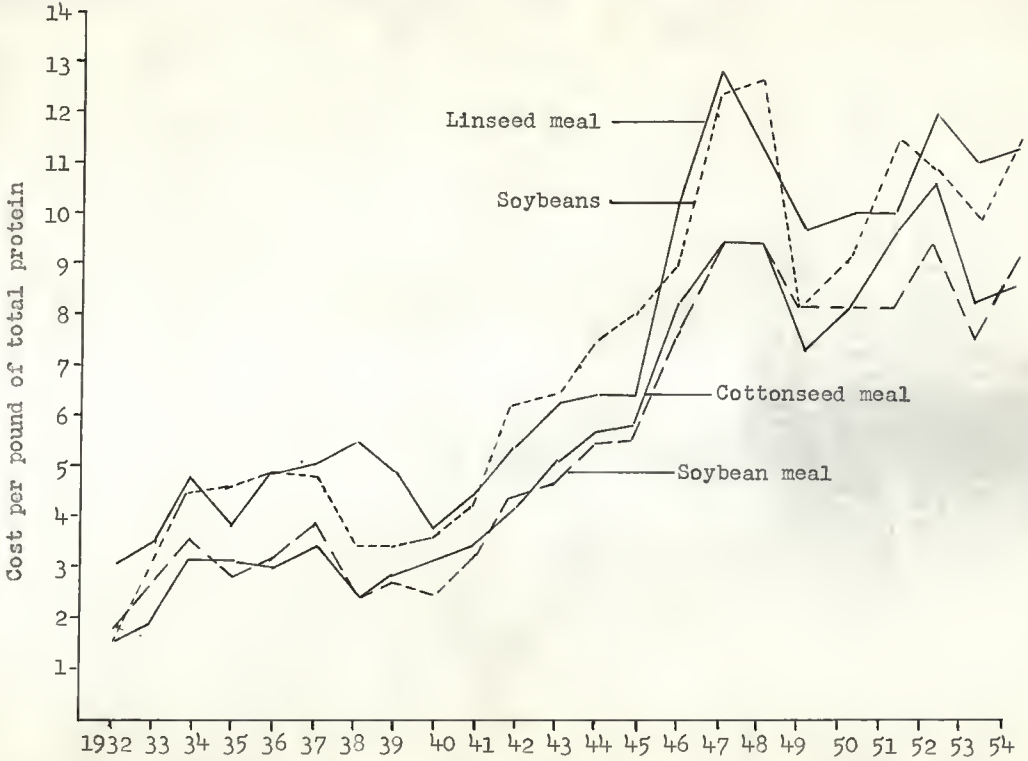

Fig. 1. Cost per pound of total crude protein in cottonseed meal, linseed meal, soybean meal, and soybeans, 1932 to 1954.

the entire period, soybeans and linseed meal were higher in price per pound of protein than cottonseed meal and soybean meal. This shows, using total protein cost as the choice indicator, that it would have been uneconomical to buy soybeans or linseed meal for feeding to liveatock. Since cottonseed meal and soybean meal alternated in being the cheapest in cost per pound of total protein, the buyer than maintained minimum cost conditions would have alternated between these two feeds. The question was then raised as to whether the digestible protein method would have shown different results.

Figure 2 shows the comparison of the prices of the four feeds according to the cost per pound of digestible protein. This figure shows a good deal of similarity to the Figure 1. Cottonseed meal and soybean meal have been the lowest in cost per pound of digestible protein during the period. Thus a comparison of these two figures shows a great deal of similarity when the average yearly prices of the feeds were used.

Digestible Protein and Non-protein Digestible Nutrients

This method was devised by Prof. Peterson of the Minnesota Experiment Station for the comparison of the various common feeds with the two most important concentrates of the time. He compared the nutrient contents of corn and cottonseed meal with the various other feeds. This method was formulated for the prime purpose of determining the relative feeding value of certain animal feeds in relation to the actual prices of

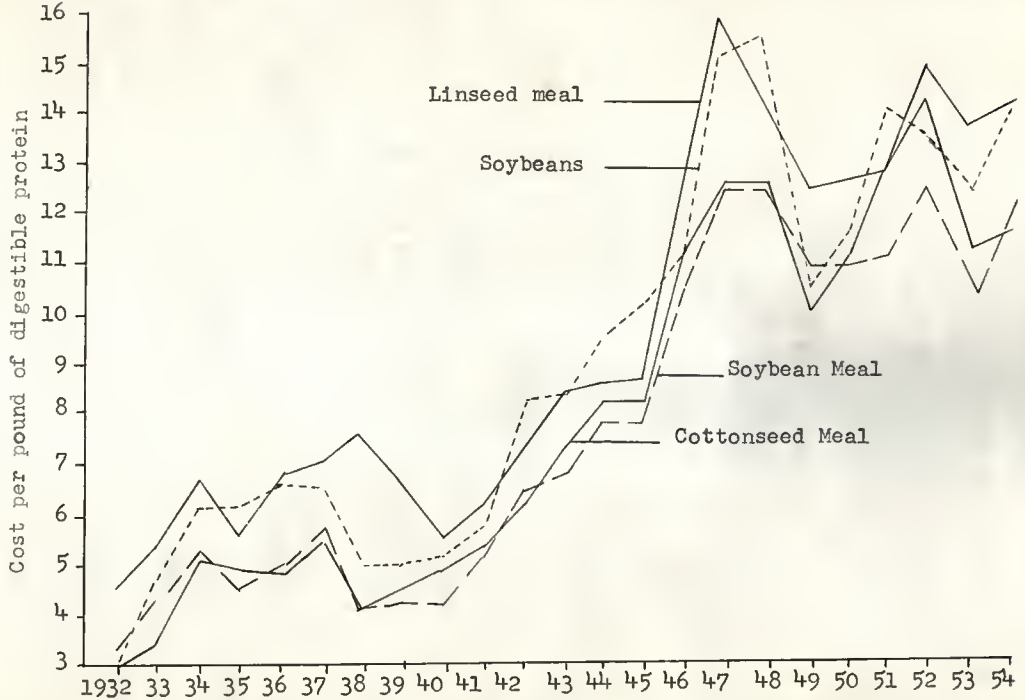

Fig. 2. Yearly average cost per pound of digestible protein contained in soybean meal, cottonseed meal, linseed meal and soybeans, 1932-1954.

corn and cottonseed meal. The feeding value (cash) of any feed in comparison with the cash value of corn and cottonseed meal varies any time the price ratio between these two base feeds varies. Therefore constants were devised which show the change in value of the particular feed in relation to a ten dollar change in the price of corn and a ten dollar change in the price of cottonseed meal. These constants can then be used at any time to give the value of a feed in relation to the base feed prices. To determine the value of a feed, these constants are multiplied by the cost of corn and the cost of cottonseed meal, at any time, and will give the approximate value of the feed in question.[1]

Prof. Morrison has also devised a set of constants using the Peterson method. Morrison uses net energy values instead of digestible nutrients because he believes net energy values more accurately show the feed's value to the animal. Morrison's method is most valuable in the comparison of roughages, as these feeds high in fiber require a greater amount of energy to be digested than low fiber feeds.[2]

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[1]W. E. Peterson, Journal of Dairy Science, Volume 15, 1932, No. 4. For more detailed statement of this method check this reference.

[2]Frank B. Morrison, Personal correspondence with the author.

Digestible Protein and Net Energy Values
Method of Feed Evaluation

This is the method used by Morrison, and the constants prepared are given in Appendix Table II of Feeds and Feeding. The following table shows the constants which were derived for the protein supplements with which we are concerned.

Table 3. Excerpts from Table II, Morrison's Feeds and Feeding.[1]

Feeding stuff	Feed evaluation factors: Constant for corn	Constant for soybean meal
Corn, dent, No. 2	1.000	---
Soybean oil meal expeller, or hydraulic process, all analysis	---	1.000
Cottonseed meal, 43% protein not inc. Texas analysis	.003	.978
Cottonseed meal, 41% protein	.022	.878
Linseed meal, old process all analysis	.202	.792
Soybean seed	.250	.861

In deriving these constants no regard was given as to the different values for the different species. Most of the work on protein digestibility and net energy values has been done with fattening lambs and fattening or wintering beef steers.[2]

[1] Morrison, op. cit., pp. 1135-1142.

[2] Ibid., p. 1084.

The values are assumed to be the same for the other types of livestock. Although this may be an erroneous assumption in certain cases, it was felt that this method was as good as any available for determining the value of various feeds in relation to the actual value of two feeds.

Use of a Summary of the Results of Animal Experiments as a Method of Protein Supplement Evaluation

A large number of feeding trials have been carried on comparing the different protein supplements. These feeding trials have been conducted in order to determine which feed is the most valuable for feeding any particular type of livestock. Since the feeding of any feed to livestock should show its actual value to the animal, a summary of a large number of experiments comparing different supplements should result in an accurate evaluation of the feeds. There are some nutritionists who feel that these feeding results determine the actual feeding value of a feed more accurately than any numerical computation possibly could. Frank B. Morrison has made the following statement in praise of the use of this method to determine the value of any feed in relation to another feed of the same general classification.

> The best guides to the relative values of various feeds for any class of stock are furnished by the results of actual feeding experiments with that particular class of stock.[1]

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[1] Ibid., p. 1133.

For greatest accuracy in the use of this method, the experiments summarized should be as homogeneous as possible, not only in relation to the kind of feeds fed and the class of livestock, but also in relation to such factors as condition of feedlots, ration composition, etc. For most accurate results any particular experimental comparison should be duplicated a number of times in order to rule out any effect from chance occurences. Prof. Morrison makes the statement that an average of several experiments is more accurate than the results from only one experiment.[1] This statement has been questioned by some nutritionists. They seem to feel that there are some exceptions to this statement. An average of several experiments tends to rule out chance and error in the results, but in the case where half of the experiments ended one way and half the other, an average might show equality and they would not necessarily be equal in feeding value. Therefore the experiments reviewed in study of this method of evaluation of feeds have not been averaged. They have been summarized in tho best manner possible.

In order to determine the value of the various feeds for the different classes of livestock, the author reviewed all the experimental results which could be found in the Kansas State College Library. The results of experiments

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[1] Ibid., p. 38.

comparing soybean meal, linseed meal, cottonseed meal, and soybeans are shown on the following pages.

Dairy Cows. The following comparisons have been made in experiments in feeding dairy cows. They have been classified according to comparisons.

Soybean Meal with Cottonseed Meal. Experiments in feeding these two supplements have mostly been done by comparing them when they are fed on a pound for pound basis. By this it is meant that one pound of soybean meal is fed to substitute for one pound of cottonseed meal, or vice versa. Four references found soybean meal and cottonseed meal to be equal when fed on a pound for pound basis, two found the soybean meal was slightly more valuable, and one found that cottonseed meal was slightly more valuable.

Two different experiment stations have tested soybean meal and cottonseed meal as substitutes for each other in the dairy ration. They found them to be fully equal pound for pound.[1] In one case the meals were of the same approximate protein content.

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[1]W. B. Nevins, Feeding the Dairy Herd, Illinois Experiment Station Bulletin No. 372, p. 49.

C. W. Holdaway, W. B. Ellett, W. G. Harris, Comparative Value of Peanut Meal, Cottonseed Meal, and Soybean Meal as Sources of Protein for Milk Production, Virginia Experiment Station, Technical Bulletin No. 28, p. 43.

Soybean meal and cottonseed meal were found to be equal when fed on a pound for pound basis at the Hawaii Experiment Station. Soybean meal was slightly better but the difference was not of a significant nature.[1]

A New Jersey experiment showed results which differed somewhat from the above experiments. They found that if cottonseed meal wae worth 33 dollars per ton, then soybean meal was worth 41 dollars per ton. Thus cottonseed meal in this test was worth only 80.48 percent as much as soybean meal.[2]

A Mississippi bulletin states that soybean meal in one experiment was a little less valuable as a protein supplement for milk and butterfat production than cottonseed meal.[3]

Soybean meal was found to be superior to cottonseed meal as a food either for milk or butterfat production in a Massachusetts experiment.[4]

A summary of comparisons of these two supplements in feeding dairy cows shows that soybean meal is definitely equal to cottonseed meal if not somewhat superior.

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[1]L. A. Henke, Protein Sources and Supplements for Dairy Cows in Hawaii, Hawaii Experiment Station Bulletin No. 95, p. 9.

[2]Alfred S. Cook, Soybean Meal Versus Cottonseed Meal, New Jersey Annual Report, 1913, p. 293.

[3]J. S. Moore, and W. C. Cowsert, Soybeans for Dairy Cows, Mississippi Experiment Station Bulletin No. 235, p. 15.

[4]Henry H. Goodell, 6th Annual Report, Massachusetts Agricultural College, 1894, pp. 13 and 14.

Linseed Meal with Soybeans. Seven references found soybeans and linseed meal to be approximately equal when fed on a pound for pound basis, thres found soybeans to be somewhat more valuable than linseed meal, and one experiment found linsesd meal slightly mors valuable than soybeans. All the experiments reported here were made on the basis of substituting one pound of soybsans for one pound of linseed meal.

A number of feeding experiments havs shown linseed meal to be practically equal pound psr pound to ground soybeans as a protein supplement for dairy rations.[1]

Some experiments have shown ground soybeans to be of somewhat greater value than linseed meal for supplementing dairy rations. Soybeans were found to be from 3 to 33 percsnt

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[1]W. B. Nsvins, Loc. cit.

O. G. Schaefer, Soybeans and Soybean Hay in ths Dairy Ration, Minnesota Experiment Station Bulletin No. 239.

J. C. Hackleman, O. H. Sears, and W. L. Burlison, Soybean Production in Illinois, Illinois Experiment Station Bulletin No. 310, p. 471.

W. B. Nevins, Utilizing the Soybsan Crop for Livestock Feeding, Illinois Experiment Station Circular No. 369, p. 8.

W. B. Nevins, Feeding the Dairy Herd, Illinois Experiment Station Circular No. 502, p. 25.

Floyd Johnston, Arthur R. Porter, and Lyle W. Jackson, Feeding Dairy Cows, Iowa Experiment Station Bulletin P-89, 1948, p. 967.

W. T. Crandall and K. L. Turk, Feeding the Dairy Cow Efficiently, Cornell Experiment Station Extension Bulletin No. 363, p. 27.

more valuable than linseed meal for supplementing home grown feeds.[1] Part, if not all, of the difference between these two was felt to be due to the higher fat content of the soybeans.[2]

An Ohio Experiment Station found that linseed meal was worth 3.6 percent more for milk production and 2.7 percent more for fat production than ground soybeans.[3]

Soybeans should be ground as should most other grains for dairy cows. It is felt that a summary of the above experiments should state that for all practical purposes soybeans, when ground seem to be equal to linseed meal when fed on a pound for pound basis to dairy cows.

Cottonseed Meal with Soybeans. Only two experiments were found which compared cottonseed meal with soybeans. The results in both of these experiments showed some superiority of the

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[1]Thomas M. Olson, Soybeans for Dairy Cows, South Dakota Experiment Station Bulletin No. 215, p. 15.

L. H. Fairchild, and J. W. Wilbur, Soybean Oil Meal and Ground Soybeans as Protein Supplements in the Dairy Ration, Indiana Experiment Station Bulletin No. 289, p. 2.

A. C. McCandlish, E. Weaver, and L. A. Lunde, Soybeans as a Home Grown Supplement for Dairy Cows, Iowa Experiment Station Bulletin No. 204, p. 52.

[2]Fairchild and Wilbur, Loc. cit.

McCandlish and Weaver, Loc. cit.

[3]C. C. Hayden and A. E. Perkins, Soybeans, Soybean Oil Meal for Milk Production, Ohio Experiment Station Bi-monthly Bulletin No. 121.

ground soybeans over cottonseed meal. Reference to these experiments is given below.

Cottonseed meal fed to young dairy cows and ground soybeans have about the same feeding value for milk and butterfat production. Ground soybeans showed better results than cottonseed meal but not a significant amount. In this experiment one pound of ground soybeans was substituted for one pound of cottonseed meal.[1]

A Mississippi experiment found ground soybeans to be of greater value for supplementing dairy rations than cottonseed meal on a pound for pound basis.[2]

Linseed Meal with Cottonseed Meal. Some experiments have shown linseed meal to be practically equal to cottonseed meal for feeding dairy cows when fed on a pound for pound substitution basis, while others have found these two supplements to be equal when fed in the same nutritive ratio.

Linseed meal and cottonseed meal were found to be equally valuable when they were fed according to protein content in Indiana experiments.[3] In one particular experiment it took only 79.71 percent as many pounds of cottonseed meal as it did linseed meal to produce the same amount of milk. In this

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[1]James N. Price, Homegrown Rations for Economical Production of Milk and Butter, Tennessee Agricultural Experiment Station Bulletin No. 80, p. 49.

[2]Moore and Cowsert, op. cit., p. 15.

[3]R. E. Caldwell, and D. F. Hunziber, Test of Three Protein Concentrates and Two Leguminous Roughages in Milk Production, Indiana Experiment Station Bulletin No. 203, p. 3.

case cottonseed meal contained 41.7 percent protein (crude) and linseed meal contained 33.3 percent crude protein.

A Vermont bulletin states that in experiments conducted at that experiment etation they found linseed meal and cottonseed meal to be equal to fieh meal when fed according to the protein content of the feeds.[1] Thus linseed meal and cottonseed meal have been found equal when fed in thie manner.

In North Carolina and Vermont experiments cottonseed meal was found to be very elightly more valuable than linseed meal for milk and butter production when fed on a pound for pound basis.[2] Their conclusions were that cottonseed meal and lineeed meal were practically equal in feeding value.

