DRIED CITRUS PULP AS A FEED FOR
DAIRY CATTLE IN ARIZONA

by

Frederick Gordon Harland

A Thesis

Submitted to the faculty of the

Department of Dairy Husbandry

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in the Graduate College, University of Arizona

1952

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INTRODUCTION

There are three components of the whole citrus fruit which are waste material in the citrus canning industry. The first component is the yellow, outside covering of skin or peel, called the flavedo (5). This part of the fruit contains many small cells filled with oil which can be recovered by pressing. The oil is important in flavoring extracts, perfumes, and other products. The flavedo also contains carotenoids, but these have no commercial value or use at present. The second waste component is situated beneath the flavedo and is important commercially as a source of citrus pectin, and other citrus by-products. This thick, white, pulpy portion, in addition to the membranes between the segments and the pith at the center of the fruit, is referred to as the albedo or rag. The third part is the seed.

The waste material after grinding and dehydrating, is called dried citrus pulp or meal. This is a by-product of the citrus canning industry and can be used commercially as a cattle feed (20). Arizona dairymen have been faced with rapidly rising feed costs. The increased price of alfalfa hay has contributed greatly to this condition. The high price of alfalfa has been caused partly by the increased acreage of cotton with resulting decreases in the amount of hay and feed grains produced. The high cost for these other feeds has brought about the use of dried citrus pulp or meal as a feed for dairy cattle.

Prior to the advent of these rising costs, the citrus canning industry was confronted with the liability of a waste disposal problem (29). The grapefruit refuse was hauled by truck to a site well removed from the town and dumped there to disintegrate. The hauling represented an additional cost to the processor from which there was no return. In addition, the dumping of this highly fermentable material became a public health problem since it provided a breeding place for flies in warm weather.

The problem of citrus waste disposal began with the canning of citrus juices. As early as 1911, the Florida Citrus Exchange established a research fellowship at Mellon Institute to study the possible utilization of wet citrus pulp as a source of commercial citrus by-products (1). McDermott, working on this fellowship, suggested the possibility of its use as a livestock feed.

Heretofore, the cannery waste was used to a very limited extent as a fertilizer in citrus groves near the canneries (9). Much more waste was produced than could be applied to a given area of land. For that reason, only a small portion could be utilized for soil conditioning. Its value as a fertilizer was as a source of organic material. The excess waste was hauled by truck to a more remote area and dumped. Attempts were made to bury the refuse in pits. The method was impractical due to high excavating costs and the land was too valuable to devote to this purpose. In other cases, small canneries dumped the material into large lakes or tidewater rivers. This practice could not be permitted for extended periods of time. City sewerage systems might have handled such waste but the tremendous seasonal fluctuation in volume made it impossible in systems not specifically designed for variations.

Hall (9) described the waste disposal of a plant which processed seven hundred and fifty tons of fruit per day during the canning season. The solids in the refuse were separated from the liquid effluent by a separator consisting of rotating screens with 0.050 mesh. The solids were then deposited in large tanks, to be disintegrated by enzymatic action. The effluent from the separator and the liquid which drained from the bottom of the tanks was pumped, with the wash water, to the natural-sand-and-gravel settling beds. These beds were filled to a depth of two and one-half feet with the partially digested material. Seepage and evaporation removed much of the moisture. The remaining solids were largely cellulose and collected on the bottom in a thin film. The residue was subsequently raked off and burned and the beds scarified. This system of disposal required seven hundred gallons of water per ton of fruit processed or approximately half a million gallons a day.

The introduction of the dehydrating plant not only eliminated these problems but also produced a livestock feed which later became beneficial to dairymen and beef cattle feeders alike (20). The salvage value of the fresh grapefruit pulp resulted in slightly higher returns to the grower in the area served by that processing plant (10). At the same time, the livestock industry has been provided with an economical, carbohydrate feed which is being produced locally. The market prices of various feeds on January 30, 1952 sold in the Salt River Valley of Arizona are compared with dried citrus meal in Table 1. This table also lists the content of the total digestible nutrients, hereinafter referred to as T.D.N. Of the feeds listed, dried citrus meal is the most economical. Part of the low cost is due to its production locally.

In the Salt River Valley of Arizona between the years of 1941 and 1948, the total production of grapefruit varied from a minimum of 2.0 million boxes in the 1942-43 season to a maximum of 3.6 million boxes in 1943-44 (22). Approximately forty-nine percent of this production was sold as fresh fruit. In the same period, the amount of fruit processed from the area varied from 23.8 percent in 1947-48 to 52.4 percent of the crop in 1942-43 with an average of forty percent for the seven year period. The difference

Table 1. Prices of various dairy cattle feeds which may be used in Arizona, together with prices per ton and cost per hundred pounds of T.D.N.

