Dehydrated Sugar Beet Leaves as a Feedstuff[1]

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Concomitant with the development and use of successful mechanical sugar beet harvesters there is a growing interest in the more efficient use of beet tops. The sugar beet industry needs more adequate information as to the most economical and effective means of utilizing this valuable by-product under various conditions. A number of workers in this country and abroad have demonstrated adequately the value of sugar beet tops as a feedstuff for ruminants. But a survey by the Beet Sugar Development Foundation (1),[6] covering 67 percent of the sugar beet acreage in 1946, shows that approximately 48 percent of the tops were left in the field for plowing under or for pasturing, approximately 46 percent were windrowed or stacked, presumably for feeding, 5 percent were fed green, and 1 percent were siloed.

It is probable that tops left in the field lose considerable nutritive value, especially carotene and to a lesser extent protein, before pasturing or feeding (2). Furthermore, much of the leafy portion, which makes up approximately 60 percent of the dried weight of the tops, is lost by shattering or trampling (3). The leaves contain most of the protein and vitamin content.

Ensiling will preserve much of the original value (2,3,4). Artificial dehydration should preserve most of the original value and provide a form of product which is easy to handle and to store. Some interest has been shown by alfalfa processors and by commercial feed manufacturers in dehydrated sugar beet leaves. Manufacturers of sugar beet harvesting machinery are vitally interested in knowing what uses will be made of tops and whether leaves will be harvested separately, since this affects the development of topping attachments on the harvester.

With these problems in mind, the Colorado Agricultural Experiment Station has initiated a project with the support of the Beet Sugar Development Foundation which has the following objectives:

1. The study the factors involved in the harvesting and dehydration of sugar beet leaves. This will include studies of the types of machinery required, comparison of products with and without the crowns, proper time of removal of leaves and effects on yield and sugar content of roots, methods and costs of dehydration, and removal of soil contamination.

2. To study the values and uses of the product, including variability of products from different areas. This phase will include determinations

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of chemical and nutritional composition, feeding value, loss of plant nutrients from the soil, and economic evaluation of the product.

3. To compare the dehydration of beet leaves from an economic standpoint with other practices of beet-top utilization, such as pasturing of beet tops, feeding of beet-top silage, and feeding of dried beet tops, with the purpose of conserving the high nutrient values in commercial application and of conserving the soil.

This paper is a preliminary report of the initial progress on this project. Because artificial dehydration appeared to be the most effective means of preserving nutritive value of beet tops, the initial approach to this project was planned to ascertain if the yields per acre, nutrient analyses, and results of feeding trials would justify a more complete investigation.

Procedures and Results

Yields per Acre.—Data were obtained from two fertilizer experiments to ascertain the effect of levels of fertility on yield and composition of tops. Experiment 3A consists of the same plots reported in these Proceedings by Whitney (5) utilizing land leveled into the subsoil. The plot treatments were set up with five replicates in the Latin-square design. This permitted statistical analysis of results to ascertain the least significant differences at the 5 percent and 1 percent levels. The tops from 20 beets were taken off each replicate. The leaves were immediately separated from the crowns by severing the stems about 2 inches above the crown in order to similate the action of a mower cuttingbar. Some low-lying leaves were thus left with the crown. Fresh weights of leaves and crowns were obtained separately. The samples were placed in an insulated box with dry ice. They were then removed to a freezing room. Each sample was reduced by careful sampling to one-half size, was finely ground in a food chopper, was remixed thoroughly, and was sampled for carotene assays immediately while frozen. A large aliquot was stored at 2 degrees centigrade for moisture and proximate analysis. Yields per acre were calculated by using an average population or stand count.

Experiment W47 consisted of a carefully selected field on which the various fertilizer applications were made on long strips of approximately 2 acres each. Two samples of tops from 20 beets were taken in the center of each plot, locations being one-third and two-thirds the distance from one end. Weighing and handling of each sample were the same as in experiment 3A.

The treatments and yields in experiment 3A are presented in table 1. The data for tops is that for leaves and crowns combined in the original proportions. Since the land had been leveled to the subsoil, the yields on the control plots were low. Phosphate alone did not improve yields. Nitrogen addition resulted in highly significant increases. The further addition of potash had no effect. The residual effect of manure was sufficient to provide significant increases in yields but not as great as in the case of the nitrogen application. There was a tendency for more succulent or moist growth on the plots receiving manure and nitrogen, the latter being accentuated by potash addition. There were no significant differences in the proportion of leaves to total tops but the proportion of tops to roots was increased by nitrogen applications. Harvest data by Whitney (5) showed yields of tops on these same plots about half of those reported here. This discrepancy might be explained in part by the fact that Whitney's data were based on salvage of tops following mechanical harvesting of the roots.

