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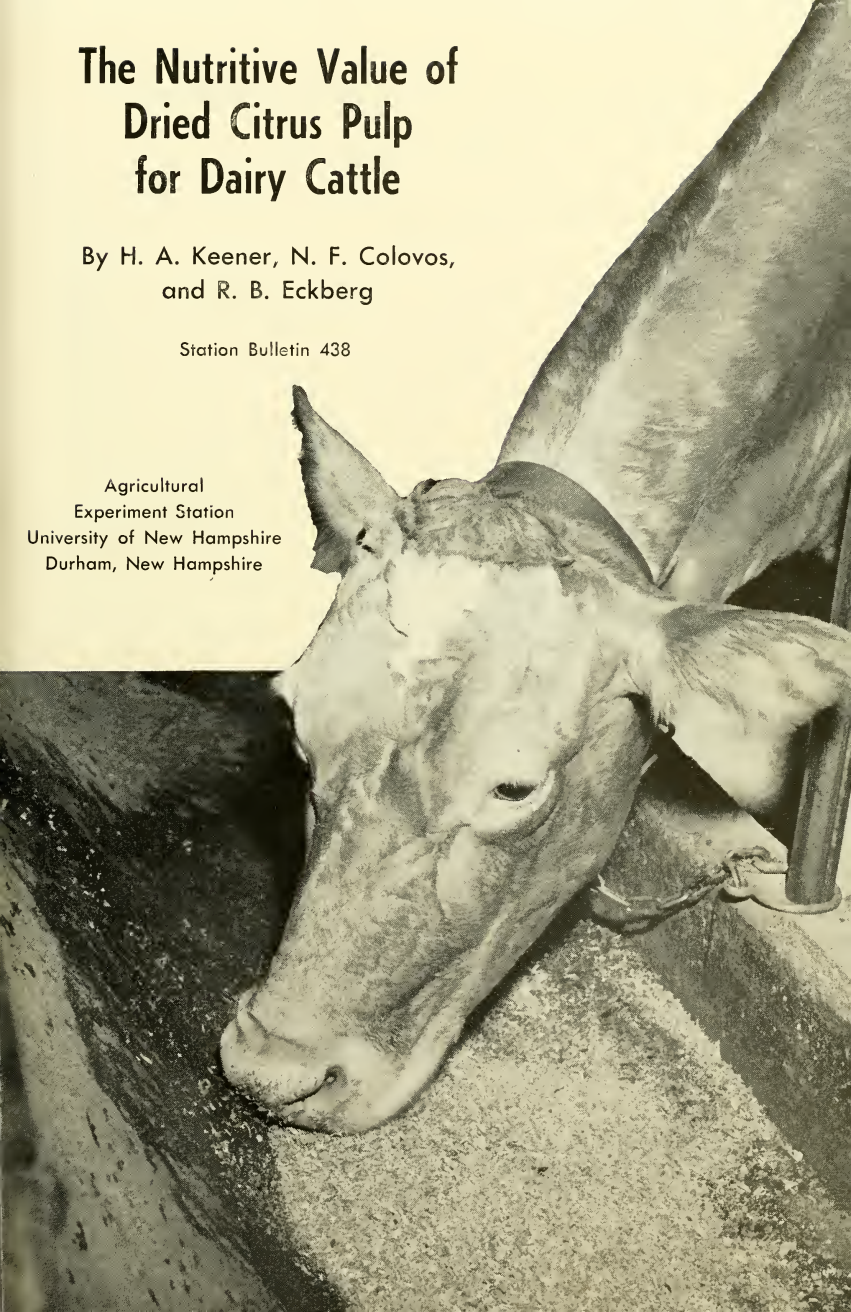

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The Nutritive Value of Dried Citrus Pulp for Dairy Cattle

By H. A. KEENER, N. F. COLOVOS, AND R. B. ECKBERG*

DURING recent years there has been much interest in New England in the use of dried citrus pulp as a supplemental concentrate feed for dairy cattle. Its use has become widespread due to its increasing availability, favorable price relationships, and apparent high nutritive value. Because the citrus industry is still expanding very rapidly, increasing quantities of dried citrus pulp will become available during the next few years. For this reason it appeared that citrus pulp might be used economically in larger quantities under New Hamphire conditions in the place of other concentrates, if the nutritive value of the ration was not lowered.