Soybean Meal with Ground Soybeane. Conflicting results have been found in comparison of theee two supplements. When fed on a pound per pound substitution basis the two have been found to be equal in feeding value, soybeane have been found to be more valuable in some cases, and soybean meal has proven to be more valuable in other instances.

An Illinois circular states that when it ie neceseary to buy a protein feed and soybeane and soybean meal sell for the same price per pound, soybean meal would be the better buy. But unless the farmer is paid for the oil he could not afford

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[1]M. H. Campbell, The Supplementary Value of Fish Meal as a Feed for Dairy Cattle, Vermont Experiment Station Bulletin No. 333, p. 7.

[2]J. L. Hille, Vermont Experiment Station Annual Report, 1907, p. 471.

John Michele, North Carolina Experiment Station Annual Report, 1910, p. 29.

to take home raised beans to the mill and haul back soybean meal.[1] If the farmer had soybeans he had raised, it would be cheaper to feed the soybeans than to buy the meal. Thus this reference found soybeans and soybean meal to be equal when fed on a pound for pound basis to dairy cows.

An article in Hoards Dairyman states, "that soybeans and soybean meal are of approximately equal feeding value for dairy cows under practical feeding conditions."[2] Also an Ohio experiment found that soybeans and soybean meal could be substituted pound for pound in the dairy ration.[3]

Mississippi experimenters found that ground soybeans were worth more for supplementing dairy cow rations than soybean meal when substituted pound for pound in the ration.[4]

An Ohio annual report states that when soybeans and soybean meal are fed in equal quantities to dairy cows, the soybean meal was slightly superior to the soybeans.[5]

Neither ground soybeans or linseed meal were found to be as palatable as soybean meal when fed to dairy cows at an Illinois Experiment Station.[6]

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[1]Nevins, op. cit., p. 8.

[2]Hoards Dairyman, December 1951, Volume 96, p. 962.

[3]Hayden and Perkins, Loc. cit.

[4]Moore and Cowsert, Loc. cit.

[5]Perkins, Backtell, and Weaver, 51st Ohio Experiment Station Annual Report, Bulletin No. 516, p. 73.

[6]Hackleman, Sears and Burlison, op. cit., p. 471.

Soybean Meal with Linseed Meal. Most of the results comparing these two supplements seem to be rather similar, but they have been found to be equal when fed on a pound for pound basis and also when fed according to protein content. This is a situation similar to the one mentioned in another portion of this paper. These two supplements cannot be equal under both situations since they have a difference of six to 10 percent in protein content. An attempt will be made to answer this problem in a later section of this thesis.

Several experiment station bulletins have stated the conclusion found in feeding experiments, that soybean meal and linseed meal were equal in feeding value for feeding dairy cows when they are compared on a pound for pound basis.[1]

The Ohio Agricultural Experiment Station found soybean meal to be worth 1.9 percent more for milk production and 3.6 percent more for producing fat than linseed meal. This particular bulletin summarizes several articles on comparison

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[1]Hackleman, Sears and Burlison, Loc. cit., p. 471.

Andrew C. McCandlish and Earl Weaver, "Cocoanut Meal, Gluten Feed, Peanut Meal and Soybean Meal as Protein Supplements for Dairy Cows," Journal of Dairy Science, Vol. 5, 1922, pp. 27-38.

Fairchild and Wilbur, op. cit., p. 2.

Williams, C. G., 44th Annual Ohio Experiment Station Report, 1924-1925, Bulletin No. 392, p. 53.

of these two supplements, and reaches the conclusion that soybean meal and linseed meal appear to be equal pound for pound for feeding dairy cows.[1]

Two experiment stations found in comparisons of soybean meal and linseed meal that these two supplements are equal in feeding value when fed to dairy cows according to the amount of protein contained in each feed.[2] This means that more linseed meal than soybean meal would be required to produce the same milk and fat when fed on a pound for pound substitution basis, but a like amount of protein from each feed would produce similar amounts when fed on the basis of the amount of total protein contained in each feed.

Fattening Beef Calves. A large number of experiments have been conducted with beef calves to determine whether any one protein supplement is more valuable than another. These experiments which have been written up and published have been reviewed to determine if any conclusive evidence has been found.

Linseed Meal with Cottonseed Meal. Some experimenters found that cottonseed meal and linseed meal were equal when fed on a pound for pound basis and other experimental results showed a good deal of variation. Some found that cottonseed meal was worth more than linseed meal and others found the

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[1] Hayden and Perkins, op. cit., p. 141.

[2] Campbell, op. cit., p. 7.

Caldwell and Hunziber, op. cit., p. 3.

opposite results. Another group of experimenters found that there was little difference between the two meals when they were fed according to protein content. Certainly two meals with differences in protein content cannot be equal when fed on a pound for pound basis and also when fed according to protein content. This is definitely not a logical situation. A situation such as this shows the need for further experimentation, if one is to find which group of experimenters found accurate results. The possibility has been raised that earlier experiments, at least those prior to 1940, were not designed accurately enough to produce results which could be used as guides in feed evaluation. If this is true, then one must have properly designed experiments before any recommendation can be made as to which supplement is more valuable for any particular class of livestock.

The experiments which were reviewed concerning the feeding of cottonseed meal and linseed meal to beef calves being fattened are given in the following paragraphs.

An Ohio experiment found that linseed meal and cottonseed meal were equal for fattening calves when fed at the rate of one pound per head daily, but when two pounds were fed, the linseed meal fed calves outproduced the cottonseed meal fed calves.[1]

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[1] Paul Gerlaugh, Protein Supplements in Rations for Fattening Calves, Ohio Experiment Station Bi-monthly Bulletin No. 140.

A number of experimente conducted at the Kansas Station found that linseed meal was more valuable than cottonseed meal when fed as substitutes on a pound for pound baeis.[1]

Colorado feeding triale found that linseed meal containing 34 percent protein and cottonseed meal containing 43 percent protein produced similar results with fattening calves when fed on a pound for pound substitution basis.[2]

An Idaho experiment concluded that cottonseed meal was superior to lineeed meal as a supplement to a calf fattening ration. The animals were fed .72 pounds of cottonseed meal per day or .59 pounde of linseed meal.[3] This experiment seems to be rather illogical since the calves fed in thie manner were definitely receiving lese protein from the linseed meal ration than from the cottonseed meal ration.

A six year summary of experimente at the Ohio Station found that there was no significant difference between 34

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[1]C. W. McCampbell, B. M. Anderson and H. W. Marston, Cattle Feeding Investigations, Kaneas Experiment Station Circular No. 117.

B. M. Anderson and H. W. Marston, Cattle Feeding Investigations, Kansas Experiment Station Circular No. 130.

C. W. McCampbell, B. M. Andereon and M. A. Alexander, Cattle Feeding Investigations, Kansas Experiment Station Circular No. 152.

[2]G. E. Morton and H. B. Osland, Ration Experiment with Calvee, Colorado Experiment Station Press Bulletin No. 78.

[3]C. W. Hickman, E. F. Rinehart and R. F. Johnson, Fattening Idaho Range Cattle, Idaho Experiment Station Bulletin No. 209.

percent linseed meal and 41 percent iron treated cottonseed meal for fattening calf rations when they were fed according to protein content.[1]

A South Dakota experiment found that cottonseed meal and linseed meal were equal when fed on an equal pound basis.[2]

Cottonseed meal containing 43 percent protein and linseed meal containing 37 percent protein were found to be approximately equal for fattening calves in Michigan experiments.[3]

Linseed Meal with Soybeans. Soybeans have been found to be less valuable for fattening calves than for fattening older beef cattle.[4] This is especially true when the beans are fed ground. Therefore whole soybeans are recommended to be fed to beef calves.[5] The reason soybeans seem to be less valuable for beef calves than for older animals seems to be due to the

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[1]Paul Gerlaugh, Iron Treated Cottonseed Meal for Steer Calves, Ohio Bi-monthly Bulletin No. 205, p. 125.

Paul Gerlaugh, Adding Supplements to Corn for Calves on Pasture, Ohio Bi-monthly Bulletin No. 205, p. 127

[2]J. W. Wilson and Turner Wright, Tankage, A Protein Supplement for Fattening Beef Calves, South Dakota Experiment Station Bulletin No. 329.

[3]G. A. Branaman, Palatability of Cottonseed Meal and Linseed Meal, Michigan Experiment Station Quarterly Bulletin, Vol. 18, No. 4, p. 253.

[4]Roscoe R. Snapp, Beef Cattle, John Wiley and Sons, Inc., New York, 3rd Edition, 16th Printing, 1950, p. 322.

H. P. Rusk, Utilizing the Soybean Crop in Livestock Feeding, Illinois Experiment Station Circular, No. 369, p. 26.

[5]Snapp, op. cit., p. 322.

fact that calves are on feed much longer than older animals, and due to the laxative quality of soybeans, they seem to tire of the beans in the latter part of the feeding period.

The experiments which have been reviewed are in favor of linseed meal over soybeans since the calves tended to go off feed when fed the soybeans.

South Dakota experiments showed that linseed meal produced greater gains than soybeans for fattening calves, but required more feed to do so. Calves being fed the soybeans would not eat over one pound of soybeans per day and they consumed more linseed meal than that.[1]

An Ohio experiment found that calves which were fed soybeans were more difficult to keep on feed than calves fed linseed meal and therefore they did not do as well as the linseed meal fed animals.[2]

Thus results show that linseed meal is more valuable than soybeans when fed in the fattening ration of beef calves.

Cottonseed Meal with Soybeans. Soybeans have in most instances been found to be slightly less valuable than cottonseed meal for fattening calves. This is shown by the following analysis.

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[1]J. W. Wilson and Turner Wright, Ground Flax and Other Protein Supplements with Corn for Fattening Calves and Pigs, South Dakota Experiment Station Bulletin No. 293.

[2]Paul Gerlaugh, op. cit., Bul. 205.

Cottonseed meal was found to be superior to soybeans for fattening calves in two experiments. Approximately equal amounts of each supplement were fed.[1] Other experiments found that soybeans and cottonseed meal were approximately equal when fed on a pound for pound substitution basis.[2]

An Ohio experiment found that calves fed soybeans were more difficult to keep on feed than cottonseed meal fed calves and those fed the soybeans did not gain as well as the others.[3]

Mr. Frank B. Morrison has made the statement that an analysis of eleven tests comparing cottonseed meal and soybeans showed that calves fed soybeans gained .11 pounds less per day than those fed cottonseed meal. The conclusion was that the soybeans were worth only 94 percent as much as cottonseed meal.[4]

Soybean Meal with Soybeans. Relatively few experiments were found which compared these two supplements, but those reviswed are given below.

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[1] J. H. Skinner and F. G. King, Cattle Feeding, Indiana Experiment Station Bulletin No. 429.

H. P. Ruek, op. cit., p. 26.

[2] J. H. Skinner and F. G. King, Cattle Feeding, Indiana Experiment Station Bulletin No. 330.

Idaho Annual Report 1934, Idaho Experiment Station Bulletin No. 217, p. 47.

[3] Gsrlaugh, op. cit., Bulletin No. 140.

[4] Morrison, op. cit., p. 540.

Soybean meal, in an Ohio experiment, produced better results than soybeans when fed to fattening calves at the same protein level.[1]

Soybean meal was found to be equal to soybeans for fattening calves in a South Dakota experiment. Soybean meal fed calves had a higher daily gain but they took more feed to produce 100 pounds of grain than the soybean fed calves.[2]

Linseed Meal with Soybean Meal. Only one experiment was found which compared these two supplements for feeding calves.

Linseed meal produced greater gains and on about the same amount of feed as soybean meal in South Dakota experiments. Conclusions of this bulletin state that linseed meal was found to be more valuable than soybean meal for fattening calves. The supplements were fed on an approximate pound for pound basis.[3]

Fattening Yearling and Two Year Old Beef Steers. Comparisons between the different protein supplements have been reviewed and are shown on the following pages.

Soybeans with Soybean Meal. Comparisons between these two supplements seem to show, in general, equality when fed on a pound for pound substitution basis. Contradiction has

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[1]Gerlaugh, op. cit., Bulletin 127.

[2]Wilson and Wright, op. cit.

[3]Loc. cit.

occurred in experimental results especially when experiments found these two feeds to be equal when fed pound for pound and also when fed according to protein content of the supplements.

Several experiments found that soybeans when fed to two year old steers were comparable in value to soybean meal when the two supplements were fed at an equal rate.[1]

Soybean meal in one Indiana experiment proved to be more valuable than soybeans for feeding two year old steers.[2]

In Cornell experiments soybeans and soybean meal were found to be equal in value when fed to older beef steers. In this case the supplements were fed according to protein content.[3]

As an example of contradictory results, the Cornell experiments mentioned above found equality when fed according to protein content while Professor Morrison in his book

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[1]Rusk, op. cit., p. 26.

J. H. Skinner and F. G. King, Cattle Feeding, Indiana Experiment Station Bulletin No. 281.

J. H. Skinner and F. G. King, Cattle Feeding, Indiana Experiment Station Bulletin No. 314.

[2]J. H. Skinner and F. G. King, Cattle Feeding, Indiana Experiment Station Bulletin No. 291.

F. G. King, Atlas Sorgo Silage for Fattening Cattle, Indiana Experiment Station Bulletin No. 500.

[3]R. B. Hinman, F. B. Morrison, J. I. Miller, and C. S. Hobbs, Cornell Experiment Station Annual Report, 1941, p. 110.

Feede and Feeding[1] makes the etatement that an average of 12 experiments with these two feeds shows that soybeans were fully equal to soybean meal for fattening two year old cattle when the feede are fed at an equal rate.

Soybeens with Linseed Meal. Two Ohio references were reviewed which compared soybeens and linseed meal for feeding yearling and two year old beef cattle. They are as follows:

One Ohio experiment compared the feeding of these two supplemente to yearling eteers. The steers fed eoybeane did not do quite as well as thoee fed linseed meal. The supplements were eubstituted on a pound for pound basis.[2]

In another Ohio experiment soybeans were found to be fully equal to linseed meal when fed to yearling steers on a pound for pound baeie.[3]

Cornell experiments found that lineeed meal was slightly more valuable than soybeane for fattening yearling steers when fed according to protein content. The difference although in favor of lineeed meal wes not significant.[4]

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[1]Morrison, op. cit., p. 540

[2]G. Bohstedt, Fattening Celves, Yearlings and Two Yeer Olde, Ohio Bi-monthly Bulletin No. 105 and 106, p. 175.

[3]Paul Gerleugh and Paul Heckett, Protein Concentretes for Yeerling Steers, Ohio Experiment Station Bi-monthly Bulletin No. 146, p. 131.

[4]Hinman, et. al, Cornell Experiment Station Annual Report 1941, p. 110.

Frank B. Morrison found that an average of 10 experiments comparing these two supplements for feeding yearling and two year old steers showed them to be equal in value.[1]

Cottonseed Meal with Soybeans. Experiments reviewed comparing these two supplements have found equality of the two feeds, soybeans to be more valuable than cottonseed meal, and cottonseed meal to be worth more than soybeans.

Illinois and Indiana experiments have found soybeans to be equal to cottonseed meal when fed to older beef steers on the pound for pound subetitution basis.[2]

In another Indiana experiment cottonseed meal proved to be more valuable for fattening two year old steers than soybeans.[3] Another experiment by this station found exactly opposite results.[4]

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[1]Morrison, op. cit., p. 540.

[2]Rusk, op. cit., p. 26.

Skinner and King, op. cit., Bulletin No. 281.

Skinner and King, op. cit., Bulletin No. 314.

F. G. King, Ground Soybeans for Fattening Cattle, Indiana Experiment Station Bulletin No. 237.

[3]Skinner and King, op. cit., Bulletin No. 291.

[4]Skinner and King, op. cit., Bulletin No. 330.

Morrison, by averaging six experiments comparing soybeans and cottonseed meal, found that soybeans were slightly more valuable than cottonseed meal for fattening two year old steers.[1]

Soybean Meal with Cottonseed Meal. Morrison reviewed 18 experiments comparing these two feeds and found that on the average equal gains were made with soybean meal or cottonseed meal when they were fed on a pound for pound substitution basis.[2]

Soybean meal has been proven equal to cottonseed meal when fed at the same rate to supplement the ration in feeding yearling and two year old steers.[3]

One Indiana publication contains the results from comparisons of these two feeds in four different experiments. Two of these experiments found soybean meal to be more valuable than cottonseed meal when sorghum silage, clover hay and corn grain were fed. One experiment found cottonseed meal and soybean meal to be equal and another found soybean meal to be more

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[1]Morrison, op. cit., p. 540.

[2]Loc. cit.

[3]Skinner and King, op. cit., Bulletins No. 281, 314 and 291.

R. R. Thalman, Protein Supplements for Fattening Cattle, Nebraska Experiment Station Bulletin No. 345.

valuable when corn silage was fed in a similar ration in place of sorghum silage.[1]

Soybean meal and cottonseed meal were also compared in Iowa experiments. They were fed according to crude protein content and were found to be approximately equal.[2] Soybean meal and cottonseed meal are very nearly alike in protein content. Therefore equality on a pound for pound basis and a protein basie aleo is not as contradictory as in the instance of linseed meal compared with cottonseed meal.

Linseed Meal with Soybean Meal. Comparisons between these two supplements seem to conclude that linseed is somewhat more valuable than soybean meal for supplementing the fattening ration for older beef cattle.

In an Illinois experiment, results found indicated that linseed meal was worth a little more in the beef fattening ration than soybean meal because of its characteristic of putting a smoother finish or bloom on the cattle.[3]

Morrison found in an average of 11 experimente comparing these two feeds that soybean meal was not quite as valuable

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[1]King, op. cit.