Table 2 shows the treatment and results obtained in experiment W47. Increments in nitrogen fertilization showed increments in top yields. Again, the dry-matter percentage in the tops decreased with increasing nitrogen application. Additional phosphate showed no effects on top yields. The proportion of leaves to tops and tops to roots increased as nitrogen additions were increased.

It is obvious that the yields of leaves and of total tops, expressed on the green or on the dry-matter basis, were sufficiently great as to yield important quantities of material when adequate nitrogen is present in the soil.

In removing leaves or tops for processing, it would be advantageous at times for the processor to remove them sometime previous to the harvesting of the roots. Therefore, the effects of removing the leaves 2 inches above the crown and of topping the beets on the sugar content of the roots at definite intervals following such removals were made. The results of two such studies, one starting September 18, 1947, and the other starting October 9, 1947, are graphically presented in figure 1. It is obvious that roots must be harvested within 24 hours after leaves or tops are removed, if a decline in sugar content in the roots is to be avoided.

FIGURE 1

EFFECT OF REMOVAL OF LEAVES & TOPS ON SUGAR CONTENT OF ROOTS

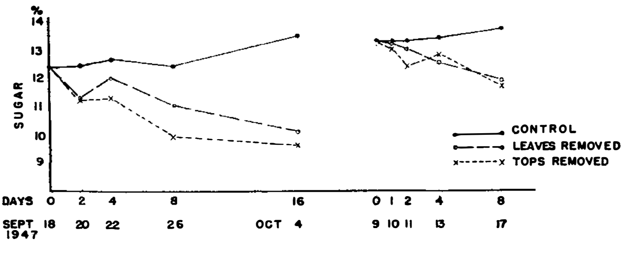

Table 1.—Experiment 3A—Effects of fertilizer treatments on yields of leaves and tops.

Treatment[1] per acre basis	Leaves			Tops			Leaves/Tops	Tops/Roots
	Fresh	Dry	Dry Matter	Fresh	Dry	Dry Matter		
	Tons	Tons	Percent	Tons	Tons	Percent	Percent	Percent
1. None	8.2	1.0	14.4	12.2	1.6	15.2	64	149
2. Manure, 27 tons[2]	13.6	1.7	13.0	20.6	2.8	13.9	62	124
3. TSP, 300	7.4	1.0	15.3	11.6	1.8	16.7	58	96
4. TSP, 300; AN, 262	23.2	2.8	11.9	34.7	4.3	12.4	65	186
5. TSP, 300, AN 262; KS, 523	23.8	2.5	10.7	34.9	4.1	11.9	61	178
L.S.D. at 5 percent	2.5	0.3	1.8	2.8	0.4	1.9		
L.S.D. at 1 percent	3.4	0.5	2.5	3.8	0.5	2.6		

[1]TSP, treble superphosphate; AN, ammonium nitrate; KS, potassium sulfate, in pounds.
[2]Applied the previous crop year.

Table 2.—Experiment W47—Effects of fertilizer treatments on yields of leaves and tops.

	Treatment[1]		Leaves			Tops			Leaves/Tops	Tops/Roots
	11-46-0	AN	Fresh	Dry	Dry Matter	Fresh	Dry	Dry Matter		
	lbs./A	lbs./A	Tons	Tons	Percent	Tons	Tons	Percent	Percent	Percent
1.	65	---	4.0	0.6	13.9	7.7	1.2	16.1	44	59
2.	65	240	7.5	1.1	14.1	12.4	1.7	14.1	61	78
3.	65	480	11.1	1.5	13.2	18.6	2.5	13.6	58	107
4.	65	720	15.6	2.1	13.2	24.0	3.1	12.9	67	153
5.	215	200	8.7	1:1	12.4	14.0	1.9	13.2	58	92
6. plus TSP, 1250	215	200	8.7	1.2	13.2	13.9	2.0	14.6	57	90

[1]AN, ammonium nitrate; TSP, treble superphosphate.