As fresh citrus fruit production began to exceed the demand at about the time of World War I, the canning industry started to process juice and hearts. Disposal of the waste peel, rag, seeds, and cull fruit became a problem. Studies of by-product utilization were undertaken and about 1920 some attempts were made to feed such materials to livestock. It was found by the California and Florida experiment stations that cattle could readily utilize the fresh waste and such a practice became common in the citrus regions. The extent of this outlet was limited by the bulk and spoilage of the fresh citrus waste.

Occasionally dried citrus by-products were left over from other uses and were fed to cattle with satisfactory results. The Florida Station then conducted some feeding trials and determined that dried citrus pulp had much the same use in cattle feeding as beet pulp. In 1938 Archibald of Massachusetts reported that dried citrus pulp could replace dried beet pulp in feeding dairy cows.

Around 1940 it was discovered that because of the high sugar content of the press juice from the pulp, it could be made into a citrus molasses. When cane molasses came into short supply during World War II, citrus molasses found wide use in the mixed feed industry as a partial replacement for it. Now it is often mixed back with the pulp after drying.

Currently the process for making the dried citrus pulp involves the addition of hydrated lime to aid the removal of bound water from the fresh pulp. The pulp is pressed to remove about half the moisture and then dried with artificial heat to a low moisture content. The press juice is concentrated to make citrus molasses which is either added to the dried pulp to make cake or is utilized separately. Such a procedure gives a wide variation in composition to the dried citrus pulp. Because almost all of the fat is contained in the seed, the fat content of the finished product is affected markedly when the seeds are removed in the processing of the

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pulp. The type of fruit processed, i. e., grapefruit, oranges, tangerines, lemons or seedless navels, affects the composition. The growing season as well as the variety of fruit also affects the product. For these reasons the analysis on the bag tag is an important consideration in feeding dried citrus pulp.

While the dried citrus pulp is quite palatable to cows, its use is limited in that its composition is somewhat like that of a concentrated carbohydrate feed such as corn. That is, it is high in carbohydrate and total digestible nutrients, but low in protein. Many feeding experiments and a lot of practical experience have shown that dried citrus pulp is a satisfactory feed for dairy cattle. About the only work to determine the digestibility of citrus pulp by cattle appears to have been carried out at the Florida Station by Neal and associates. The work reported here was carried out for that purpose as well as to determine its value as an ingredient in the concentrate mixture.

Digestion and Utilization Study

Experimental Procedure

The dried citrus pulp was evaluated in digestion and utilization studies carried out in the Animal Metabolism Laboratory of the Department of Dairy Husbandry of the New Hampshire Agricultural Experiment Station. Four 18-24 month old dairy heifers were used as experimental subjects. In order to evaluate dried citrus pulp under typical feeding conditions four different rations were fed. During the course of the experiment each ration was evaluated with each animal. The rations studied were hay alone, hay plus dried citrus pulp (50-50), hay plus a 14 percent protein concentrate mixture (50-50), and hay plus 20 percent protein concentrate mixture and dried citrus pulp (50-25-25). The citrus pulp was fed with the 20 percent protein grain mixture because the protein content of the mixture would be approximately the same as that of the 14 percent mixture.

The hay fed was grass hay of average quality. The citrus pulp was a blend of pulps produced by members of the Citrus Processors Association. The concentrate mixtures are given in Table 1. The chemical composition of the various feeds used is given in Table 2.