[2]C. C. Culbertson and P. S. Shearer, Iowa Experiment Station Annual Reports, 1940, p. 114, and 1942, p. 223.

[3]E. T. Robbins, Raising and Feeding Beef Cattle, Illinois Experiment Station Circular No. 613.

as linseed meal for fattening yearling and two year old cattle, when fed on a pound for pound substitution basis.[1]

Cornell experiments found that linseed meal was slightly more valuable than soybean meal for fattening yearling steers. The differences found were not felt to be significsnt. In this instance the supplements were fed according to protein content.[2]

A certain discrepancy may be seen here, in comparing the feeds according to protein content and on the pound basis. If linseed meal is worth more than soybean meal on the protein basis then it is worth a great deal more than soybesn mesl when fed on the pound basis.

Cottonseed and Linseed Meal. There seems to be a great deal more experimental comparisons which have been made between these two supplements than between any other two feeds. According to nutritionists, the more experiments there are, the better is the possibility of accurate evaluation of a protein supplement. Most of the experiments reviewed concerning these two supplements have found linseed meal to be of greater value than cottonseed meal for fattening yearling and two year old steers.

A number of experiment stations have found linseed meal to be superior to cottonseed meal when used as the only protein

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[1] Morrison, op. cit, pp. 540-541.

[2] Hinman, et. al, op. cit.

supplement in the ration for fattening yearling and two year old steers. This has been true when the supplements have been substituted pound for pound in the ration.[1] The feeding trials represented by this group of references comprise approximately thirty separate experiments.

There have also been a number of feeding experiments which resulted in the conclusion that cottonseed meal outproduced linseed meal when fed on a pound for pound basis.[2]

A Pennsylvania bulletin states that after two years of research they found that there was very little difference

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[1]H. R. Smith, Economical Rations in Beef Production, Nebraska Experiment Station Bulletin No. 100.

Robbins, op. cit.

C. C. Culbertson, John Evvard, W. E. Hammond and Q. W. Wallace, American Society of Animal Production Proceedings, 1923, p. 13.

W. H. Tomhave and F. L. Bentley, Steer Feeding Experiments, Pennsylvania Experiment Station Bulletin No. 183.

H. R. Smith, Economical Beef Production, Nebraska Experiment Station Bulletin No. 116.

H. M. Gerlock, Cottonseed Meal, Cold Pressed Cake, Linseed Oil Meal in Rations for Fattening Cattle, Missouri Experiment Station Circular No. 153, p. 3.

H. O. Allison, Corn Silage in Rations for Fattening Steers, Missouri Experiment Station Bulletin No. 150.

[2]Allison, op. cit.

F. A. Hays, Homegrown Feeds for Range Steers, Wyoming Experiment Station Bulletin No. 128.

between linseed meal and cottonseed meal when fed to fatten two year old steers. They fed a little more linseed meal than cottonseed meal in the ration but not enough to state that the comparison was made on the crude protein basis.[1]

Morrison has compiled 42 different experiments comparing cottonseed meal and linseed meal and presents the following conclusion.

> Considering only daily gain and feed required per 100 pounds of gain, cottonseed meal would have been worth about 89 percent as much as linseed meal in these trials.
>
> However, in nearly all of the experiments the cattle that had been fed linseed meal sold for a slightly higher price, either because of better finish or a sleeker appearance. On the average, there was a difference of 16 cents per hundredweight in selling price in favor of the linseed meal fed cattle.
>
> Taking both the difference in selling price and the difference in amounts of feed required per 100 lbs. of gain into consideration, in these experiments it would have been necessary to buy cottonseed meal at only 62 percent of the price of linseed meal to make an equal net profit per head.[2]

The significance of the above statements is extremely important to the man who feeds beef cattle. If the above is true, it tends to present some doubt as to the validity of the crude protein method of feed evaluation. Since linseed meal is lower in protein content, according to the crude protein method it would be worth less than cottonseed meal.

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[1]W. H. Tomhave, et. al, Two Years of Research, Pennsylvania Experiment Station Bulletin No. 170, p. 5.

[2]Morrison, op. cit., p. 561.

But experimental feeding trials have shown lineeed meal to be more valuable than cottonseed meal, thue the possibility ie raised ae to whether the crude protein method ie as accurate ae eome nutritioniete believe. This, of course, has merit only if the assumption is true that theee experimental results are valid.

Two experiments have been conducted at the Iowa Experiment Station which found that linseed meal was more valuable than cottonseed meal when fed according to protein content to yearling eteere.[1] Thie further accentuates the possibility that the crude protein method of protein supplement evaluation hae little merit when used to compare linseed meal and cottonseed meal for fattening yearling and two year old beef cattle.

In review of theee experimente, it hae been found that soybeans are equal to linseed meal and equal to cottonseed meal. Thus by definition linseed meal should be equal to cottonseed meal for fattening older beef cattle. This hae not been found to be true in actual experimentation. One ie led to believe that there are some inaccuracies in experimental results. Two feeds cannot be both equal to another feed and not to each other. This situation seems to require clarification. Poseibly the most accurate means of clarification would be to conduct further experiments along this line in order to determine what is right and what is wrong.

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[1]Culbertson and Shearer, op. cit.

Fattening Lambs. Numerous experimental feeding trials concerned with protein supplement substitution in fattening lamb rations have been reviewed and reported below.

Cottonseed Meal and Linseed Meal. Results of lamb fattening trials comparing these two supplements seem to depend upon the type of roughage which was fed in the ration. Experiments which found linseed meal and cottonseed meal to be equal used legume hay as a good portion of the roughage ration. Those experiments which found cottonseed meal to be more valuable than linseed meal used non-legume roughages as the principal non-concentrate portion of the ration.

Fifteen different experiments done at various experiment stations have found that cottonseed meal and linseed meal were of equal value when supplementing rations containing legume hay and corn silage, or supplementing legume hay as the only

roughage in the ration for fattening lambs. The supplements were found to be equal on a pound for pound substitution basis.[1]

Another group of four experiments where little if any legume hay was fed, found that cottonseed meal proved to be more valuable than linseed meal. These supplemsnts were fed on a pound for pound basis.[2] The roughage ration in these experiments consisted either of native hays, straw or sorghum fodder.

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[1]J. H. Skinner and C. G. Starr, Fattening Western Lambs, Indiana Experiment Station Bulletin No. 221.

J. H. Skinner and F. G. King, Fattening Lambs, Indiana Experiment Station Bulletin No. 263.

J. H. Skinner and C. M. Vestal, Fattening Western Lambs, Indiana Experiment Station Bulletin No. 256.

James A. Holden, Lamb Feeding Experiments in the Sugar Beet Growing Districts, Nebraska Experiment Station Bulletin No. 216.

P. S. Jordan and W. H. Peters, Feeding Methods and Rations for Fattening Lambs, Minnesota Experiment Station Bul. No. 306.

E. J. Maynard, G. E. Morton and H. B. Osland, Colorado Drylot Fattening Rations for Lambs, Colorado Experiment Sta. Bul. 379.

A. M. Paterson, Lamb Feeding Investigations, 1919, Kansas Experiment Station Circular No. 79.

A. M. Paterson and H. B. Winchester, Sheep Feeding Investigations, 1920-21, Kansas Experiment Station Circular No. 96.

A. M. Paterson, Some Lamb Feeding Results, Kansas Experiment Station Circular, No. 108.

[2]G. E. Morton, H. B. Osland and J. F. Brandon, Dryland Fattening Rations for Lambs, Colo. Exp. Sta. Press Bul. No. 80.

F. A. Hays, Native Feeds for Fattening Lambs, Wyoming Experiment Station Bulletin No. 130.

Skinner and Vestal, op. cit.

Two experiments were reviewed which compared cottonseed meal and linseed meal for fattening lambs on the condition that the same amount of total protein was fed from each meal.[1] These two supplements produced equal results when they were fed in this manner.

One Kansas experiment found that lambs fed cottonseed meal made greater and more economical gains than lambs fed linseed meal.[2]

Linseed Meal with Soybeans. Experimental conclusions in comparisons of these two supplements have found that they are equal when fed according to protein content and also when fed on a pound for pound substitution basis. Linseed meal and soybeans are fairly similar in their protein contents, so equality by both methods seems possible.

Four references found in feeding trials that linseed meal was equal to soybeans when fed at the same rate to fattening lambs.[3]

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[1]G. E. Morton and B. W. Fairbanks, Feedlot Fattening Rations for Lambs, Colorado Experiment Station Press Bul. No. 79.

H. L. Russell and F. B. Morrison, New Farm Facts, Wisconsin Experiment Station Annual Report 1919-20, Bul. No. 323, p. 13.

[2]Kansas Experiment Station 9th Biennial Report 1936-38, p. 75.

[3]Skinner and King, op. cit., Bul. No. 221.

W. G. Kammlade and A. K. Mackey, Soybean Crop for Fattening Western Lambs, Illinois Experiment Station Bulletin No. 260.

Ohio 42nd Annual Experiment Station Report, Bul. No. 373, p. 58.

Morton, Osland and Brandon, op. cit.

A Cornell Experiment Station bulletin states that linseed meal was found to be equal to soybeans when fed according to protein content in the lamb fattening ration.[1]

Soybean Meal with Cottonseed Meal. Only one experiment was found where cottonseed meal and soybean meal are compared for fattening lambs. This experiment was conducted at the Indiana Experiment Station, and results showed that soybean meal was fully equal to cottonseed meal for fattening lambs when substituted pound for pound in the ration.[2]

Soybean Meal with Linseed Meal. Only two experiments were found which compared these two supplements, one found them to be equal on a pound for pound basis and the other found them to be equal when fed according to protein content. Both of these results cannot be accurate, since linseed meal contains at least 6-8 percent less protein than soybean meal.

Soybean meal was found to be approximately equal to linseed meal for fattening lambs when fed on a pound for pound substitution basis at the Indiana Experiment Station.[3]

A Cornell Experiment Station bulletin states that in experiments conducted at that station soybean meal and linseed meal were found to be approximately equal in value when

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[1] J. P. Willman and F. B. Morrison and E. W. Klosterman, Lamb Feeding Experiments, Cornell Experiment Sta. Bul. No. 834.

[2] J. H. Skinner and F. G. King, Fattening Western Lambs, Indiana Experiment Station Bulletin No. 296.

[3] Kammlade and Mackey, op. cit., Bul. No. 260.

fed as supplements to the lamb fattening rations according to protein content.[1]

Cottonseed Meal with Soybeans. Indiana and Colorado experiments found these two supplements to be equal in value on a pound basis while Idaho experiments found that cottonseed meal was slightly more valuable than soybeans.

Experiments in substituting soybeans for cottonseed meal in the lamb fattening ration have found that they are equal in feeding value on a pound for pound basis.[2]

Idaho experiments comparing these two protein feeds found that soybeans were not quite as valuable for fattening lambs as was cottonseed meal.[3]

Soybean Meal with Soybeans. Experiments reviewed comparing these two supplements show them to be equal on a pound for pound basis and also when the same amount of protein is

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[1]Willman, Morrison, and Klosterman, op. cit.

[2]J. H. Skinner and F. G. King, Fattening Western Lambs, Indiana Experiment Station Bulletin No. 273.

Skinner and Starr, op. cit.

Morton, Osland and Brandon, op. cit.

Skinner and King, op. cit., Bul. No. 296.

J. H. Skinner and F. G. King, Fattening Western Lambs, Indiana Experiment Station Bulletin No. 202.

[3]Idaho Experiment Station Annual Report, 1933, Science Aids Idaho Farmers, Idaho Bulletin No. 205, p. 66.

Idaho Experiment Station Annual Report, 1934, Science Aids Idaho Farmers, Idaho Bulletin No. 217, p. 47.

fed from each feed. One experiment found soybeans to be more valuable and another found soybean meal to produce more gain than soybeans.

Indiana experiments found that soybean meal and soybeans were equal when fed on a pound for pound basis with corn silage, corn grain and clover hay.[1]

Cornell experiments found that soybeans were equal to soybean meal when fed according to the crude protein content of the supplement. The roughage in this ration was almost entirely corn silage.[2] Three feeding trials were conducted using the same rations and under similar conditions.

A South Dakota bulletin concludes that when whole soybeans can be purchased or produced for less than it costs to buy an equal amount of soybean meal, then it will be to the feeder's advantage to feed soybeans. In this experiment soybeans outproiuced the soybean meal when fed on a pound per pound basis as supplements to a corn grain and brome hay ration for fattening lambs.[3]

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[1]Skinner and King, op. cit., Bul. No. 273.

Skinner and King, op. cit., Bul. No. 296.

[2]Willman, Morrison and Klosterman, op. cit.

[3]R. M. Jordan, Soybeans for Fattening Lambs, South Dakota Experiment Station Bulletin No. 442.

In an Illinois experiment soybean meal fed lambs outproduced soybean fed lambs but there was no significant difference.[1]

Wintering Beef Cattle. Protein supplements are valuable as additions to winter rations for beef cattle. A number of experiments have been reviewed comparing the different protein supplements as substitutes in the ration for wintering feeder cattle and these experiments are compared below.

At the Hays, Kansas, Experiment Station experiments in feeding of the various protein supplements with a full feed of sorghum silage showed that 3 pounds of wheat bran produced the best gains on yearling cattle and that 4 pounds of alfalfa hay as the protein supplement produced second best gains. The high protein supplements which were compared were fed at the rate of 1 pound per head per day and the supplements ranked in the following order: (1) Cottonseed meal, (2) Corn gluten meal, (3) Soybean meal, (4) Tankage, (5) Linseed meal (6) Peanut oil meal. There was less difference between cottonseed meal and corn gluten meal than between these two supplements fed in the experiment. Essentially when fed in this cottonseed meal and corn gluten meal are equal but the other supplements have a somewhat lower value.[2]

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[1]Kammlade and Mackey, op. cit., Bul. No. 260.

[2]C. W. McCampbell and L. C. Aicher, 28th Annual Cattleman's Roundup, 1941, 1942 and 1943, Reports of the Kansas Experiment Station.

In an Oklahoma experiment soybean meal and cottonseed meal were compared when fed to two year old steers being wintered on dry grass. These two high protein supplements were fed at the same protein level and soybean meal was found to produce greater gains than cottonseed meal.[1] This bulletin states that these results of this experiment bear out previous results of similar experiments.

Other Kansas experiments, with wintering heifers, when 1 pound of either cottonseed meal, linseed meal or soybean meal was added to the ration of corn silage and prairie hay, found that increased gains were a result. Very little difference was found between the responses of the different supplements, except that soybean meal produced slightly better results.[2]

A Nebraska Experiment Station report states that calves wintered on prairie hay and 1 pound of either cottonseed cake or soybean cake, gained more on the cottonseed cake and ate less feed to do so.[3]

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[1] L. S. Pope, Dwight Stephens, P. E. Loggins and V. G. Heller, Oklahoma Progress Report, Oklahoma Experiment Station Misc. Publication No. 31, p. 124.

[2] A. G. Pickett and Ed F. Smith, Kansas Experiment Station, Feeder's Day Bulletin (36th).

[3] E. M. Brouse, Wintering Steer Calves in the Nebraska Sandhills, Nebraska Experiment Station Bulletin No. 357.

Results of Illinois experiments, show ground soybeans to be equal to linseed meal when added to yearling stocker rations. These supplements were fed according to protein content.[1]

A comparison of linseed meal and cottonseed meal for wintering steers fed a full feed of corn silage, made at the South Dakota Experiment Station, showed that animals fed linseed meal outproduced those fed cottonseed meal. The supplements in this case were fed on an equal pound basis.[2]

An Indiana experiment found that ground raw soybeans and linseed meal were equally effective as protein supplements in the grain rations for growing heifer calves when fed with alfalfa hay.[3]

Summary of Experimental Conclusions. If any definite conclusions can be made from the experiments reviewed, then the following statements may be used as the general concensus of opinion in relation to the value of these four feeds in comparison with each other for the different classes of livestock.

Dairy Cattle (pound for pound)

1. Soybean meal is at least equal to cottonseed meal, if not somewhat superior.

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[1]Rusk, op. cit.

[2]James W. Wilson, Corn Silage and Mill Products for Steers, South Dakota Experiment Station Bulletin No. 148.

[3]L. H. Fairchild and J. W. Wilbur, Journal of Dairy Science, Vol. 18, p. 238.

2. Linseed meal is equal in feeding value to soybeans.
3. Soybeans have been found to be slightly more valuable than cottonseed meal.
4. Linseed meal is equal in feeding value to cottonseed meal.
5. Soybean meal has been found to be equal in feeding value to ground soybeans.

Fattening Beef Calves (pound for pound)

1. Linseed meal has been found to be more valuable than cottonseed meal.
2. Linseed meal has been found to be slightly more valuable than soybeans.
3. Cottonseed meal has been found to be more valuable than soybeans.
4. Soybean meal has been found to be at least equal to soybeans if not somewhat more valuable.
5. Linseed meal has been found to be more valuable than soybean meal.

Fattening Yearling and Two Year Old Cattle (pound for pound)

1. Soybean meal has been found to be equal to soybeans in feeding value.
2. Soybeans have been proven equal to linseed meal.
3. Soybeans have been found to be slightly more valuable than cottonseed meal.
4. Soybean meal has been found to be equal to cottonseed meal.

5. Linseed meal has been found to be worth somewhat more than soybean meal.
6. Linseed meal has been found to be worth somewhat more than cottonseed meal.