Common Feeds for Dairy Cattle	T.D.N.1/ %	Price per ton 1-30-52 $	Cost per 100 lbs. T.D.N. $
Dried Citrus Pulp or Meal	74.4	49.54	3.33 2/
Alfalfa Hay	51.5	48.00	4.66 2/
Hegari	80.5	77.74	4.83 2/
43% Cottonseed Meal	75.8	73.62	4.86 2/
Barley	77.7	77.80	5.01 2/
Molasses	54.0	63.90	5.91 3/
Wheat Bran	67.2	79.56	5.92 3/
Corn No. 2 Dent	80.1	95.22	5.94 4/
Wheat	80.0	93.60	6.02 4/
Linseed Meal	77.2	97.74	6.33 4/
Dried Beet Pulp	67.8	89.64	6.67 4/
Oats	70.1	93.60	6.68 4/
Soybean Meal	78.4	111.24	7.09 4/

1/ The T.D.N. of a feed represents the sum of the digestible protein, fiber, nitrogen-free-extract plus 2.25 times the digestible fat content of the feed (13).

2/ The most economical sources of either digestible protein or T.D.N. in Arizona dairy rations.

3/ These feeds provide certain desirable qualities such as palatability and bulk, and in the case of wheat bran, a good source of phosphorus.

4/ Feeds little used mainly because of their high costs.

between the production and the combined figure for fresh fruit sales and processed fruit represented that which was left on the ground to rot. Heavy frost damage occurred in the 1947-48 season which rendered much of the fruit unfit for sale as a fresh product. A small portion of the damaged fruit was salvaged as canned citrus juice. The value of the dried citrus pulp is so low that no attempt has been made to utilize the entire fruit for livestock feed since it would not cover picking and hauling costs. As an example, when dried citrus meal sells for $47.00 per ton wholesale, the processor can pay only up to $2.50 per ton of fresh fruit for feed production (10). The low monetary value is due to the low solids content of the fruit and the high dehydrating costs. These costs were estimated to be about $5.75 per ton in the year of heavy frost damage. This was also higher than the delivered price of field chopped silage crops. Therefore, the economical production of dried citrus pulp depends on the utilization of the fresh fruit for processing and dehydrating the refuse.

A citrus pulp dehydrating plant in the Salt River Valley is owned by the Desert Citrus Division of the Exchange Orange Products Company and is located at Tempe. Fruit has been processed there for its member-growers in that area since 1934 (21). The waste disposal problem mentioned above became more important each year, with the result that the dehydrating operation began with the 1948-49 season. The plant's output of livestock feed varies from two thousand to three thousand tons per operating year, depending on the volume of grapefruit processed. The production of other citrus areas of the United States greatly influences the demand for Salt River Valley fresh fruit. This, in turn, influences the amount that will be processed and subsequently regulates the amount of livestock feed produced.

A. Commercial Drying of Citrus Pulp

1. Preparation. Braverman (5) described the method used to dehydrate the citrus waste. The diagrammatic flow sheet from McNary (11) for the dehydration of the product is shown (Figure 1). The material was crushed, minced, or shredded in a hammer mill. Due to the pectin present, a sticky mass was produced and it could not be dried successfully. Case hardening occurred wherein it dried only on the surface. Ten to twelve pounds of a special lime formula, with calcium or magnesium oxide, was added per ton to the slimy, shredded citrus waste to catalyze the demethylation and ultimate precipitation of the pectin (5,23) by enzymatic and chemical action. It was mixed with the lime and permitted to stand from one-half to two hours. This caused syneresis and reduced case hardening. McNary (11) referred to a slight modification of this procedure