Table 1. Pounds of Concentrate Mixtures Used

	Crude Protein in Mixture	
	14%	20%
Ground corn	600	
Crimped oats	500	
Wheat bran	500	
Soybean oil meal	200	150.0
Molasses	200	
Dicalcium phosphate	20	1.5
Trace mineralized salt	20	1.5
14% protein mixture		600.0

Table 2. Chemical Composition of Feeds

	Hay	Citrus Pulp	Grain Mixture 14% Protein	Grain Mixture 20% Protein
Protein %	6.39	5.81	15.63	20.86
Ether extract %	1.16	4.34	3.55	3.05
Crude fiber %	32.76	12.63	6.52	6.46
Nitrogen-free extract %	46.53	63.69	58.31	53.79
Ash %	4.79	5.68	5.39	5.70
Moisture %	8.37	7.85	10.60	10.14

Each animal was given free choice of trace mineralized salt. They were watered and fed twice daily. The rate of feeding was adjusted to the amount that each animal would clean up. The general plan of the experiment is given in Table 3.

Table 3. General Plan of Experiment

Animal Number	Period 1	Period 2	Period 3	Period 4
Guernsey 4	Hay, 20% grain, citrus pulp	Hay, 14% grain	Hay, citrus pulp	Hay
Guernsey 5	Hay	Hay, 20% grain, citrus pulp	Hay, 14% grain	Hay, citrus pulp
Holstein 35	Hay, 14% grain	Hay, citrus pulp	Hay	Hay, 20% grain, citrus pulp
Holstein 36	Hay, citrus pulp	Hay	Hay, 20% grain, citrus pulp	Hay, 14% grain

The methods generally used in the laboratory were followed. These consist of a 10-14 day preliminary period during which the animal becomes adjusted to the kind and amount of feed to be evaluated. This is followed by a 14-day collection period during which the feed eaten and the urine and feces voided are carefully weighed, sampled, and analyzed. At the end of each collection period each animal is placed in the respiration chamber for two consecutive 12-hour periods during which heat and methane production are measured. From such studies results on both digestibility and utilization are obtained.

Results and Discussion

The average digestion coefficients for the various rations are given in Table 4. The "digestibility of the energy" of the ration which contained citrus pulp and grain was not significantly different from that which contained the 14 percent protein grain. The difference in digestibility of protein, however, was significant at the 5 percent level. The difference between the digestibility of the energy of the citrus pulp-hay ration and that of the 14 percent grain-hay ration was significant at better than the 5 percent level and the difference between that of the citrus pulp-hay ration and the citrus-grain-hay ration was significant at the 1 percent level. The differences between the digestibility of the protein of the citrus

pulp-hay ration and the two rations which contained grain were significant at the 1 percent level.

Table 4. Average Digestion Coefficients for Various Rations

	Energy	Protein	Ether Extract	Crude Fiber	Nitrogen-free Extract
	%	%	%	%	%
Hay	48.4	34.3	29.5	58.5	60.9
Hay, 14% grain	60.5	65.4	68.9	49.6	71.6
Hay, citrus pulp	55.4	37.1	74.6	45.1	71.7
Hay, 20% grain, citrus pulp	62.7	59.0	72.2	56.7	74.0

Using the values for the chemical composition of the various feeds and the digestion coefficients for the entire rations, the digestion coefficients for the grain mixture and citrus pulp were calculated by difference. Because citrus pulp was fed in two different rations, values for each were calculated. These values are given in Table 5.

Table 5. Digestion Coefficients for 14 percent Grain and Citrus Pulp Calculated by Difference

	Energy	Crude Protein	Ether Extract	Crude Fiber	Nitrogen-free Extract
	%	%	%	%	%
Grain 14%	72.6	96.5	108.3	40.7	82.3
Citrus pulp fed with hay	62.4	39.9	119.4	31.8	82.4
Citrus pulp fed with hay and grain	81.4	70.9	121.5	69.1	91.9

Digestible crude protein, total digestible nutrients, and "digestible energy" values for the entire rations and values calculated by difference for the individual ingredients are given in Table 6.