Fattening Lambs (pound for pound)

1. Linseed meal has been found to be equal to cottonseed meal when legume hay was fed in the ration.
2. Cottonseed meal has been found to be slightly more valuable than linseed meal when non-legume roughages are fed in the ration.
3. Linseed meal is equal to soybeans.
4. Soybean meal is equal to cottonseed meal.
5. Soybean meal is equal to linseed meal.
6. Cottonseed meal is equal to soybeans.
7. Soybean meal is equal to soybeans.

Wintering Beef Cattle (pound for pound)

1. Cottonseed meal or cake has been found to be slightly more valuable than soybean meal or cake, for wintering steers.
2. Ground soybeans and linseed meal have been found to be equally effective in supplementing wintering rations.
3. Soybean meal has been found to be slightly more valuable than cottonseed meal for wintering heifers.
4. The Kansas experiments reported on page 49 of this thesis seem to show a somewhat better experimental

design than others reviewed. Here linseed meal was slightly less valuable as a protein supplement than either cottonseed meal or soybean meal.

The conclusions arrived at from the review of literature on feeding protein supplements to the different classes of livestock are shown in Table 4. Only those conclusions which relate to the feeding of the supplements on a pound for pound basis are presented in this table. The supplements are compared to soybean meal as the base feed in all instances except for soybeans for wintering cattle. In this instance comparison was made with linseed meal instead of soybean meal, since no experiments were found which compared soybeans with soybean meal.

Statement of the Problem. Some experimental results have shown comparability when the supplements have been substituted pound for pound of feed, and also when they have been fed according to their respective protein contents, i.e., the same amount of protein from each feed was supplied in the ration. Those comparisons which found this to be true are for dairy cattle; linseed meal was found to be equal to cottonseed meal and soybean meal was found to be equal to linseed meal. For fattening beef calves, linseed meal was found to be somewhat more valuable than cottonseed meal. For fattening older cattle, soybean meal was found to be equal to soybeans, linseed meal was found to be more valuable than cottonseed meal, and linseed meal was found to be more valuable than

Table 4. The results and summary of the experiments reviewed on the feeding of different protein supplements to the different types of livestock. When compared on a pound for pound of supplement basis.

Type of livestock	Linseed meal	Cottonseed meal	Soybeans[a]
Dairy cattle	Equal to soybean meal	Worth less than soybean meal	Equal to soybean meal
Fattening older beef cattle	Superior to soybean meal and cottonseed meal	Equal to soybean meal	Equal to soybean meal
Fattening beef calves	Superior to soybean meal and cottonseed meal	Worth less than linseed meal	Worth less than soybean meal[a]
Wintering beef cattle	Worth less than soybean meal or cottonseed meal	Worth more than soybean meal	Equal to linseed meal
Fattening lambs	Equal to soybean meal	Equal to soybean meal	Equal to soybean meal

[a]Soybeans should not be ground for beef calves. For other types of stock they should be ground in most cases.

soybean meal. For fattening lambs, linseed meal was found to be equal to soybeans, linseed meal was found to be equal to soybean meal, soybean meal was found to be equal to soybeans, and linseed meal was found to be equal to cottonseed meal.

A definite problem presents itself when the above possibilities occur. In certain instances there is the possibility that two feeds could be comparable under both methods of feeding. Theoretically, this could only be true when the protein contents of the two feeds are the same or very nearly the same. It seems possible that this could happen, and be sufficiently accurate, in the comparison of cottonseed meal with soybean meal since these two feeds contain approximately the same amount of protein. It might also occur in the case of soybeans being compared with linseed meal since these two feeds contain nearly the same amount of total protein. But it certainly is not very likely in the case of comparison of cottonseed meal or soybean meal with linseed meal since their protein contents differ considerably. Linseed meal contains approximately 32 to 36 percent protein while cottonseed meal contains 41 to 43 percent protein and soybean meal contains from 41 to 44 percent total protein.

For example experimental results showed, for both fattening calves and for fattening older beef animals, that linseed meal was found to be more valuable than cottonseed meal both on a pound for pound basis and on a crude protein basis. When linseed meal is more valuable than the

cottonseed meal on a pound for pound basie, then theoretically the linseed meal should be a great deal more valuable when fed according to the protein content of the feede. This basically should be true since the animals fed the linseed meal would be receiving more pounds of feed than the animals fed the cottonseed meal. This certainly presents a major problem eince it is not feasible for them to obtain equivalent results under two such opposing methods of feeding.

If these experimental results can be relied upon, then the possibility is raised that the crude protein method of protein supplement evaluation does not merit the credit that it has been given. The possibility is also raised that the experimente in some instances may not have been too accurate. It is not the purpose of this paper to refute any method of feed evaluation, but merely to find the most accurate method which can be used by livestock producers. Due to the disagreement among nutritioniets themselves as to the proper method, it becomes a very complex problem indeed for an economist to determine the most accurate one. It seems, that if any one of the methods corresponde closer than any of the others to the actual prices which have occurred in the past, then that method should be the most accurate. But first, we must prove our hypothesie to be invalid and if that cannot be done we must assume that it ie correct.

Statement of Relative Feeding Values. Interpretation of Table 4 has been done in the following manner. Soybean meal, currently the most important protein supplement, has been used as the basis for comparison. Thus soybean meal has been given a value of 100 percent in Table 5. Where any of the other supplements were found to be equal on a total pound for pound basis to soybean meal they have also been given a value of 100 percent in the table. In the case where the supplements have been found to be more or less valuable than soybean meal, an approximate percentage value has been given to that supplement. It is important to realize that these are only approximate values since no attempt has been made to average experimental results.

Table 5. The relative feeding values of four major plant protein supplements for feeding certain classes of livestock.

Supplement	Dairy cattle	Older beef steers	Beef calves	Lambs[a]	Wintering beef steers
Soybean meal	100	100	100	100	100
Linseed meal	100	115	120	100	95
Cottonseed meal	95	100	100	100	105
Soybeans	100	100	90	100	95

[a]These relative feeding values for fattening lambs are valid when legume hay is fed in the ration.

This table can be substantiated not only by the experimental results reviewed, but also by a similar table prepared

by Mr. R. D. Jennings, of the United States Department of Agriculture. Mr. Jennings compares these same four protein supplements for four different classes of livestock with corn as the base feed. A portion of the table prepared by Mr. Jennings is shown in Table 6.

Table 6. Relative feeding values of various feeds as compared to corn for different classes of livestock.[1]

Supplement	Dairy cattle	Fattening beef cattle	Wintering beef cattle	Fattening lambs
Cottonseed meal	160	250	125	225
Linseed meal	160	300	---	225
Soybean meal	170	250	---	225
Soybeans	170	250	---	225

In personal correspondence with Mr. Jennings, he makes the following statement about the table referred to above:

> The percentages in Table 27 of U.S.D.A. Circular 836, are based mostly on feeding trials as reported by Morrison in Feeds and Feeding. Most of the figures were rounded to the nearest five percent as it was felt that the data were not that accurate.[2]

Thus it is felt that Table 5 can be uses as the source of relative feeding values for use in comparing them with the actual market prices which have occurred in the past in order

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[1]R. D. Jennings, Consumption of Feed by Livestock, 1909-1947, Table 27, p. 53, U. S. D. A. Circular No. 836.

[2]Jennings, personal correspondence with the author.

to determine if market prices have reflected actual relative feeding values.

PRICE RELATIONSHIPS

Have actual price relationships in the past reflected relative feeding values of soybean meal, soybeans, cottonseed meal and linseed meal? This is the question which must be answered.

Past price relationships most important to Kansas farmers can be approximated by observing relationships on the Kansas City market. The average monthly prices of the three supplements, linseed meal, cottonseed meal and soybean meal have been derived by averaging the highs and lows for each month on the Kansas City market for the years, 1932 to 1954 inclusive. Cash prices were not used for soybeans since we are primarily concerned with the soybeans which are fed on the farm where they are grown. Thus prices received by Kansas farmers have been used for soybeans. The mid-month average price received by farmers for soybeans has been used for the years, 1932 to 1954 inclusive.

Tables 7, 8, 9 and 10 show the average monthly prices for the four feeds, soybean meal, cottonseed meal, linseed meal, and soybeans, in that order. Soybean prices were taken from the Farm Facts publications of the Kansas State Board of Agriculture and the prices for the other three feeds were taken from the Kansas City Grain Market Review, published

Table 7. Cash price—41 percent soybean meal, 1932-1954, Kansas City.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
1932	24.45	23.35	21.87	21.50	21.58	21.55	21.50	22.60	22.87	23.40	23.00	22.95	22.55
1933	22.70	22.24	23.09	24.66	28.34	30.44	37.00	37.00	37.00[a]	32.30	31.94	32.30	29.92
1934	30.49	32.80	32.83	34.25	34.67	35.50	36.72	41.31	41.06	40.30	39.80	43.80	36.96
1935	42.39	39.82	38.54	35.61	35.40	32.90	28.52	25.00	23.63	27.10	27.33	27.84	32.01
1936	27.87	26.31	24.89	24.39	27.60	27.46	40.03	46.47	44.60	38.19	41.38	44.30	34.46
1937	45.73	43.70	42.36	48.44	49.76	43.48	38.15	37.00	34.35	30.05	30.02	29.52	39.38
1938	30.23	31.46	28.35	27.33	27.38	26.95	28.46	27.97	27.90	27.05	26.37	27.64	28.04
1939	28.26	26.75	26.05	26.58	27.56	27.49	26.50	27.02	37.04	29.65	34.84	35.97	29.48
1940	34.42	31.17	30.70	29.78	30.00	25.85	23.64	25.33	27.31	27.84	32.06	30.53	29.05
1941	30.73	28.53	28.00	28.92	29.42	31.61	37.72	36.99	43.88	41.40	40.78	43.74	35.14
1942	47.70	48.56	45.85	42.74	40.47	39.65	42.70	43.22	44.74	46.99	49.00	40.63[b]	44.35
1943	40.98	41.23	42.23	42.23	42.18	42.03	42.03	53.53	53.53	53.53	53.53	53.53	46.71
1944	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53	53.53
1945	53.53	53.53	53.53	53.66	53.78	53.78	53.78	53.78	53.78	53.78	53.78	53.78	53.71
1946	53.78	53.78	53.78	53.78	62.18	67.78	95.50	95.13	67.28	84.59	93.44	79.20	71.68
1947	72.89	85.21	79.04	72.06	66.32	78.49	89.89	92.03	100.37	92.69	93.31	101.75	85.34
1948	110.31	86.76	82.67	83.84	86.59	92.99	96.43	80.37	83.27	66.70	80.63	76.42	85.42
1949	70.16	66.83	65.64	68.95	70.59	74.51	83.99	100.12	83.56	73.17	69.60	69.20	74.69
1950	65.41	64.73	68.13	71.57	82.05	84.60	95.66	78.56	77.09	65.64	72.36	75.75	75.13
1951	75.54	80.44	78.59	77.19	77.01[c]	77.83	82.61	80.21	85.07	87.85	87.91	87.92	81.51
1952	87.93	87.93	87.93	90.02	95.71	96.05	96.05	96.05	96.16	93.72	89.18	85.19	91.83
1953	79.97	77.37	76.89	74.59	77.78	76.88	77.67	73.41	70.35	69.44	70.31	81.61	75.52
1954	82.18	86.24	93.50	103.37	99.50	98.17	103.38	97.71	79.48	76.49	77.78	73.50	89.60

[a]September 1933, no supplies so used August price.

[b]December 1, 1942 to July 31, 1943, supplies were absent on Kansas City market so prices are adjusted from Chicago prices for that period. (Chicago price + 1.63 = Kansas City price.)

[c]Soybean meal quoted at 41 percent protein until May 7, 1951. May 8, 1951 to December 31, 1954, 44 percent.

Source: Kansas City Grain Market Review.

Table 8. Cash price—41 percent cottonseed meal, 1932-1954, Kansas City.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly av.
1932	21.07[a]	20.89	20.36	20.00	19.38	19.95	19.55	21.43	21.07	19.24	18.95	18.33	20.02
1933	19.97[b]	17.78	18.85	19.70	22.57	24.13	34.39	29.12	24.20	24.30	26.95	26.90	23.99
1934	29.24	30.72	30.71	30.66	29.95	33.05	36.98	43.68[c]	41.80	41.68	44.22	44.58	36.44
1935	41.76	39.72	37.89	37.78	36.62	33.43	31.45	28.18	26.94	30.34	29.34	28.63	33.51
1936	27.93	27.63	26.55	27.30	28.16	28.71	38.33	40.85	38.07	35.29	37.51	40.57	33.08
1937	41.21	41.60	41.12	45.64	46.52	40.86	37.89	31.40	27.10	28.25	28.90	27.31	36.48
1938	28.98	28.22	27.43	27.43	26.85	26.65	29.01	28.25	27.46	28.00	28.25	29.03	27.97
1939	29.50	28.61	29.03	29.90	30.27	29.47	28.40	27.95	33.75	31.92	34.76	35.74	30.78
1940	35.91	35.22	35.29	36.03	35.40	30.40	30.70	32.12	29.47	30.22	34.84	34.42	33.34
1941	33.81	30.29	29.54	30.81	30.21	31.45	35.98	39.34	45.94	41.94	41.93	43.73	36.25
1942	45.32	43.70	42.41	41.41	40.10	39.89	41.03	40.72	40.92	40.47	44.23	45.96	42.18
1943	45.90	45.90	45.90	45.90	45.90	45.90	45.90	55.00	55.00	55.00	55.00	55.00	49.69
1944	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
1945	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.68	55.90	55.90	55.90	55.90	55.36
1946	55.90	55.90	55.90	55.90	63.68	69.90	102.75	100.92	68.21	91.11	97.97	86.75	75.41
1947	78.55	68.35	81.05	75.56	70.57	78.36	84.53	88.09	96.69	95.59	97.90	103.98	84.94
1948	105.53	88.70	89.56	88.23	88.47	94.07	89.39	72.71	71.16	72.92	82.24	78.83	85.15
1949	71.64	67.75	63.93	63.57	64.09	65.77	72.13	73.05	65.53	67.90	69.64	69.04	67.84
1950	67.12	65.04	67.15	69.43	69.43	68.95	77.90	81.56	79.47	77.62	82.84	89.49	74.67
1951	88.06	89.17	89.28	91.50	91.47	85.97	82.01	79.06	77.85	87.84	92.06	93.26	87.29
1952	96.94	95.39	94.46	96.39	97.12	97.23	97.89	98.83	96.55	95.00	95.00	94.34	96.26
1953	72.45	74.46	70.66	65.76	67.96	73.82	91.25	85.28	83.59	76.52	70.53	70.36	75.22
1954	77.65	75.86	77.21	79.35	77.31	75.24	79.76	84.46	76.74	78.47	80.18	80.95	78.60

[a]41 percent from January 1932 to December 1932.

[b]January 1933 to August 14, 1934, 43 percent.

[c]August 15, 1934 to December 1954, 41 percent.

Source: Kansas City Grain Market Review.

Table 9. Cash price--linseed oil meal, 1932-1954, Kansas City.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
1932	33.21[a]	32.06	31.67	31.09	28.54	25.38	24.37	24.83	25.53	24.61	23.65	23.46	27.37
1933	23.54	23.45	24.25	26.63	28.95	30.36	40.82	38.67	34.73	35.46	35.18	34.50	31.38
1934	35.19	34.88	33.96	34.64	33.56	36.24	36.97	44.47	48.13	45.05	45.28	47.22	39.63
1935	43.70	39.42	35.17	35.69	34.89	28.73	24.29	29.60	29.42	31.82	30.53	31.02	32.86
1936	30.95	29.66	28.72	28.79	29.37	31.63	45.32	51.62	52.24	49.95	50.62	52.22	40.09
1937	52.13	47.89	43.77	44.58	43.76	41.94	38.27	35.19	34.73	37.05	38.95	41.56	41.65
1938	45.82	46.57	44.67	45.24	47.96	45.04	45.08	42.99	39.48	41.72	42.98	43.91	44.29
1939	44.41	42.89	42.33	42.54	41.94	41.46	37.64	31.83	39.36	37.84	36.96	38.60	39.82
1940	38.66	35.64	33.97	34.30	34.14	31.11	28.66	28.99	28.30	28.99	32.78	33.34	32.41
1941	33.80	32.71	31.70	32.63	31.92	32.35	35.88	37.85	42.67	41.99	40.32	42.88	36.39
1942	45.76	47.30	46.83	42.59	40.38	40.07	39.70	39.21	40.60	40.94	45.61	47.55	43.04
1943	47.60	47.60	47.60	47.60	47.60	47.60	48.50	53.53	53.53	53.53	53.53	50.43	49.89
1944	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43	50.43
1945	50.43	50.43	50.43	50.52	50.65	50.65	50.65	50.65	50.65	50.65	50.65	50.65	50.58
1946	50.65	50.65	50.65[b]	50.65	59.05	64.65	94.00	90.22	64.04	90.47	99.42	89.98	71.20
1947	90.28	90.73	89.75	90.60	75.57	76.38	82.98	82.94	91.84[c]	93.85	94.37	98.86	88.18
1948	116.70	96.78[d]	84.70	78.17	78.08	79.46	78.33	73.15	70.61	70.90	81.04	88.76	83.06
1949	90.09	77.24	71.50	70.88	67.12	71.48	67.17	69.54	68.76	73.10	76.61	79.68	72.70
1950	76.42	74.49	76.97	79.99	79.68	79.07	76.94	74.48	70.86	67.55	70.80	71.78	74.67
1951	75.73	76.50	76.32	72.15	68.34	64.86	67.02	73.51	78.64	81.05	82.00	81.81	74.83
1952	81.82	81.82	82.05	87.32	87.84	86.98	86.94	91.26[e]	91.25	91.25	91.25	94.53	87.86
1953	93.67	87.00	80.96	74.88	75.76	72.16	69.81	70.87	71.64	71.65	70.83	78.50	76.48
1954	81.58	81.61	80.47	89.06	89.78	74.56	70.66	70.36	72.00	74.30	76.97	79.27	78.39

[a]January 1, 1932 to March 12, 1946, 34 percent protein.