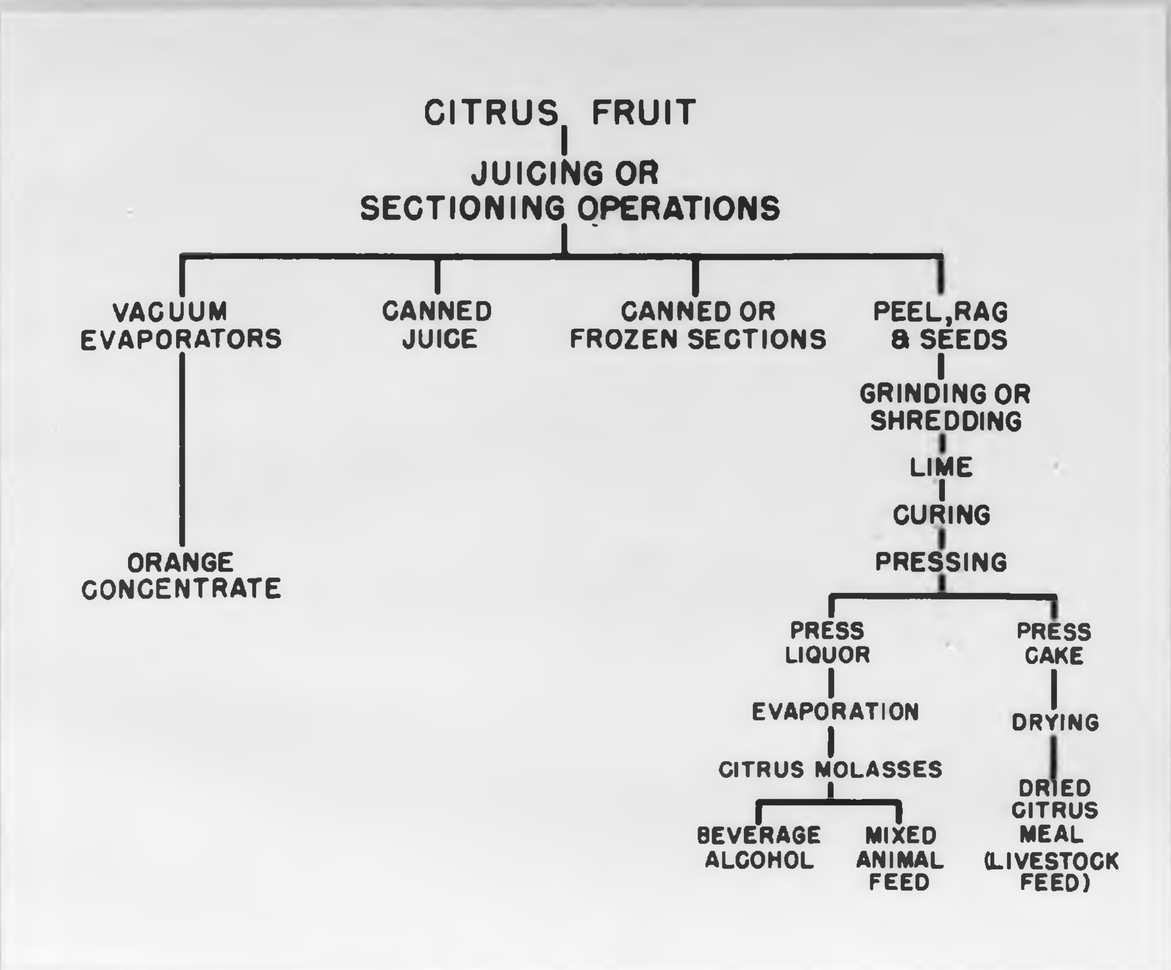

Fig. 1. Flow sheet for the dehydration of dried citrus pulp

wherein part of the moisture was removed as peel juice by pressing. This peel juice is also referred to as peel or press liquor.

2. Curing. The usual curing period of two hours permitted the lime to neutralize all the acid-forming substances present. Also, the lime combined with certain scale-forming substances to form a precipitate which contained calcium pectate, calcium citrate, and other calcium salts. The pectin coagulated at pH 5.8 and a syneresis of the jellied mass occurred.

3. Drying and Yield. Murdock (14) described a drying operation which was carried out by use of four rotary kilns. These kilns were sixty feet long and eight feet in diameter and were equipped with inside baffle plates. They were direct fired with natural gas to produce temperature of twenty-four to twenty-eight hundred degrees Fahrenheit. Three kilns were used to reduce the moisture content to approximately forty percent. All the material then went to the fourth kiln which was maintained at two hundred degrees Fahrenheit. The moisture content was reduced there to less than eight percent. The capacity of this equipment was 5.5 tons of light colored livestock feed per hour.

The product had hygroscopic properties and took up a slight amount of moisture from humid atmospheres during prolonged storage. The addition of lime mentioned above was responsible for reducing the moisture content from eighty-two percent to seventy-two percent before drying. In the case where the refuse was pressed, the moisture content was reduced further, and at that point represented fifty-five percent of the original weight of the refuse.

Braverman (5) showed that one hundred kilograms of fruit yielded thirty-five kilos of juice for beverage use, thirty-five kilos of effluent from the peels, and thirty kilos of wet pulp which when dried, yielded nine kilos of livestock feed. Figures obtained from the Exchange Orange Products Company (10) showed that the fruit contained forty-five percent juice, and the yield of dried citrus meal was ten percent of the original weight of the wet pulp.