Composition of Tops.—A. *Fertilizer trials.*—Proximate analyses for crude protein and ash were done on the samples from each plot in the usual manner. Soluble ash was obtained by treating the total ash with hot 10 percent hydrochloric acid and filtering. The residue was dried and weighed to obtain the insoluble ash. This represents very crudely the contamination with dirt, hence the soluble ash more nearly represents the true inherent ash content of samples.

Analyses for carotene were done by a modification of the method described by Charkey and Wilgus (6). Riboflavin assays were conducted according to the method of Roberts and Snell (7).

The results of analyses in experiment 3A are given in table 3. Crude protein contents of both leaves and tops were increased to a highly significant degree by nitrogen additions to the soil but not by the residual effect of manure or by additions of phosphate or potash. Soluble ash contents were unaffected by manure or potash, were increased significantly by phosphate alone, but were decreased significantly by the addition of nitrogen in addition to the phosphate. Carotene and riboflavin contents were so variable within samples and between samples as to render any differences in the average results of questionable significance.

The crude protein analyses of the leaves and tops in experiment W47, table 4, did not show any consistent trend, although those of the tops without nitrogen addition were somewhat lower. As in experiment 3A, the soluble ash was depressed by nitrogen additions to the soil and was increased by phosphate additions (lots 5 and 6). Again, there were wide and evidently independent variations in carotene content.

B. *Dehydrated samples.*—Samples of dehydrated sugar beet leaf meal were obtained from commercial alfalfa dehydrating plants. One processed in 1945 was from a Nebraska source. Another processed in 1946 was from a Minnesota processor. In both instances the material was chopped and then dehydrated in a commercial dehydrator commonly used for alfalfa.

In 1947, two loads each of fresh beet leaves and of fresh beet tops were dehydrated by a near-by alfalfa processor. The former were cut and chopped with a field chopper and dehydrated after about 8 hours accidental delay between harvesting and drying. Owing to the low temperature in the dehydrator, it was necessary to complete the drying of the material in a barn loft. The tops were of low quality and dirty. They were chopped in a hammermill equipped with a 4-inch square screen and no blower. The material was finely pulped, the result of reducing the crowns to the degree necessary for drying. Both products were abnormally brown. Complete analyses have not been completed but the crude protein content of the leaf meal was 12.2 percent and that of the top meal was 8.1 percent.

A comparison of the analyses of the 1945 and 1946 meals with the average analysis of other meals is given in table 5.

Table 3.—Experiment 3A—Effects of fertilizer treatments on composition of leaves and tops.

Treatment[1] per acre basis	Leaves, dry-matter basis					Tops, dry-matter basis				
	Crude protein	Ash[2] Total	Ash[2] Soluble	Carotene	Riboflavin	Crude protein	Ash[2] Total	Ash[2] Soluble	Carotene	Riboflavin
	percent	percent	percent	mg./kg.	mg./kg.	percent	percent	percent	mg./kg.	mg./kg.
1. None	15.7	17.7	15.4	262	14.6	14.0	19.9	14.6	196	12.5
2. Manure, 27 tons[3]	15.9	16.0	14.7	233	13.0	13.8	17.6	14.4	176	11.6
3. TSP, 300	13.8	19.5	16.8	222	13.4	12.2	22.9	16.1	154	11.4
4. TSP, 300; AN, 262	19.5	13.7	13.2	314	14.9	17.8	15.5	13.6	231	13.0
5. TSP, 300; AN, 262; KS, 523	21.5	14.9	14.2	263	13.4	18.4	16.0	13.7	193	11.5
L.S.D. at 5 percent	2.7	2.2	1.4			2.0	2.8	1.2		
L.S.D. at 1 percent	3.7	3.1	1.9			2.7	3.9	1.6		

[1]TSP, treble superphosphate; AN, ammonium nitrate; KS, potassium sulfate, in pounds.
[2]Soluble ash based on solubility in hot 10 percent hydrochloric acid.
[3]Applied the previous crop year.

Table 4.—Experiment W47—Effects of fertilizer treatments on composition of leaves and tops.