[b]March 13, 1946 to September 10, 1947, 32 percent protein.

[c]September 11, 1947 to February 10, 1948, 35 percent protein.

[d]February 11, 1948 to July 30, 1952, 34 percent protein.

[e]August 1, 1952 to December 31, 1954, 32 percent protein.

Source: Kansas City Grain Market Review.

Table 10. Average prices received by Kansas farmers for soybeans on the 15th of the month, 1932-1954. (Dollars per bushel.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Per bu.av.
1932	.46	.50	.55	.60	.70	.80	.75	.60	.60	.60	.40	.55	59.2
1933	.55	.60	.65	.90	1.05	1.30	1.30	1.25	1.25	1.00	.75	.75	94.6
1934	.80	1.05	1.20	1.25	1.45	1.70	1.65	1.55	1.55	1.35	1.20	1.20	124.6
1935	1.20	1.20	1.20	1.50	1.50	1.50	1.50	1.25	1.20	1.00	1.05	1.05	126.2
1936	1.00	1.00	1.00	1.00	1.25	1.50	1.60	1.60	1.55	1.50	1.50	1.60	134.2
1937	1.60	1.60	1.60	1.60	1.60	1.60	1.50	1.25	1.10	.80	.80	.80	132.1
1938	.85	.95	.95	.95	1.20	1.20	1.20	1.10	1.10	.85	.85	.85	100.4
1939	.85	.85	.95	1.05	1.15	1.20	1.20	1.10	1.20	.70	.80	1.00	100.4
1940	1.05	1.05	1.15	1.15	1.25	1.25	1.25	1.25	.80	.62	.80	.80	103.5
1941	.85	.90	.85	1.05	1.20	1.20	1.30	1.35	1.50	1.30	1.30	1.35	118.3
1942	1.45	1.60	1.70	1.75	1.80	1.75	1.70	1.70	1.75	1.55	1.55	1.55	165.4
1943	1.60	1.60	1.70	1.70	1.70	1.65	1.63	1.64	1.65	1.80	1.80	1.80	168.9
1944	1.80	1.85	1.85	1.85	1.90	1.95	1.85	1.85	1.95	2.00	2.05	2.05	191.2
1945	2.05	2.10	2.10	2.10	2.15	2.15	2.20	2.10	2.05	2.05	2.05	2.10	205.8
1946	2.10	2.10	2.10	2.10	2.15	2.10	2.20	2.20	2.10	2.25	3.05	2.70	226.2
1947	2.85	2.95	3.35	3.45	3.05	2.80	2.65	2.75	2.75	3.05	3.35	3.50	304.2
1948	4.00	3.00	3.10	3.55	3.65	3.80	3.70	2.80	2.55	2.25	2.50	2.35	310.4
1949	2.25	2.00	2.05	2.02	2.08	2.02	2.18	2.40	2.15	2.05	1.95	2.05	210.0
1950	2.03	2.02	2.14	2.37	2.52	2.60	2.65	2.40	2.17	1.95	2.50	2.58	232.8
1951	2.83	3.02	3.06	3.07	3.07	2.93	2.79	2.62	2.45	2.59	2.77	2.83	283.6
1952	2.74	2.74	2.71	2.65	2.63	2.79	2.75	2.86	2.75	2.65	2.58	2.68	271.1
1953	2.56	2.48	2.60	2.64	2.57	2.47	2.30	2.26	2.18	2.34	2.46	2.62	245.7
1954	2.65	2.74	3.01	3.27	3.37	3.15	3.20	2.90	2.35	2.46	2.54	2.51	284.6

Source: Price Patterns, Report of Kansas State Board of Agriculture. February 1950 and 1951, 1952, 1953 figures, Kansas Farm Facts. 1954 figures from Agricultural Prices.

by the Kansas City Board of Trade. These tables are presented to show the prices which have been used for comparison with relative feeding values and other statistical methods of comparison which are shown on the following pages.

Table 4 was used as the basis for the relative feeding values used and Tables 7, 8, 9 and 10 were used as the prices in preparing the price ratio charts which are shown on later pages.

The Regression Line

Before a comparison could be made between actual prices and relative feeding values, a statistical measure had to be used to determine the actual price relationship between any two of the feeds. A type of simple regression has been used since only two variables were encountered in actual price data. The formula used for this simple regression was Y equals A + Bx.

A regression line has been computed from price data for comparison of the prices of each of the feeds with the other three. It is not necessary to show each of these lines in graphic form since the regression lines are shown on the price ratio charts on the following pages. The formulas for each of the regression lines computed have been shown in Table 11.

Price Ratio Charts

A price ratio chart has been used here to compare the relative feeding values for the different claesee of livestock with the regreeeion relationehip of the prices of each of the two feeds.

Linseed Meal with Soybean Meal. Figure 4 ehows the comparison of linseed meal with eoybean meal for feeding the five classee of liveetock, dairy cows, fattening calves, fattening yeerling and two year old cattle, wintering beef cattle, and fattening lambs.

The regreseion line ZZ ehowe the actual price relationship between the two feeds for the yeare studied. The regression line ehowe that there has been a change in the relationehip between linseed meal and soybean meal pricee during the period. At lower prices lineeed meal was higher in cost than soybean meal while at higher pricee the relationship is exactly the opposite. It must be explained that the lower pricee all occurred prior to and during the second World War, and the prices eince 1946 have been above those occurring in the earlier period. During the war the price of theee two feeds was stabilized between 50 and 54 dollars per ton. Figure 3 ehows that after prices went above 50 dollare per ton, there tended to be a greater differential between the actual price relationehip and the relative feeding values for the different claseee of livestock.

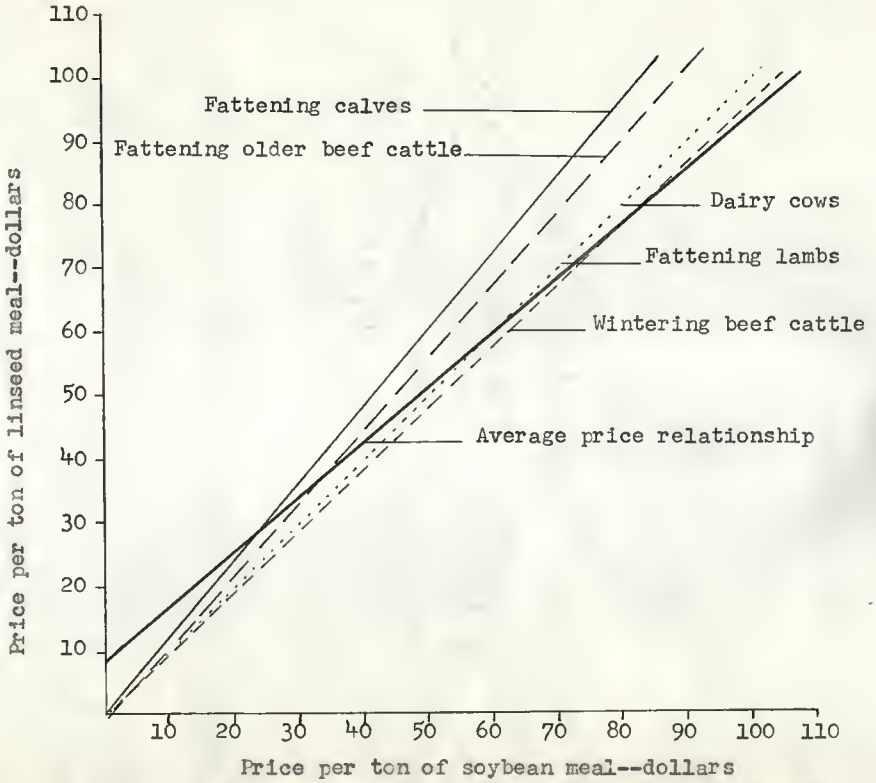

Fig. 3. Comparison of the relative feeding values for the five classes of livestock and the average price relationship of soybean meal and linseed meal, 1932-1954.

Table 11. Computed values for the regression equation, standard error and correlation for the different price comparisons between each of the four feeds, 1932-1954.

Y	X	Value of A	Value of B	Standard error	Correlation coefficient
LSM	SMB	9.397	.84348	5.4035	.9804
SBM	SB	- 1.092	.9095	5.274	.9741
LSM	SB	8.62	.7648	6.8927	.9527
CSM	SBM	.021	.9943	3.783	.9869
LSM	SBM	10.291	.8314	6.1553	.9735
CSM	SB	- 1.69	.9146	5.493	.9725

Since it has been aeeumed that the relative feeding valuee are correct, the conclusion from etudy of this figure hae been that livestock feedere could have paid more for linseed meal than they did. That is, it would have been more profitable to feed linseed meal than soybean meal to either fattening calvee or for fattening older beef animals. The figure shows, above pricee of 70 dollare per ton, that the actual price relationehip in the market did reflect the relative feeding value of the feede for fattening lambe, dairy cattle, and for wintering beef cattle.

Soybean Meal and Cottonseed Meal. Figure 4 shows the relationship between the actual prices on the Kaneas City market for soybean meal and cottonseed meal, and the relative feeding valuee for the five classes of livestock with which we have been concerned. The regression line denoting prices of the two feeds ehowe equality between them. The relative feeding value of cottonseed meal and eoybean meal shows them of equal value for fattening lambs, for fattening beef calvee and for fattening older cattle. The relative feeding valuee for dairy cattle and for wintering beef cattle do not exactly coincide with the actual price relationship line ae do the others, but they still fall within the standard error of 3.783. Thus in the case of theee two feeds, actual average yearly price relationehipe have reflected the relative feeding value for the different claseee of liveetock.

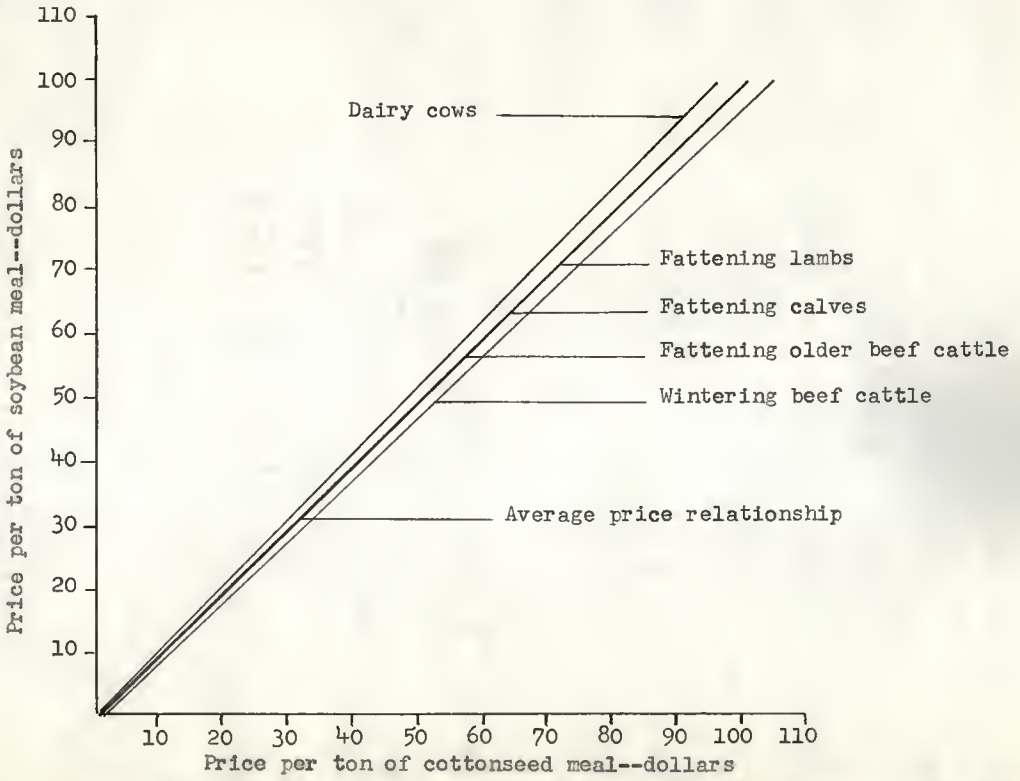

Fig. 4. The price relationship between soybean meal and cottonseed meal 1932-1954, compared with their relative feeding value for five classes of livestock.

Linseed Meal and Cottonseed Meal. Figure 5 shows the relationship between actual prices and relative feeding values for linseed meal and cottonseed meal. The regression line ZZ shows that cottonseed meal prices have been higher on the market than linseed meal prices. Thus according to the relative feeding values for fattening calves, dairy cows and fattening older steers, the actual prices have not reflected feeding values. This is true for the higher prices as near the middle of the regression line all the relative feeding values fall within the standard error of 6.1553. Since the high prices have been in the last 10 years, it is felt that during this period up to December of 1954 the actual prices have not reflected relative feeding values. According to the figure the livestock feeder could have paid a higher price for the linseed meal and still have the more economical feed.

Soybeans with Linseed Meal. Figure 6 shows the comparison relative feeding values and past price relationships between linseed meal and soybeans. According to the relative feeding values of soybeans and linseed meal (Fig. 7) linseed meal has been found to be at least equal to, if not better than, soybeans for feeding the different classes of livestock. The actual price relationships have not shown this to be true. Thus accordingly one could not economically feed his soybeans raised on the farm since linseed meal could be bought at a lower price relative to its feeding value.

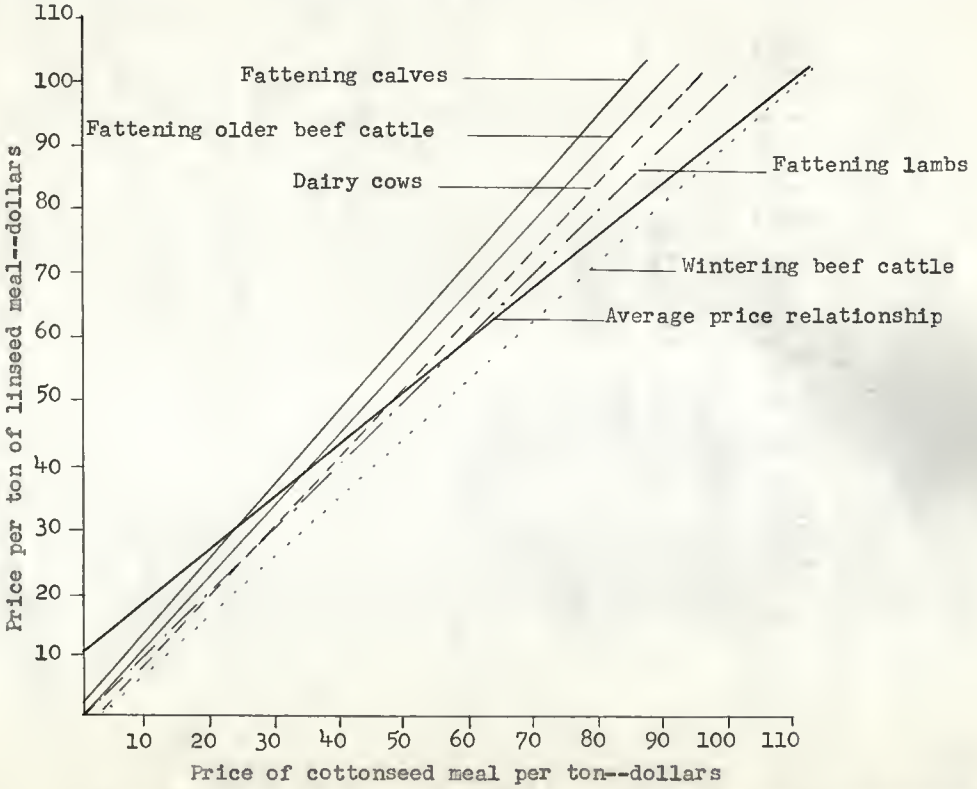

Fig. 5. Comparison of the relative feeding values for five classes of livestock and the average price relationship for linseed meal and cottonseed meal, 1932-1954.

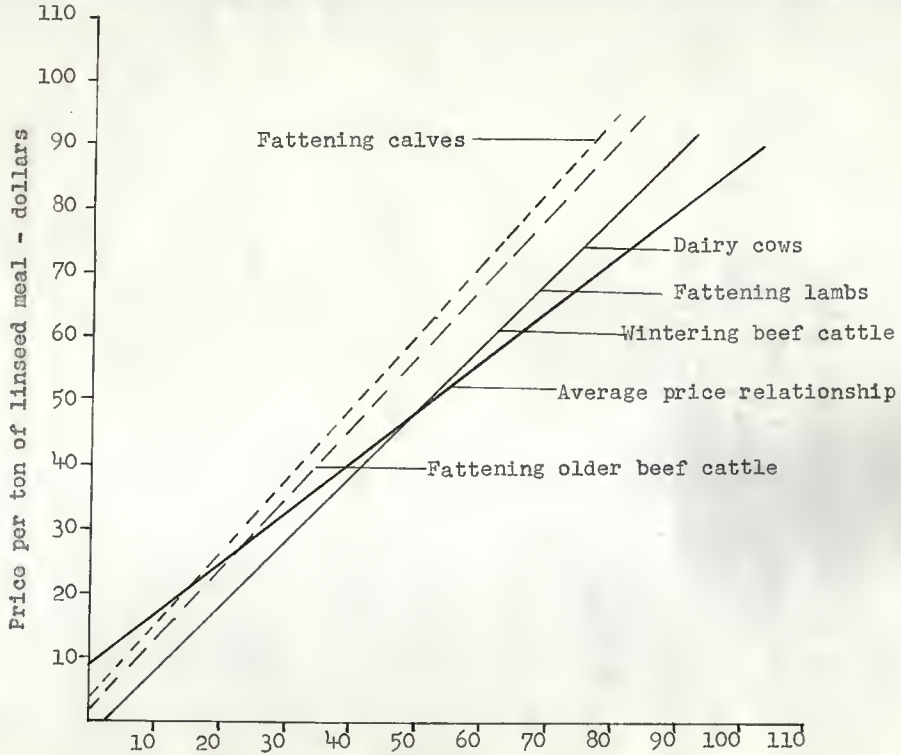

Fig. 6. Comparison of the relative feeding values for the five classes of livestock and the average price relationship between linseed meal and soybeans, 1932 to 1954.