Table 6. Digestible Crude Protein, Total Digestible Nutrients, and Digestible Energy in Entire Rations and in Individual Ingredients

	Digestible Crude Protein	Total Digestible Nutrients	Digestible Energy
	%	%	Therms/100 lb.
Hay	2.2	50.4	89.0
Hay, 14% grain	7.2	58.1	111.4
Hay, citrus pulp	2.3	56.6	101.2
Hay, 20% grain, citrus pulp	5.8	60.7	114.5
Grain 14%	15.1	65.8	133.8
Citrus pulp fed with hay	2.3	62.8	113.4
Citrus pulp fed with hay and grain	4.1	76.1	146.2

The amount of each ration fed and the amount of protein and energy gained by the animal body is given in Table 7. The amount of protein and energy stored from the hay, citrus pulp, and grain ration was not significantly different from that stored on the hay and grain ration. The storage of protein and energy from the hay, citrus, and grain ration was greater than that on the hay and citrus ration with the difference for protein being significant at the 1 percent level and the difference for energy being significant at the 5 percent level.

Table 7. Average Daily Feed Intake and Gain in Protein and Energy on Each Ration

	Average Daily Wt. Fed	Protein	Energy
	lb.	g.	Cal.
Hay	12.1	—4.52*	2238
Hay, 14% grain	16.0	157.43	6984
Hay, citrus pulp	13.3	37.99	3376
Hay, 20% grain, citrus pulp	15.0	180.64	6015

* Represents a loss

The chemical analyses indicate that dried citrus pulp is relatively low in crude protein, higher than grain in ether extract, intermediate in crude fiber, and high in nitrogen-free extract. This would indicate that it might be a good source of energy. The digestion coefficients for the entire rations indicate that when the hay-dried citrus pulp ration was fed, the mixture was digested more efficiently than hay with respect to energy, ether extract and nitrogen-free extract, about the same with respect to protein and more poorly with respect to crude fiber. When grain was added to the hay-citrus pulp ration, however, this ration was digested just as efficiently as the hay-grain mixture with respect to all constituents except crude protein. This indicates a supplementing effect between the energy constituents of grain and citrus pulp.

The calculated digestibility values for grain and citrus pulp actually credit all the differences due to the supplementing effect to the value of the grain or the citrus pulp. While this is not correct, there is no satisfactory method of getting around this problem. The digestion coefficients for citrus pulp fed with grain make it appear to be superior to grain with respect to energy, ether extract, crude fiber, and nitrogen-free extract. This is probably not the case. The truth of the situation probably is that grain, citrus pulp, and hay when combined are all digested more efficiently than when fed in the other mixtures. It is interesting to note that the calculated value of 76.1 percent total digestible nutrients for dried citrus pulp is very close to the value of 76.0 percent for dried grapefruit as obtained by Neal and co-workers. Digestible protein values obtained in this experiment, however, were somewhat higher than those reported by the Florida workers.

Feeding Experiment with Lactating Cows

Experimental Procedure

This phase of the evaluation of citrus pulp was carried out on a privately owned herd of purebred Guernsey cattle. The purpose was to see if dried citrus pulp could be used successfully to replace half of the grain. The herd was managed and fed in the customary manner except for the use of citrus pulp. Early-cut grass hay and grass silage were fed during the winter months and high quality pasture during the summer months. A commercial grain mixture containing 16 percent crude protein was fed at a rate of 1 lb. for each 3½ lb. milk during most of the year, but the ratio was widened some when the cows were on pasture. A record was kept of milk production, grain, and citrus pulp consumption and breeding dates. The body weight of each cow, estimated by means of a tape, and a condition rating were determined at monthly intervals.

This study was divided into two parts. The first part was a reversal experiment which was carried out with six pairs of cows. These animals were paired as well as possible on the basis of freshening date, age, and previous production rate. Beginning at parturition one member of each pair was fed in the usual manner. The other member of the pair was given dried citrus pulp as the concentrate at one feeding and the same weight of the usual grain mixture at the other. Thirty days after parturi-