	Treatment[1]		Leaves, dry-matter basis				Tops, dry-matter basis			
	11-46-0	AN	Crude protein	Ash[2] Total	Ash[2] Soluble	Carotene	Crude protein	Ash[2] Total	Ash[2] Soluble	Carotene
	Pounds/A	Pounds/A	percent	percent	percent	mg./kg.	percent	percent	percent	mg./kg.
1.	65	---	14.6	18.9	18.4	293	12.7	19.6	17.5	198
2.	65	240	14.6	16.4	16.2	248	14.4	18.3	17.3	147
3.	65	480	16.2	16.1	15.9	202	16.6	18.1	16.6	136
4.	65	720	15.0	16.1	15.9	213	15.0	17.4	16.3	187
5.	215	200	17.0	20.2	19.8	273	16.4	21.4	19.7	209
6. plus TSP, 1250	215	200	17.3	21.0	20.6	255	15.5	22.3	20.0	180

[1]AN, ammonium nitrate; TSP, treble superphosphate.
[2]Soluble ash based on solubility in hot 10 percent hydrochloric acid.

Some of the data on the 1945 sample from Nebraska was derived from the paper by Robertson, Brin, and Norris (8). This paper was a report on chick growth trials using material from this same production.

The crude protein analyses of the beet-leaf meals were lower than expected from the analysis of green material reported in tables 3 and 4. The commercial laboratories analyzing the 1945 and 1946 samples immediately after dehydration reported 21.3 percent and 22.2 percent crude protein, respectively. Analyses by the Cornell and Colorado Experiment Stations at a later date, however, were the ones reported in table 5. In the case of the 1947 sample, the green chopped leaves sampled at time of harvest showed 20.0 percent crude protein on a dry-matter basis. This is materially higher than the amount found in the dehydrated meal, namely, 12.2 percent. The lower figures obtained in the two Experiment Station laboratories on the 1945 and 1946 samples and the discrepancy between the crude protein at the time the 1947 sample was harvested and the time it was dried undoubtedly represent a loss of non-protein nitrogen. Guilbert, Miller, and Goss (3) reported figures from the literature indicating that true protein of beet tops runs from 58 to 74 percent of the crude protein.

The variations in carotene reported for the dehydrated products are not unusual. They reflect not only differences present in the raw material, but also the results of processing and of storage.

The data taken as a whole indicate that properly processed sugar beet leaf meal may be comparable to alfalfa leaf meal in general composition. It may run variably lower in crude protein, may contain about half as much fiber and twice as much ash, and about the same range of carotene content.

Feeding Trials.—A. *Chickens.*—Since a considerable portion of dehydrated green feed is incorporated in poultry rations in this country and since poultry are much more critical in their nutritional requirements than ruminants, trials comparing dehydrated beet leaves and tops with dehydrated alfalfa leaf meal were conducted with chickens. Because beet leaves are rich in oxalates (table 5) which are known to interfere with calcium metabolism, the trials were in part designed to ascertain the effects of this component in poultry rations. Details of these experiments will be published elsewhere. The pertinent observations are presented here.

The dehydrated beet leaf meal prepared in 1945 was compared with dehydrated alfalfa leaf meal at a 10-percent level in starting mashes. No differences in growth to 6 weeks of age were noted when the mashes contained 50 percent over the minimum level of calcium required by chicks. When the calcium level was reduced to the minimum requirement, the beet leaf meal caused reduced growth and calcification, presumably because the oxalate in the meal rendered some of the dietary calcium unavailable.

The beet leaf meal prepared in 1946 was similarly compared to dehydrated alfalfa leaf meal at the 5 percent level but with adequate calcium in the ration. The growth of chicks to 5 weeks of age fed the ration containing beet leaf meal slightly exceeded the growth of those fed the ration containing alfalfa leaf meal.

In a third trial, the beet leaf meal prepared in 1947 was compared to dehydrated alfalfa leaf meal at levels of 5 and 10 percent and with the beet top meal prepared in 1947 at levels of 5, 10, and 15 percent. Growth was comparable at the 5 percent level of all three products but the beet leaf meal and the beet top meal produced increases in growth at the 10 percent levels, whereas the alfalfa leaf meal caused a marked decrease in growth.

A trial was conducted with laying pullets comparing 5 percent of dehydrated alfalfa meal with the same amount of the beet leaf meal prepared in 1946. An all-mash breeding ration was used. No differences in body weight, hatchability, early growth of offspring, egg weight, or calcium and phosphorus balances were noted. Fertility was lower on the beet product but this may have been due to the individual male in this pen. The beet leaf meal did cause slight abnormal discoloration of the yolks of eggs during prolonged storage.