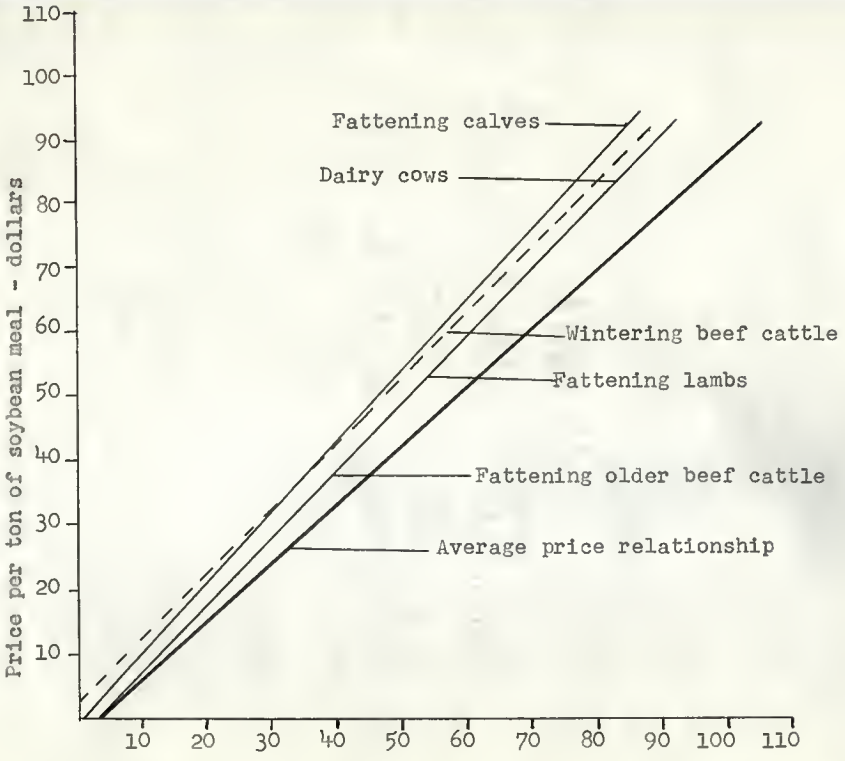

Fig. 7. Comparison of the relative feeding values for the five classes of livestock and the average price relationship between soybean meal and soybeans, 1932 to 1954.

Soybeans with Soybean Meal. Figure 7 shows the comparison between soybeans and soybean meal. In this case relative feeding values seem to show that a higher price could have been paid for soybean meal then for soybeans, than the actual price relationship denotes.

Soybeans with Cottonseed Meal. Figure 8 shows the comparison of the relative feeding values and the past price relationships between cottonseed meal and soybeans. Analysis shows that the soybean prices have been higher on the market than their relative feeding value has warranted.

Comparison of the Figures 6, 7 and 8 show that soybeans have been overpriced on the market in relation to their relative feeding value for the different classes of livestock. The actual reason seems to be that processors pay a higher price for soybeans because the oil contained in the beans has a relatively higher value. Thus an outside factor causes the price of soybeans to be out of proportion to their feeding value.

Determining the most Economical Supplement using the Different Methods of Evaluation

For 1949. It was felt that a random selection of one year should be made to determine if there has been any close relationship between the lowest cost supplement for each month by the use of the four different methods of protein supplement evaluation. Therefore the 23 years were arrayed and by the use of

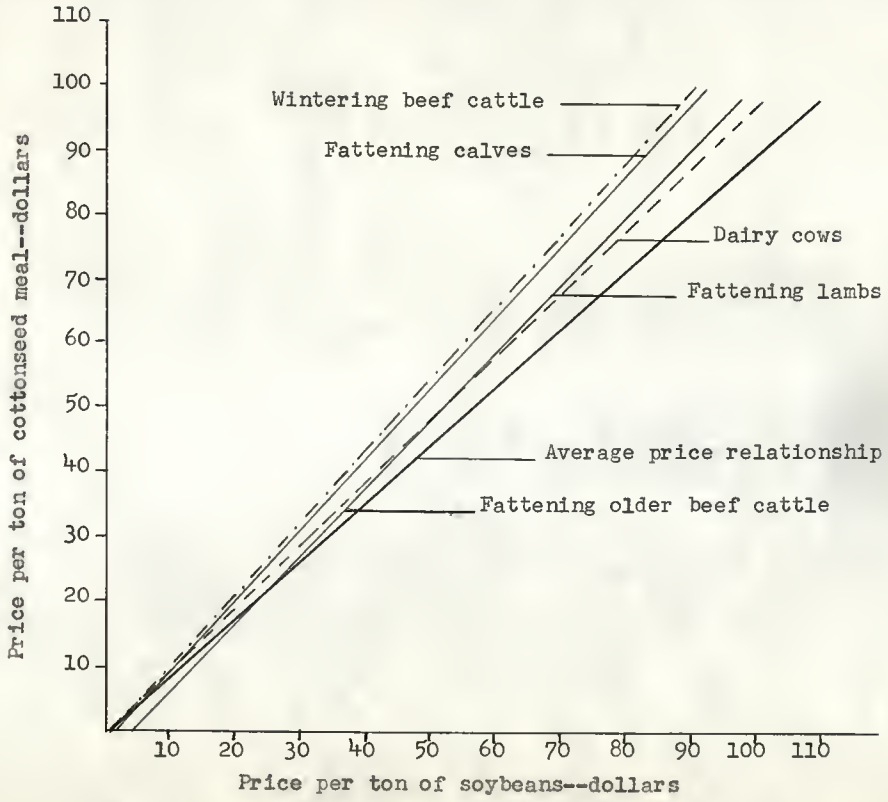

Fig. 8. Comparison of the relative feeding values for the five classes of livestock and the average price relationship between cottonseed meal and soybeans, 1932-1954.

a table of random numbers the particular year to be studied was selected. The sample year was selected by using a table of random numbers. This year which was selected was 1949.

Table 12 shows the average monthly prices of the four supplements for 1949. These prices have been used for computation of the least cost supplements using the different methods of protein supplement evaluation.

Tables 5 and 12 have been used to determine the most economical supplement for the different classes of livestock when the relative feeding value method has been used. The lowest cost supplements found by use of this method have been shown in Table 13.

Table 13 shows that there was a good deal of variability as to the most economical supplement for feeding to the five different classes of livestock during the months of 1949. In particular linseed meal was found to be most economical during 11 months of the year for fattening calves, and the most economical during 10 months of the year for fattening older steers.

The least cost supplements have been computed by use of the total protein method and the digestible protein method for the months of 1949. The results of this computation have been shown in Table 14.

Table 14 shows that at no time during 1949 was linseed meal found to be the least cost supplement when the digestible protein and total protein methods were used, as was the case when the relative feeding value method was used.

Table 12. Average monthly prices of the various supplements for 1949.[a]

Month	Dollars per ton 1949			
	Soybean meal	Linseed meal	Cottonseed meal	Soybeana
January	70.16	90.09	71.64	75.00
February	66.83	77.24	67.75	66.67
March	65.64	71.50	63.93	68.32
April	68.95	70.08	63.57	67.32
May	70.59	67.12	64.09	69.32
June	74.51	61.48	65.77	67.32
July	83.99	67.17	72.13	72.67
August	100.12	69.54	73.05	80.00
September	83.56	68.76	65.53	71.76
October	73.17	73.10	67.90	68.32
November	69.60	76.61	69.64	65.00
December	69.20	79.68	69.04	68.32

[a]Sources of these prices are Tables 7, 8, 9 and 10.

Table 13. The most economical supplement to buy by use of the relative feeding value method for the different classes of livestock for 1949.

Month	Fattening calves	Dairy cows	Fattening older steers	Fattening lambs	Wintering beef cattle
January	SBM	SBM	SBM	SBM	CSM
February	LSM	SBNS	SBNS	SBNS	CSM
March	LSM	SBM	LSM	CSM	CSM
April	LSM	CSM	LSM	CSM	CSM
May	LSM	LSM	LSM	CSM	CSM
June	LSM	LSM	LSM	LSM	CSM
July	LSM	LSM	LSM	LSM	CSM
August	LSM	LSM	LSM	LSM	CSM
September	LSM	LSM	LSM	CSM	CSM
October	LSM	SBNS	LSM	CSM	CSM
November	LSM	SBNS	LSM	SBNS	CSM
December	LSM	SBNS	LSM	SBNS	CSM

Table 14. The cheapest supplement by both the total protein and digestible protein methods of feed evaluation for 1949.

Month	Total protein	Cost (cents per lb.)	Digestible protein	Cost (cents per lb.)
January	SBM	.0855	SBM	.1018
February	SBM	.0815	SBM	.0970
March	CSM	.07796	CSM	.0939
April	CSM	.07752	CSM	.0933
May	CSM	.07815	CSM	.0942
June	CSM	.08021	CSM	.0966
July	CSM	.08797	CSM	.1059
August	CSM	.08908	CSM	.1073
September	CSM	.07991	CSM	.0962
October	CSM	.08280	CSM	.0990
November	SBM/CSM	.08483	SBNS	.0964
December	SBM	.08429	SBNS	.1137

Table 15 has been prepared to show the value of the four feeds as compared to soybean meal during 1949. Since the price of corn effects the value of the feeds when the Morrison constant method has been used, it was felt that any fluctuation which might have occurred in the price of corn should not be allowed to effect the value of the feeds. Therefore the price of corn was held constant at $1.50 a bushel in the computations.

Table 16 shows the comparison of the most economical supplement for fattening lambs by the use of the four different methods of protein supplement evaluation.

Analysis of Table 16 shows considerable agreement among the total protein, digestible protein, and the relative feeding value methods for fattening lambs, while the Morrison constant

Table 15. The value of the four feeds as compared to corn and soybean meal by use of the Morrison constant method for 1949.[a]

Linseed meal	Cottonseed meal	Soybeans	Soybean meal	Least cost supplement[b]
66.39	62.78	73.80	70.16	SBM
63.75	59.86	70.93	66.83	SBNS
62.81	58.81	69.91	65.64	SBNS
65.43	61.72	72.76	68.95	SBNS
66.73	63.16	74.17	70.59	SBNS
69.83	66.60	77.54	74.51	SBNS
77.34	74.92	85.71	83.99	SBNS
90.12	89.09	99.59	100.12	LSM
77.00	74.55	85.34	83.56	SBNS
68.77	65.42	76.39	73.17	SBNS
65.94	62.29	73.32	69.60	SBNS
65.63	61.94	72.97	69.20	SBNS

[a]Constants were taken from Table 1 and prices of the feeds from Table 12.

[b]The least cost supplement was determined by comparing the values in this table with the average monthly prices in Table 12.

Table 16. Comparison of four methods of protein supplement evaluation for fattening lambs using average monthly prices for 1949.

Month	Total protein	Digestible protein	Relative feeding values	Morrison constant
January	SBM	SBM	SBM	SBM
February	SBM	SBM	SBNS	SBNS
March	CSM	CSM	CSM	SBNS
April	CSM	CSM	CSM	SBNS
May	CSM	CSM	CSM	SBNS
June	CSM	CSM	CSM	SBNS
July	CSM	CSM	CSM	SBNS
August	CSM	CSM	CSM	LSM
September	CSM	CSM	CSM	SBNS
October	CSM	CSM	CSM	SBNS
November	CSM/SBM	SBNS	CSM	SBNS
December	SBM	SBNS	CSM	SBNS

method seems to show considerable disagreement with the other three methods.

Comparison of Table 16 with Table 13 shows that the relative feeding value method hardly compares at all with the other three methods for fattening calves, fattening older beef cattle and for feeding dairy cows. Results show that comparison of the relative feeding value method for wintering cattle with the total protein and digestible protein methods are somewhat similar, but for the Morrison constant method shows relatively little similarity. This situation seemed to warrant the study of another year's prices before making any definite conclusion as to the comparability of these four different methods of feed evaluation. Therefore 1954 prices were selected to be studied.

For 1954. Table 17 shows the average monthly prices of the four protein feeds for 1954.

Table 17. The average monthly prices of the various supplements for 1954.

Month	Cottonseed meal	Soybean meal	Linseed meal	Soybeans
January	77.65	82.18	81.58	88.26
February	75.86	86.24	81.61	91.32
March	77.21	93.50	80.47	100.32
April	79.35	103.37	89.06	109.00
May	77.31	99.50	89.78	112.32
June	75.24	98.17	74.56	105.00
July	79.76	103.38	70.66	106.66
August	84.46	97.71	70.36	96.66
September	76.74	79.48	72.00	78.32
October	78.47	76.49	74.30	82.00
November	80.18	77.78	76.97	84.66
December	80.95	78.50	79.27	83.70

Table 18 shows the cheapest supplement to feed to the five different classes of livestock when the relative feeding value method is used for prices occurring in 1954.

Table 18. The cheapest supplement during the months of 1954 when the relative feeding value method is used.

Month	Dairy cows	Beef calves	Older beef cattle	Wintering beef cattle	Lambs
January	LSM	LSM	LSM	CSM	CSM
February	CSM	LSM	LSM	CSM	CSM
March	LSM	LSM	LSM	CSM	CSM
April	CSM	LSM	LSM	CSM	CSM
May	CSM	LSM	LSM	CSM	CSM
June	LSM	LSM	LSM	CSM	LSM
July	LSM	LSM	LSM	CSM	LSM
August	LSM	LSM	LSM	LSM	LSM
September	LSM	LSM	LSM	CSM	LSM
October	LSM	LSM	LSM	CSM	LSM
November	LSM	LSM	LSM	CSM	LSM
December	SBM	LSM	LSM	CSM	SBM

Table 19 has been prepared to show the lowest cost supplement for the months of 1954 of the digestible protein method and the total protein method.

Analysis of Table 19 shows that only soybean meal and cottonseed meal were found to be the cheapest supplement by either the total protein method or the digestible protein method for the months of 1954. By making a comparison between these two methods and the relative feeding value method we can see if the results of this year's prices are similar to those for 1949.

Table 19. The cheapest supplement by both the digestible protein and total protein methods of feed evaluation for 1954.

Month	Total protein	Cost (cents per lb.)	Digestible protein	Cost (cents per lb.)
January	SBM	.0934	SBM	.1111
February	CSM	.0925	CSM	.1114
March	CSM	.0941	CSM	.1134
April	CSM	.0967	CSM	.1165
May	CSM	.0942	CSM	.1135
June	CSM	.0917	CSM	.1105
July	CSM	.0972	CSM	.1172
August	CSM	.1040	CSM	.1241
September	SBM	.0903	SBM	.1074
October	SBM	.0869	SBM	.1033
November	SBM	.0884	SBM	.1051
December	SBM	.0892	SBM	.1061

It was found, upon analyzing Table 18, that according to the relative feeding value method linseed meal was the cheapest feed for fattening lambs for six months out of the year of 1954. Only soybean meal and cottonseed meal were found to be the cheapest feeds when total protein or digestible protein methods were used as shown in Table 19. For this particular year the two protein content methods indicated that the same supplement was the cheapest for each month. If our hypothesis is correct, then there is something wrong with the other two methods. It is possible, since these two are in relative agreement for both 1949 and 1954, that the hypothesis is incorrect although it is a difficult problem to attempt to prove that animal feeding results are not the most accurate method of protein supplement evaluation. Before

any further statements can be made on this subject, there is another method of feed evaluation, the Morrison constant method, which has been compared to market prices.

Table 20 shows the value of cottonseed meal, linseed meal, and soybeans as compared to soybean meal when the Morrison constant method has been used to determine the value of the feeds. Soybean meal and corn have been used as the base feeds in this computation. It must be realized, when this method of evaluation is used, that the price of corn may have a profound effect in the determination of the cheapest feed. Thus not only is one concerned with fluctuation in the price of the protein feeds, but also with any fluctuation in the price of corn. It is felt that it would be advantageous to show what the cheapest feed would have been if the price of corn did not fluctuate during the year of 1954. Thus the corn price was held constant at a value of $1.50 per bushel in the computations made for Table 20.

Table 21 contains the supplements which were found to be most economical for fattening lambs during the months of 1954 by the four methods of protein supplement evaluation.

There is some disagreement between the four different methods of evaluation, but in the main they are very similar for fattening lambs. Would this be true for the other classes of livestock? To be able to answer this question, it becomes necessary to check only the relative feeding value method since the other three make no distinction between classes of livestock.

Table 20. The value of the various feeds using Morrison constant values for 1954.[a]

Cotton-seed meal	Soybean meal	Linseed meal	Soybeans	Least cost supplement[b]
73.33	82.18	75.91	84.15	SBM
75.72	86.24	79.12	87.64	SBM
83.27	93.50	84.87	93.89	CSM
91.94	103.37	92.69	102.39	CSM
88.54	99.50	89.62	99.06	CSM
87.37	98.17	88.57	97.91	LSM
91.95	103.38	92.70	102.40	LSM
86.97	97.71	88.21	97.52	LSM
70.96	79.48	73.77	81.82	SBNS
68.34	76.49	71.40	79.25	CSM
69.47	77.78	72.42	80.36	SBM
70.10	78.50	72.99	80.98	SBM

[a]Constants have been taken from Table 2.