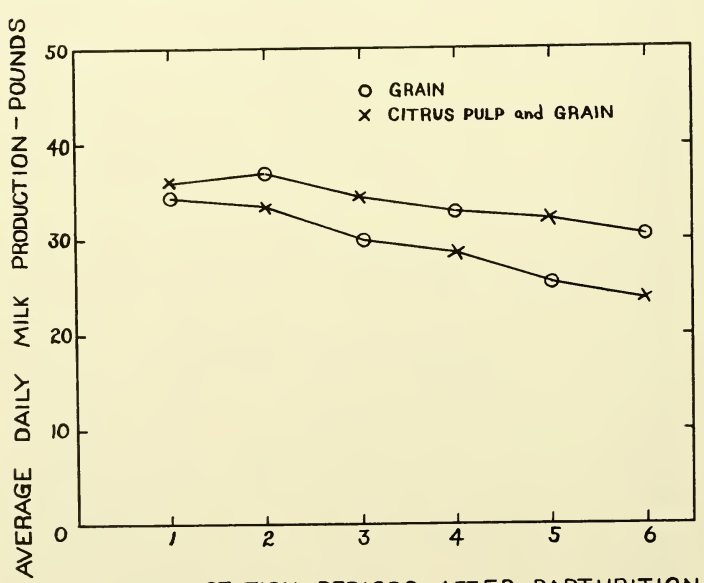

Figure 1. Average daily milk production (4 percent basis) by 30-day periods for cows on grain and citrus and grain.

Table 8. Summary of Average Number of Services per Conception

Experimental Group	Period of Experiment	Previous Year
Reversal animals	1.5	1.5
Citrus-fed animals	2.1	1.6
Grain-fed animals	2.2	2.0

tion and every thirty days thereafter during their lactations these animals were changed to the other feeding program.

The remaining cows in the herd were divided into two similar groups on the basis of production, calving date, and age. One group was fed dried citrus pulp at one feeding and an equal amount of the conventional grain mixture at the other for one calendar year. The other group received no citrus pulp during the same period. Records kept were similar to those for the reversal animals.

Results and Discussion

The average daily milk production, 4 percent fat corrected, for the two groups of reversal cows during the first six months of lactation is shown in Figure 1. The average daily production for this period was 31.9 lb. on grain and 31.5 lb. on citrus pulp. Analysis of the data showed that there was no difference in milk production on the two rations. Milk production values for the remainder of the animals in the herd were not suitable for study because the data usually consisted of parts of two lactations. There was no evidence of any effect of citrus pulp feeding on lactation, however.

When the monthly body condition ratings for those cows which received one feed per day of dried citrus pulp for one year were compared with those for the grain-fed animals, it was found that the difference was not significant. Those animals which received citrus pulp appeared to be in just as good condition as the other animals.

Breeding efficiency as shown by a summary of conception rates for the period of the experiment and for the previous year is given in Table 8. A statistical analysis of these data indicated that the animals conceived just as readily as during the previous year and that there was no difference between those animals which received citrus pulp and those which did not.

Summary

A digestion and utilization experiment was carried out with dairy heifers to determine the nutritive value of citrus pulp fed along with hay and as a 50 percent replacement for grain. It was found that a concentrate mixture containing 50 percent dried citrus pulp and 50 percent of a 20 percent protein concentrate mixture was equal to a 14 percent protein concentrate mixture as a source of energy. It was found that citrus pulp was not nearly as valuable as a 14 percent protein grain mixture when fed as the sole concentrate. These results suggest a very important supplementing effect between citrus pulp and grain from the energy standpoint, but not with respect to protein.

A feeding experiment also was carried out with cows to determine the effects of replacing one feed of concentrate daily with dried citrus pulp. It was found that when two groups of animals were reversed at 30-day intervals from two feeds of grain to one feed of grain and one of dried citrus pulp, there was no difference in milk production. Animals given one feed of dried citrus pulp and one of grain daily for a period of one year conceived just as readily and maintained body condition just as well as comparable animals fed no citrus pulp. Citrus pulp was well accepted up to 6 to 8 lb. per day with the exception of one cow.

The results of these two experiments indicate that dried citrus pulp is a valuable energy feed for dairy cattle, particularly when fed along with grain. The digestion study suggests that better results might have been obtained on the feeding experiment if the citrus pulp had been fed with grain at each feeding instead of at separate feedings. These studies indicate that dried citrus pulp may be used to make up an appreciable portion of the dairy concentrate mixture when the price situation is favorable. Care should be taken, however, to balance the low protein content of this product.

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