B. *Lamb fattening.*—Two lots of 20 lambs each were fattened for 126 days in the winter of 1946-47. One pen received a ration of rolled barley, ground corn, chopped alfalfa, and salt. The other received 0.1 pound per head per day of beet by-product pellets in addition. These pellets were composed of the dehydrated beet leaf meal prepared in 1946, 20; soybean oil meal, 20; dried beet pulp, 34; beet molasses, 20; limestone, 4; steamed bone meal, 2. The results of this trial, shown in table 6, indicate that the pellets were highly acceptable and could be profitably utilized.

Preliminary results of another similar trial with lambs in 1947-48 season indicate that the dehydrated beet leaf meal and the dehydrated beet top meal prepared in 1947 were comparable to dehydrated alfalfa leaf meal in acceptability and results when hand-fed to lambs.

Discussion

The yields per acre of leaves and tops observed on intermediate levels of nitrogen fertilizer additions in these studies approximated for the leaves about 8 tons fresh and 1 ton dry and for the whole tops about 14 tons fresh and 1.75 tons dry. The fresh top yield was approximately the same as that of the roots in weight. Skuderna and Sheets (9) quote an average yield of fresh tops at 30 to 70 percent that of the marketed weight of roots on irrigated land. Dunn and Rost (10) reported a yield of 75 percent in the Red River Valley. The figures in this paper show that the ratio depends on the level of nitrogen fertility. This is not in conformity with the results reported by Dunn and Rost (10). Some of the improvement in this ratio may be due to the fact that our samples were harvested by hand. Discrepancies in yields of tops noted in experiment 3A may be the result of hand-versus-machine harvesting.

Table 5. Composition of dehydrated meals, dry-matter basis.

Sample	Crude protein	Crude fat	Crude fiber	Total ash	Ca	P	Oxalate	Carotene	Ribo-flavin/lb.
	percent	percent	percent	percent	percent	percent	percent	mg./kg.	mg.
1. 1944 Beet Leaf[1]	18.8	2.3	11.9	18.0	--	--	--	95	9
2. 1945 Beet Leaf (Nebraska)[2]	14.4	2.7	10.3	18.0	.67	.28	4.5	128	13
3. 1946 Beet Leaf (Minnesota)[3]	14.4	3.8	9.9	19.5	.93	.20	7.8	282	--
4. Alfalfa Leaf[4]	21	3.0	18.0	11.0	1.40	.30	1.5	200	17
5. Alfalfa Hay[4]	16.3	2.2	32.1	9.2	1.58	.23	--	--	--

[1]Data from Holly Sugar Corp.
[2]Data from commercial laboratory, Colorado and Cornell Experiment Stations.
[3]Data from commercial laboratory and Colorado Agricultural Experiment Station.
[4]Data adapted from Feeds and Feeding by Morrison.

Table 6.—Preliminary lamb fattening trial, 1946-1947.

Lot	Average gain per day	Average feed cost	Cost per 100 pounds gain	Comments
	pounds	$	$	
1. Control	.35	9.82	23.01	No differences in carcass
2. Beet Meal Pellets	.33	9.59	22.01	yields, grade, or price.

The proportion of leaves to entire tops (60 percent) in these data agree well with those reported by Skuderna et al. (9) and Guilbert and co-workers (3).

The data in the two fertilizer experiments demonstrate that the leaves and tops at time of harvest are rich in crude protein and carotene. The supply of these two nutrients is deficient for livestock needs in the more important beet-growing areas in the United States. Not only the yields per acre, but also the crude protein content can evidently be increased by assuring adequate nitrogen in the soil. The high ash content, which is a limiting factor in feeding beet tops and leaves, is evidently reduced by such nitrogen additions. On the other hand, the added nitrogen apparently produces a more succulent or moist top which would be a drawback in dehydrating or ensiling. The additional increase of moisture in the presence of additional potash in experiment 3A is in agreement with the observations of Dunn and Rost (10).

The data presented in this paper on the composition of the tops are in close agreement with those reported by Dunn and Rost (10) and by Guilbert et al. (3). Both of these groups of authors indicate that the feeding value of beet tops is equal to that of alfalfa hay on a dry-matter basis. The beet tops are slightly higher in crude protein and nitrogen-free extract. They contain only about one-third as much fiber but about twice as much ash.

The composition of the dry matter in green leaves found in this study is quite comparable to dehydrated alfalfa leaf meal except that the crude protein may be slightly lower, the fiber half as high, and the ash twice as high. The carotene contents appear to be very much in the same ranges. The riboflavin appears to be slightly lower. The evident loss of nitrogen on dehydration and possibly subsequent storage, an observation in agreement with that of Ingraham (11), warrants further investigation on the nature of the nitrogenous compounds in beet leaves and tops. The loss indicated in our observation is very close to the non-protein nitrogen percentages quoted by Guilbert et al. (3).