[b]The least cost supplement was found by comparing the values shown in this table with the price of the feeds shown in Table 17.

Table 21. The cheapest supplement for fattening lambs during 1954, by four different methods of feed evaluation.[a]

Month	Digestible protein	Total protein	Relative feeding values	Morrison's constant
January	SBM	SBM	CSM	SBM
February	CSM	CSM	CSM	SBM
March	CSM	CSM	CSM	CSM
April	CSM	CSM	CSM	CSM
May	CSM	CSM	CSM	CSM
June	CSM	CSM	LSM	LSM
July	CSM	CSM	LSM	LSM
August	CSM	CSM	LSM	LSM
September	SBM	SBM	LSM	SBNS
October	SBM	SBM	LSM	CSM
November	SBM	SBM	LSM	SBM
December	SBM	SBM	SBM	SBM

[a]Summary of Tables 18, 19 and 20.

In comparison of Table 21 with Table 18 it can be seen that the relative feeding value method does not agree very well with the other three methods when they are used to determine the value of the various feeds for fattening calves and for fattening older beef steers. The relative feeding value method for dairy cows is more comparable with the other three methods, but still is not too satisfactory. For wintering cattle and fattening lambs the results are more similar.

It is not an economist's position to determine which of these methods is most accurate. This is the obligation of the animal nutritionist. Thus, an economist must, of necessity, use what the nutritionist finds and analyze prices accordingly. Thus, since some important nutritionists, such as Frank B. Morrison, have made the statement that results of animal experiments most accurately show the feeding value of the different feeds, it is felt that this method is more accurate than any of the others. Possibly one of the reasons is that this method distinguishes between the different classes of livestock while the digestible protein, the crude protein, and the Morrison constant methods are merely arithmetic computations using feed contents as the basis of the value (only lamb and steer rations have been used to determine the digestibility of the nutrients in the feeds).

The greatest variation between methods has occurred in the case of fattening beef cattle, both calves and older

animals. Reference is made here to the value found, in experiments, for linseed meal in relation to the other feeds. Linseed meal was found to be considerably more valuable on a pound basis than either cottonseed meal, soybean meal, or soybeans. The statement has been made in personal interviews with animal nutritionists that in many of the experiments more protein was supplied than necessary and that some factor contained by linseed meal other than protein caused cattle to which it was fed to have somewhat more glossy finish than cattle fed other supplements. Also if only sufficient protein was fed to balance the ration, linseed meal might not so greatly outproduce the other feeds. If this is true, further experimentation must be necessary.

It has also been stated, in reference to fattening lambs in particular and the other classes of livestock in general, that rations which contain legume hay cannot be used in accurate protein supplement comparisons. If this is true, than this accentuates the need for further experimentation in this field.

A Half Way Measure

In reference to the value of linseed meal for fattening cattle, one experiment station tends to hedge the difference between the crude protein method of evaluation and the relative feeding value method. In personal correspondence with

Prof. T. W. Perry of the Purdue (Indiana) Experiment Station, Prof. Perry makes the following statements:

> Actually it is rather hard to evaluate the comparative feeding value of linseed meal, cottonseed meal, or soybean meal as sources of protein supplement for fattening beef cattle. It has been our opinion that the three are interchangeable on a pound for pound basis under most beef cattle feeding conditions. I realize that the whole story is rather confusing because we list the protein requirements of cattle on the basis of pounds of actual protein or crude protein.
>
> Many showmen feel that linseed meal is superior to either of the two other oil meals due to the fact that it contains a 'bloom' production material. However, from a nutrition point of view I believe that I would rate the three as almost equal on a pound for pound basis.
>
> We have been recommending to cattle feeders that they buy protein supplements on a cost per pound of supplement--not on the cost of crude protein.[1]

Thus Prof. Perry seems to have come half way between the results of the two methods in making the above statements.

Using Prof. Perry's basis of comparison a table has been prepared which shows which supplement was the cheapest on the Kansas City market for the years 1932 to 1954. The supplement which was the cheapest in cost per pound of feed during each month of the 23 years is shown in Table 22.

Rather startling results were found when this comparison was made. It will be noted in Table 22 that certain supplements tended to have a period during the year when they were cheaper than the other feeds. This is more easily seen in Table 23. This table shows the percentage of times each

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[1]Personal correspondence with Prof. T. W. Perry.

Table 22. Lowest cost supplement on a pound basis, Kansas City, 1932-1954. Comparing cottonseed meal, linseed meal, and soybean meal.[a]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM
1933	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM
1934	CSM	CSM	CSM	CSM	CSM	CSM	SBM	SBM	SBM	SBM	SBM	SBM
1935	CSM	LSM	LSM	SBM	LSM	LSM	LSM	SBM	SBM	SBM	SBM	SBM
1936	SBM	SBM	SBM	SBM	SBM	SBM	CSM	CSM	CSM	CSM	CSM	CSM
1937	CSM	CSM	CSM	LSM	LSM	CSM	CSM	CSM	CSM	CSM	CSM	CSM
1938	CSM	CSM	CSM	SBM	CSM	CSM	SBM	SBM	CSM	SBM	SBM	SBM
1939	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM	CSM	SBM	CSM	CSM
1940	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM	SBM
1941	SBM	SBM	SBM	SBM	SBM	CSM	LSM	SBM	LSM	SBM	LSM	LSM
1942	CSM	CSM	CSM	CSM	CSM	SBM	LSM	LSM	LSM	CSM	CSM	SBM
1943	SBM	SBM	SBM	SBM	SBM	SBM	SBM	b	b	b	b	LSM
1944	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM
1945	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM
1946	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	SBM	SBM	SBM
1947	SBM	CSM	SBM	SBM	SBM	LSM	LSM	LSM	LSM	SBM	SBM	SBM
1948	CSM	SBM	SBM	LSM	LSM	LSM	LSM	CSM	LSM	SBM	SBM	SBM
1949	SBM	SBM	CSM	CSM	CSM	LSM	LSM	LSM	CSM	CSM	SBM	CSM
1950	SBM	SBM	CSM	CSM	CSM	CSM	LSM	LSM	LSM	SBM	LSM	LSM
1951	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	CSM	LSM	LSM	LSM
1952	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	LSM	SBM	SBM
1953	CSM	CSM	CSM	CSM	CSM	LSM	LSM	LSM	SBM	SBM	SBM	CSM
1954	CSM	CSM	CSM	CSM	CSM	LSM	LSM	LSM	LSM	LSM	LSM	SBM

[a]CSM is the abbreviation for cottonseed meal.
LSM is the abbreviation for linseed meal.
SBM is the abbreviation for soybean meal.

[b]The average soybean meal price and the average linseed meal price for these four months were the same.

Table 23. The percentage of times each supplement has been the cheapest by months, 1932 to 1954.

Meal	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Soybean meal	34.8	34.8	30.4	34.8	26.1	21.7	21.7	30.4	21.7	52.2	47.8	39.1
Cottonseed meal	43.5	39.1	43.5	34.8	39.1	30.4	17.4	21.7	34.8	26.1	26.1	30.4
Linseed meal	21.7	26.1	26.1	30.4	34.8	47.8	60.9	52.2	47.8	26.1	30.4	30.4

supplement has been the cheapest per pound for each month of the year for the 23 years of prices which have been used. It seems that linseed meal has tended to be lowest in price during the months of June, July, August, and September from 47 to 52 percent of the time. Soybean meal has tended to be lowest in cost during the months of October and November from 47 to 52 percent of the time. Cottonseed meal has tended to be cheapest in price during the spring of the year, although not in as great a proportion of the time as have the other two feeds during other periods of the year.

A much more outstanding relationship was found when only prices from 1940 to 1954 were used. When only prices for these years were used linseed meal was the cheapest supplement in cost per pound from 66 to 87 percent of the time during June, July, August, and September. This is shown in Table 24.

If Prof. Perry's basis of comparison is valid, it becomes a very simple thing to determine which feed to buy for fattening beef cattle. Some question can be made as to its validity as it seems to be merely a hedge which is used in lieu of the use of the conflicting results from other protein supplement evaluation methods.

It is felt, at the present time, that sufficient proof is not available as to which is the most accurate method of protein supplement evaluation. Therefore it is recommended that experiments be designed to provide nutritionists and economists with positive results so that the most accurate method can be identified.

Table 24. The percentage of times each supplement has been lowest in price by months for the years 1940-1954.

Meal	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Soybean meal	40.0	40.0	33.3	26.7	20.0	20.0	13.3	20.0	20.0	53.3	53.3	40.0
Cottonseed meal	26.7	26.7	33.3	33.3	33.3	13.3	00.0	06.7	13.3	13.3	06.7	13.3
Linseed meal	33.3	33.3	33.3	40.0	46.7	66.7	86.7	80.0	73.3	40.0	46.7	46.7

As soon as further experiments have been conducted and the most accurate method of evaluation has been determined then methods of long-run planning can be utilized. Such methods as an index of seasonal variation can be used at the present time but their reliability is effected by the method of evaluation which is used.

The Index of Seasonal Variation

An index of seasonal variation is a statistical measure defined as a tool which shows the month to month change in a time series that is due to the season of the year.[1] That is, all effects of trend and cycle have been removed and only the effects of the season or time of the year effect the series of prices. The seasonal high and low periods of the year can be used as choice indicators in selecting the most economical feed during the different months of the year. The seasonal index is one means of solving the problem of when the average low price has occurred during the year. This index is, however, only an average. Therefore it is not safe to rely entirely upon the seasonal for price forecasting. It is important to know just how often the seasonal price change has occurred. With the seasonal index and the relative frequency of the seasonal occurance, one has the tools necessary for use in long-run planning.

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[1]Blair, Morris and Myers, Elementary Statistics, p. 443.

Amplitude of seasonal variation is the range from the lowest to the highest month.[1] The greater the amplitude of a seasonal the greater the tendency for the seasonal to react in its average way. This is true providing the index of irregularity is not overly large. An index of irregularity is described as the average deviation, disregarding plus or minus signs, from the seasonal.

An index of seasonal variation has been computed for each of the four major plant protein supplements, linseed meal, soybean meal, cottonseed meal, and soybeans, for the years 1932 to 1954. These seasonals show the average change which has occurred during this period from month to month during the year. The index of irregularity has been computed for each of the seasonals showing the average deviation from the index. The seasonal index for soybeans shows much more aplitude than do the seasonals for any of the other feeds. Thus it is felt that a livestock feeder can rely more on the soybean seasonal index than on any of the others.

Table 25 shows the seasonal indexes and the indexes of irregularity for the four feeds for the 23 years of prices which were studied. This table also shows the seasonals for the same feeds for the years 1948 to 1954. These seasonals were prepared to determine if there had been any change in seasonal price increases and decreases since the war. Except for soybeans, the seasonals were more pronounced for this

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[1] Blair, Morris and Myers, op. cit., p.444.

Table 25. Indexes of seasonal variation and indexes of irregularity from the seasonal for soybean, linseed, cottonseed meals, and soybeans, for 1932 to 1954 and for 1948 to 1954.

S = Index D = Deviation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932 to 1954												
S Soybean meal	99.7	97.4	95.5	96.2	98.2	98.4	103.9	104.4	104.1	99.2	101.6	101.4
D " "	6.9	6.1	5.9	6.4	6.9	6.3	9.7	10.4	8.0	5.7	6.1	5.0
S Cottonseed meal	100.6	97.2	96.9	97.1	96.9	96.5	104.2	103.4	99.5	99.6	102.8	103.3
D " "	5.2	5.6	5.3	6.8	6.6	4.3	9.2	8.9	7.9	4.8	5.4	4.8
S Linseed meal	106.0	101.6	98.2	98.1	97.1	94.2	97.8	99.4	99.2	100.8	102.9	104.9
D " "	6.3	5.2	5.2	5.8	6.6	5.2	8.4	8.0	7.3	5.6	4.8	5.1
S Soybeans	94.1	95.2	99.1	104.7	109.4	111.1	110.6	104.1	99.2	89.5	90.6	92.5
D "	8.9	7.1	7.5	6.9	7.5	10.6	11.7	8.6	9.3	9.2	10.0	8.5
1948 to 1954												
S Soybean meal	97.0	93.9	94.8	98.3	101.5	104.0	108.9	106.3	104.0	95.2	97.2	99.0
D " "	6.3	5.3	5.7	5.2	6.0	5.1	7.5	9.0	6.3	8.9	6.6	3.8
S Cottonseed meal	98.8	97.5	96.7	97.2	97.2	97.2	105.9	102.4	98.9	99.6	102.8	105.8
D " "	4.6	4.6	5.5	6.9	5.5	2.1	5.7	8.3	7.0	3.2	4.8	2.9
S Linseed meal	107.5	103.1	100.9	101.7	100.3	93.1	94.4	96.7	96.8	97.6	101.3	106.5
D " "	5.5	3.0	3.2	5.9	7.2	5.5	4.1	3.1	4.1	5.6	4.9	5.4
S Soybeans	98.3	98.1	102.6	105.7	106.7	104.7	105.7	100.6	93.1	90.1	95.8	98.4
D "	3.7	6.3	6.1	6.7	7.3	5.3	7.9	7.4	6.9	7.2	2.7	3.4

shorter period. Also the index of irregularity for each of the feeds tended to be smaller for the shorter period than for the full 23 years. This seems to show that there has been a greater tendency for prices to increase or decrease in the same fashion year after year.

CONCLUSIONS

From a thorough study of these four methods of protein supplement evaluation, it has been noted that it was an extremely difficult problem to determine the most accurate or valuable method. This was true primarily for the simple reason that animal nutritionists themselves have not agreed and do not agree at the present time as to which is the most valid method.

Insufficient data was found to enable one to prove or disprove the hypothesis presented in the Introduction. Therefore it is felt to be true that the use of actual experiments conducted by experiment stations provide the most accurate basis for determination of relative feeding values of these four protein feeds for the different classes of livestock.

Table 26 has been presented as the principle conclusion of this study. This table is a reproduction of Table 5 shown in the body of this thesis.

The relative feeding values presented in Table 26 show only approximated values, since no attempt has been made to

Table 26. The relative feeding values of four major plant protein supplements for feeding certain classes of livestock.

Supplement	Dairy cattle	Older beef steers	Beef calves	Lambs[a]	Wintering beef steers
Soybean meal	100	100	100	100	100
Linseed meal	100	115	120	100	95
Cottonseed meal	95	100	100	100	105
Soybeans	100	100	90	100	95

[a]These relative feeding values for fattening lambs are valid when legume hay is fed in the ration.

average experimental results. Therefore the summary figures shown have been presented as being as near as possible to the actual relative value of the fesds for the five different classes of livestock. These relative feeding values are felt to be as accurate as the experimental results themselves.

A further conclusion of the study has been that there are certain inconsistencies in the experimental results. A number of contradictions have been found, some of these of a type which cannot be true. It has been concluded that further experiments should be conducted in order to substantiate the previous results and to clarify those situations where conflicting results have been found.

Future experiments should be designed to allow accurate statistical computation of relative feeding values.

The purpose of this study was to provide an accurate and simple method of determination of the most economical supplement to purchase at any particular time. This has been done by the presentation of protein supplement substitution scales derived from Table 26. These scales have been computed from the relative feeding values shown in this table and are based on the feeding experiments presented in the review of literature of this thesis. They can be used to determine the protein supplement of least cost in accordance with its feeding value. It is assumed that these supplements will be of average quality, will be fed in recommended amounts, and will be used to supplement an otherwise balanced ration. These scales are shown on the following five pages.

Under most conditions, one of the protein supplements will be lower in price relative to its feeding value than any other supplement. These scales were developed to assist livestock producers in deciding which protein supplement is the lowest in price relative to its feeding value.

The following illustrations explain how to use the scales. Suppose you are feeding calves on a full feeding ration and you are going to buy a protein supplement to supply the amount of protein which is needed to balance the ration. You know that you can buy soybean meal for 60 dollars per ton, and that you can purchase linseed meal at 64 dollars per ton. The following steps explain how to use the scales.

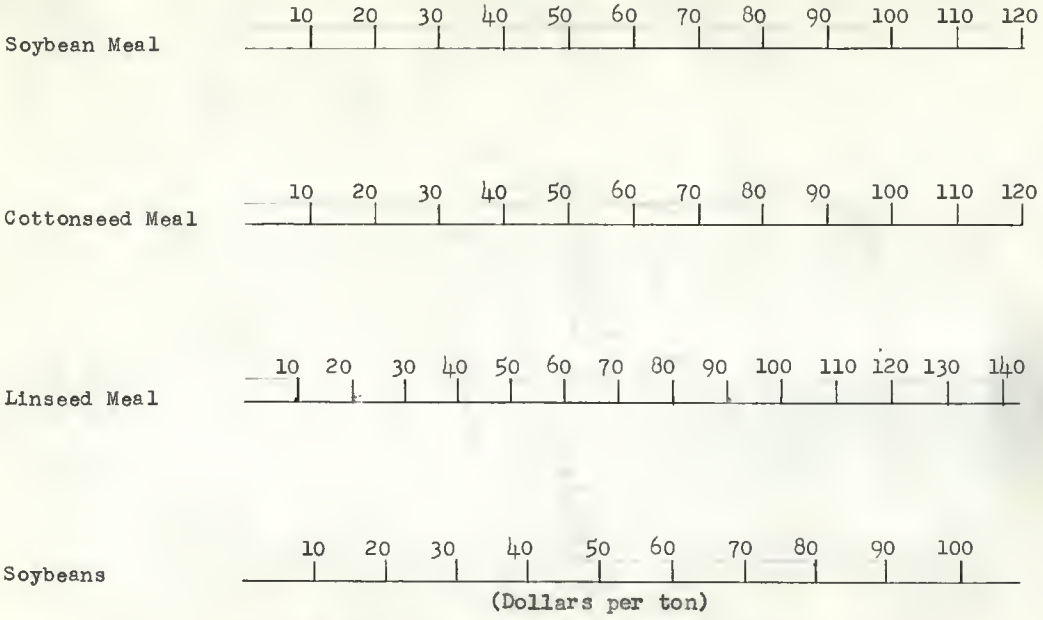

Fig. 9. Use this scale for fattening beef calves.

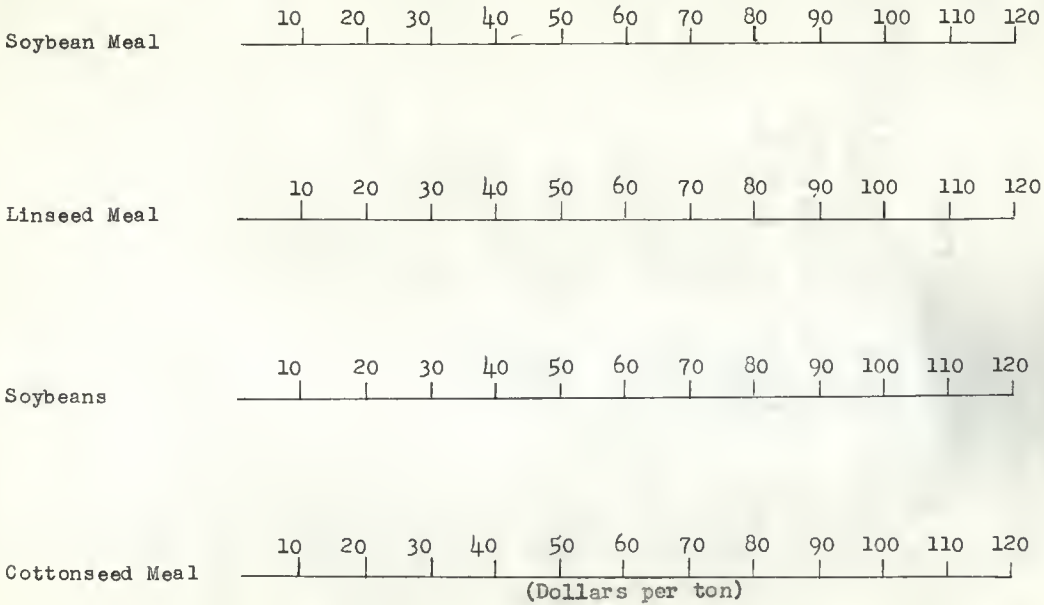

Fig. 10. Use this scale for fattening lambs.

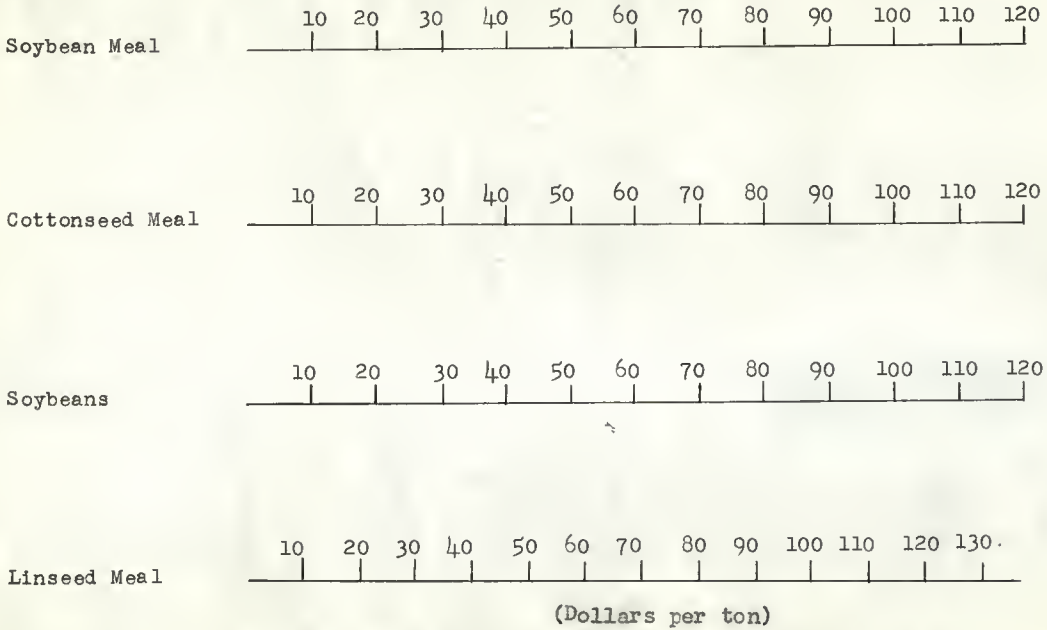

Fig. 11. Use this scale for fattening yearling and two year old beef cattle

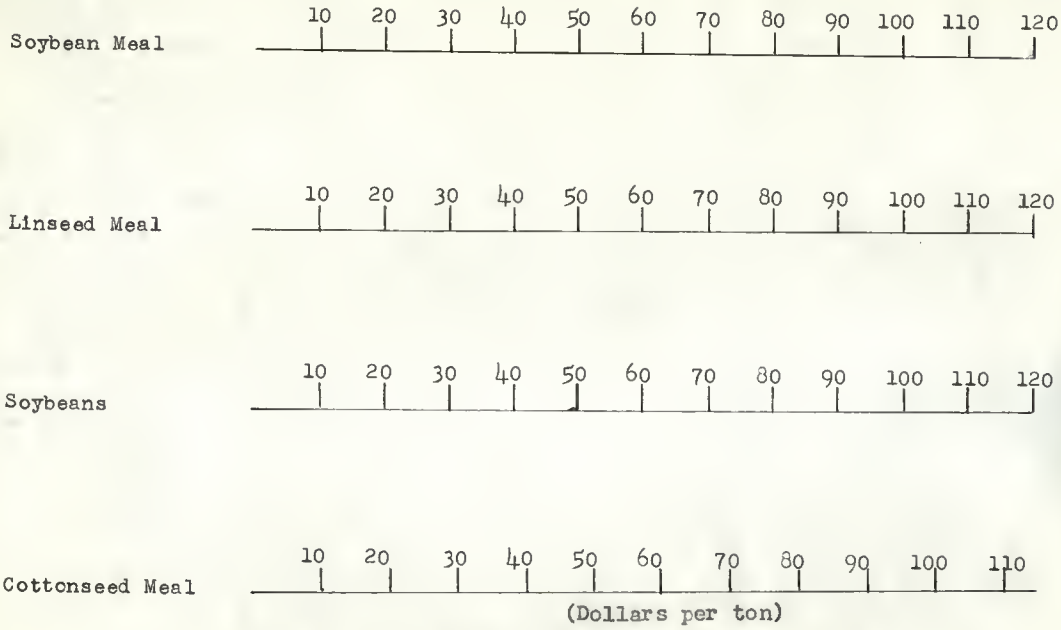

Fig. 12. Use this scale for feeding dairy cows.

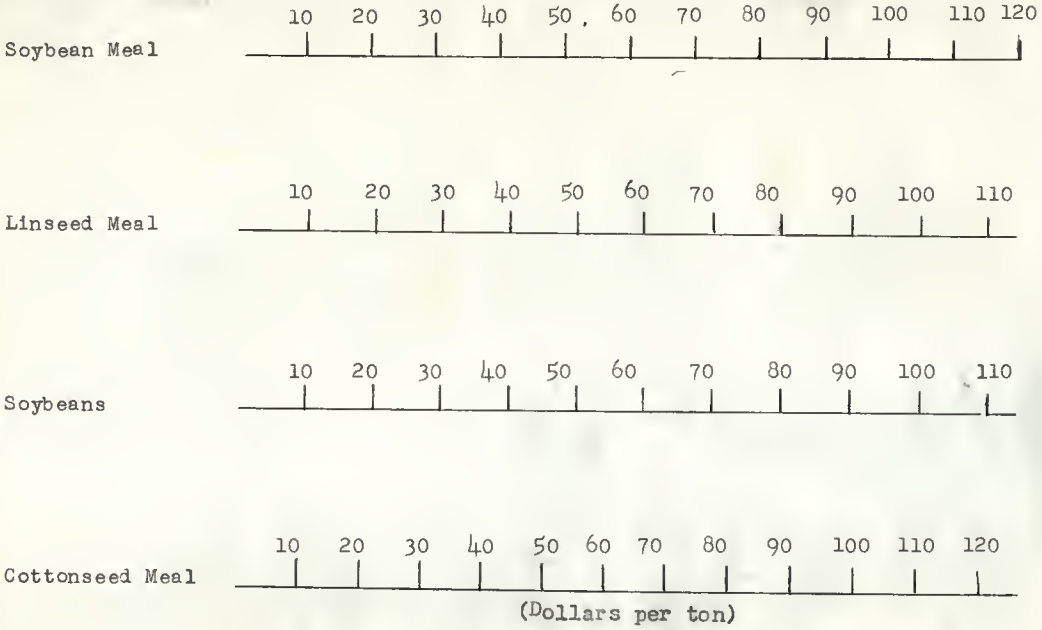

Fig. 13. Use this scale for wintering beef cattle.

First, find the scale for fattening calves on page 99 and then read over on the soybean meal line to $60 per ton.

Second, place a ruler or a straight edge verticle to this line so the price on the linseed meal line can be read. This is about $72 per ton.

This means that linseed meal is worth $72 per ton when soybean meal is worth $60 per ton. In this example with linseed meal selling for $64 per hundred pounds it would be much more economical to feed the linseed meal than the soybean meal. This same procedure may be followed when comparing prices of other protein supplements or when feeding other classes of livestock.[1]

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[1]Portions of the wording and method shown above were adapted from: Leonard W. Schruben, and R. E. Clifton, Grain Substitution in Feeding Livestock, Kansas Experiment Station Circular No. 299.

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EVALUATION OF PROTEIN SUPPLEMENTS

by

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Feeds have been classified by animal nutritionists into three main groups. They are roughages, concentrates, and roots. A part of the group known as concentrates are to be discussed in this paper. The concentrate feeds concerned are classified as high protein feeds or protein supplements. These protein supplements are soybean oil meal, linseed oil meal, cottonseed oil meal and soybeans. A protein supplement has been defined as a feed which is added to the livestock ration for the sole purpose of adding the nutrient protein.

The problem facing the livestock feeder is the determination of which supplement is most economical to buy and feed. It has been shown that most farm rations need some supplementary protein to balance the ration. Under average conditions the farm livestock ration made up entirely of farm raised feeds does not contain sufficient protein for maximum growth or for economic production, therefore, to balance the ration most livestock feeders must purchase protein.

Protein supplements are normally much higher in price than roughages, roots, or grains. Because of this higher price, even though only small amounts are normally fed, they make up a rather sizable portion of the cost of the ration. Since protein supplement purchases amount to a fairly large expense to the feeder, it is important to select the most economical feed. Thus a need is shown for the development of a choice indicator since these feeds are not all of equal feeding value and they seldom sell for the same price. Any one particular supplement may be worth more for one type of

livestock than for another. The classification of these various protein supplements, according to their value for the different species of livestock, is an important problem which is to be discussed.

The general purpose of this thesis is to review a number of previously expounded methods of comparison in order to examine their value as guides to more economical feed buying.

A number of noted animal nutritionists have stated that the most accurate method of feed evaluation is one which uses actual results of experiments with the different types of livestock. Therefore the hypothesis which has been presented is: The use of actual experiments conducted by experiment stations provide us with a method of feed evaluation which is most accurate due to its closer relationship to actual farm feeding conditions. It distinguishes between the different classes of livestock, thus making it more specific than other methods.

Thus a more specific purpose is to determine the most accurate method of protein supplement evaluation and to propose relative feeding values in a simple form which can be used by livestock feeders in more economical feed buying.

Once the decision has been made as to which of the methods proposed is most accurate, it then becomes necessary to use this method in comparison with actual market prices to determine its accuracy for future use by livestock feeders. The relative feeding values proposed plus the relative prices will then

provide the tools neceseary for decision making relative to which supplement is most economical at any particular time for any particular class of livestock.

The ecope of this paper includes only the determination of the relative feeding value of the various feeds for ruminant animals. In particular thoee are dairy cows, fattening yearling and two year old beef cattle, fattening beef calves, wintering beef cattle, and fattening sheep.

There are a number of methode of prctein supplement evaluation which have been used. These are the total crude protein method, the digestible protein method, the Morrieon constant method, and the relative feeding value method.

The total crude protein method constitutes buying the feed with the lowest cost per pound of total protein contained in the supplement. Thie method is relatively simple and easily computed but it does not take into account the amount of the protein in a feed which can be utilized by the animal.

The total digestible protein method constitutes buying the feed with the lowest cost per pound of digestible protein contained in the eupplement. The amount of digestible protein in the different feeds has been found by digeetion trials and have been reported ae digeetion coefficients. These digestion coefficients are multiplied by the amount of total protein in a feed to determine the amount of digestible protein it contains.

The digeetion coefficients were determined by experiments with feeding beef animals and lambs, and the valuee have been

assumed to be the same for other classes of livestock. Thie aesumption may not necessarily be true.

The Morrison constant method takes into account the other factors in a feed besides its protein content. Thus both digestible protein content and net energy values havo beon ueed for this arithmetic computation of feeding values. This method uses the digestible protein content and net energy value of corn and eoybean meal which have been used as the baee feede. The value of other feede are related to their respective digeetible protein and net energy values in relation to a high energy value feed euch ae corn and a high protein value feed euch as eoybean meal. Constant valuee were determined by Prof. Morrieon of the Cornell Experiment Station for all important feeds in the United Statee.

Theee above methode are more or lees arithmetic computatione and although they may have their value, there is a fourth important method of evaluation which ueee actual experimental reeults of comparieone of protein eupplemente for the different claesee of livestock.

Thie fourth method has been called the Relative Feeding Value Method. Experimente comparing the four eupplemente were reviewed for five different clasees of livestock. From this review of literature a table was prepared which ehowe the approximate value of each of the eupplements when soybean meal hae been ueed ae the baee feed.

Table 5. The relative feeding values of four major plant protein supplements for feeding certain classes of livestock.

Supplement	Dairy cattle	Older beef steers	Beef calves	Lambs[a]	Wintering beef steers
Soybean meal	100	100	100	100	100
Linseed meal	100	115	120	100	95
Cottonseed meal	95	100	100	100	105
Soybeans	100	100	90	100	95

[a]These relative feeding values for fattening lambs are valid when legume hay is fed in the ration.

The values shown in this table are only approximates since no attempt has been made to average the experimental results. An average of experimental results would possibly provide a more accurate figure. But this averaging can only be done if all experimental results have shown the same tendency. This has not been found to be true. Therefore, the summary figures shown in the table have been presented as being as near as possible to the actual relative value of the feeds for the five different classes of livestock.

The relative feeding values have been compared with the average price relationships between each of the two feeds for the period 1932 to 1954. The purpose of this comparison was to determine whether prices on the market had reflected the relative feeding value of the different feeds.

Results have shown that in general prices have not reflected the relative feeding value except for the comparison of soybean

meal and cottonseed meal. Linseed meal comparisons with both soybean meal and cottonseed meal have shown that prices of linseed meal were somewhat lower than the relative feeding values indicated. This tends to show that feeders were using protein content as the basis for protein supplement purchasing.

Comparisons of all three protein meals with soybeans showed the price of soybeans was normally higher than their relative feeding value indicated. The reason for this situation was felt to be due to the value of the oil contained in the beans.

Computation of the least cost supplement was made for each month of the two years 1949 and 1954. The least cost supplement was computed by the four different methods of evaluation for each of the five classes of livestock. Since only the relative feeding value method shows a separate result for the different classes of livestock, the other three methods produced the same least cost feed for each type of livestock.

The prices used were the monthly high and low average of daily prices on the Kansas City market for soybean meal, linseed meal, and cottonseed meal. For soybeans the average monthly prices received by farmers in Kansas were used.

The computations have shown that for certain classes of livestock similar results were obtained by all four methods of evaluation. For other classes of livestock this has not necessarily been true. Computations for fattening lambs have shown greater similarity by use of the four different methods, than they have for fattening both calves and older beef cattle.

The conclusion of this study has been that while each of the methods have some validity, there has been no general agreement by animal nutritionists as to the one specific method which has been most accurate. One of the noted authorities, in particular Frank B. Morrison, makes the statement that use of actual experimental results shows most accurately the value of a feed for a particular class of livestock. This relative feeding value method is based on actual feeding experiments and therefore if the experiments have been accurate, should provide the most accurate basis of feed evaluation.

Thus it has determined that this method should provide for more economical feed buying than any of the other three, since they do not distinguish between livestock classes. Therefore, it has been recommended that the relative feeding value method of protein supplement evaluation should be used in determining the least cost and most economical feed for any of the five classes of livestock.

Conflicting results have been found in examination of feeding experiments. It has been recommended that further experiments be conducted with the major protein supplements to substantiate the previous experimental results to reduce the indecision which can and has occurred due to these contradictory results.

Protein supplement substitution scales were produced from the table on relative feeding values. By the use of these scales the livestock producer can easily determine the most economical feed for his specific livestock program at any particular time.