The successful use of dehydrated beet leaf meals in growing rations containing adequate calcium substantiates the report of Robertson, Brin, and Norris (8). It is possible that dehydrated beet leaf meal and beet top meal do not possess the growth-inhibiting property found in some alfalfa meals.

While beet leaf meal was used successfully in a chicken breeding ration, further trials are essential to ascertain the reliability of observations on discoloration of yolks of eggs during storage. Also the efficiency of utilization of carotene and other vitamins and the biological value of the protein must be determined.

The preliminary trials on the fattening of lambs indicate that the dehydrated beet products are acceptable to lambs. Their true place in lamb and cattle rations, especially as protein and carotene carriers similar to dehydrated alfalfa, awaits evaluation. The high values for cattle and lambs of the fresh and pastured tops and of the ensiled tops have been demonstrated by Maynard (12) and Guilbert et al. (3). These reports indicate that beet tops and alfalfa hay are equivalent in feeding value on the dry-matter basis. Thus a 15-ton yield of sugar beets may yield about 15 tons of tops which on a dry-matter basis is equivalent to about 2.25 tons of alfalfa hay or 1.5 tons of barley.

The analytical data indicate that beet leaves and tops are of great potential value as sources of crude protein and carotene. The feeding trials show that the dehydrated products are highly acceptable to poultry and lambs. It appears obvious that these materials are so comparable to similar alfalfa products as to be competitive as a feed stuff. Further analytical and feeding data are essential to ascertain whether the beet products may not prove superior to those from alfalfa. Such studies will include methods of ensiling.

In competition with alfalfa as a source of material for dehydration, beet-top products have several disadvantages which must be overcome. The leaves contained about 87.5 percent moisture in these trials and the tops contained about 86 percent. This is in contrast to alfalfa which averages between 75 and 80 percent moisture. This means that to get a ton of dehydrated leaf meal, containing 10 percent of residual moisture, there must be dehydrated approximately 14,500 pounds of fresh beet leaves as compared to approximately 8,000 pounds of green alfalfa containing 77.5 percent moisture. This requires the evaporation of approximately 12,500 pounds of water in the case of the beet leaves as compared to approximately 6,200 pounds of water in the case of alfalfa. Thus, dehydration costs of beet leaves will be approximately twice that of alfalfa.

The higher moisture content of beet leaves and beet tops is also a problem in ensiling them. Material for ensilage should contain approximately 65 to 70 percent moisture in order to aid the preservation and to avoid heavy drainage losses.

Another problem in dehydrating beet-top products is the difficulty of finely chopping three types of wet materials, leaf, stem, and crown, which occur in the whole tops without finely macerating the green tissue and thereby hastening enzymatic destruction of carotene. Unless the crown particles are very finely divided they will cork over in the dehydrator and will not dry out inside.

Another problem is the need for developing mechanical means of harvesting and handling the tops or leaves with an absolute minimum of soil contamination. Still more serious is the problem of overcoming the labor and equipment load needed at harvest time in competition with the harvesting of the roots. This is caused by the fact that it is necessary to harvest the roots the same day, or not later than 24 hours after removing the tops or leaves, if loss of sugar in the roots is to be avoided. These and many other lesser problems are the subject of further intensive study in which progress is being made.

Conclusions

Under favorable conditions the yield of sugar beet tops may equal or exceed the yield of roots on a fresh water basis. The leaves constitute about 60 percent the weight of the tops (leaves plus crowns). Yields of sugar beet leaves and tops can be improved by assuring adequate amounts of nitrogen in the soil.

Sugar beet leaves and tops possess nutritive values, especially in crude protein and carotene, quite similar to comparative alfalfa products on a dry-matter basis. Feeding trials with chicks, breeding hens, and fattening lambs indicate that dehydrated beet leaf meal is highly acceptable in comparison with alfalfa leaf meal.

The roots should be harvested within 24 hours following the removal of the tops or leaves in order to avoid significant loss of sugar. This creates a labor and machinery problem in handling the tops or leaves for immediate processing. The high moisture content of sugar beet leaves or tops at least doubles the dehydration cost in comparison with alfalfa and causes greater losses in ensiling.

The preliminary data obtained in this study are sufficiently encouraging to justify the intensive study in progress on these problems.

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