B. OTHER BY-PRODUCTS

1. Pectin. Owens (16) pointed out that citrus peel contained about three percent pectin and was one of the richest sources of that material. The only other commercial source of pectin is apple pomace which contains less than half that amount. The maximum recovery from the citrus peel however, requires more gentle treatment than that used in processing the material for livestock feed.

2. Molasses. The peel liquor removed by pressing represents about twenty percent of the original weight of the citrus peel. It contains eight to twelve percent dissolved solids of which five to seven percent is sugar (2,24). The liquor is heated to one hundred and ninety degrees Fahr-

enheit for thirty to sixty minutes to precipitate further scale-forming substances. This also serves to pasteurize the material and prevents fermentation during the storage and until such time as the liquor can be processed. By use of multiple effect evaporators, the resulting clear solution is then concentrated into citrus molasses. Any excess lime present in the liquor is combined with carbon dioxide in the process to form insoluble calcium carbonate during the evaporating process and is removed.

Citrus molasses contains seventy to seventy-five percent solids of which approximately forty percent are soluble sugars. Other properties of this molasses are: (a) it is dark in color, and (b) it is bitter in taste due principally to the naringin content, the latter property makes it unfit for human food without further high cost processing. As a result, it is used for livestock feed or in alcoholic fermentations of the beverage industry. Owens et al (16) reported that the production of citrus molasses increased from none in 1940 to nearly forty-two thousand tons in the 1949-50 season. In some cases, the utilization of the molasses is increased by spraying it on the pulp before it is dried thereby increasing the palatability and yield of the feed.

II. REVIEW OF LITERATURE

A. The Use of Fresh Citrus Pulp. Grapefruit refuse has been used as a fresh, succulent feed for dairy cattle for thirty years or more (1). Its use as such was limited to the area adjacent to the processing plant. Oftentimes, there were not sufficient cattle in the vicinity to consume the daily output of wet pulp. The feed was difficult to handle and fermented very easily and quickly, especially during the warm weather. This necessitated daily deliveries to the farms and thus reduced its practicability as an economical feed.

B. The Use of Citrus Pulp Silage. The material has been used in making silage experimentally, at the Florida Experiment Station (4). Feeding trials were conducted with both fresh pulp and silage made from the pulp. The fresh refuse was readily consumed by mature range cattle at the rate of fifteen to twenty-five pounds per head per day. However, the material was not available during the latter part of the summer when it was needed most. The pastures in that area matured and dried up in late summer and supplementary feeding was needed. Conservation and storage of succulent feed was solved by ensiling the citrus pulp and using it the following summer.

Becker and his coworkers (4) conducted field trials using citrus silage made by four different ensiling methods. The first section of a large trench silo was filled with the plain, fresh pulp. A second portion was filled with about twenty-five percent Natal hay and seventy-five percent pulp to increase the dry matter content and to insure proper conditions for acid-forming microorganisms. The pulp and hay were added in alternate layers. A third section was filled with twenty-five percent freshly chopped sugar cane and seventy-five percent pulp. The final section was filled with citrus press cake. This press cake was the wet citrus pulp which had part of the moisture removed by pressing before ensiling.

The different sections of the silo were opened and examined after a fifty-day ensiling period which is commonly regarded as sufficient time for the completion of the process. The pH which varied from 3.2 to pH 3.55 was comparable to the value of pH 3.47 for silage made from well-matured corn. Also, this silage was reported to be more acid than legume silage and less acid than that made from sugar cane.

The citrus pulp silage contained about eighty-five percent moisture. Although very little "free moisture" was observed, it was very soft in consistency. Workmen in the silo sank eight to twelve inches into the feed when removing the silage. The silages which contained the cut hay or sugar cane or the silage made from citrus press cake were well packed and had a much firmer consistency. These feeds were fed to cattle and in all cases the cattle preferred the silage made from the citrus press cake to that made with hay, or sugar cane, or the plain citrus pulp, respectively.

These investigators (4) believed that some use might be made of the citrus pulp silages in locations near canneries. Its main use would be as a feed when fresh citrus pulp was not available.

Stanley (26) used grapefruit refuse silage for fattening rations in which steers ate 14.6 pounds per head per day. This cannery refuse was fed with a basal ration of cottonseed meal, grain, and alfalfa hay and had about 82 percent of the feeding value of hegari silage in these trials.

C. The Use of Dehydrated Citrus Pulp. Arnold *et al* (1) reported that the dehydration of a small amount of grapefruit was accomplished experimentally by Seth S. Walker in 1925. The peel, rag, and seed were dried over a system of steam coils and then ground. The resulting material, containing eighteen percent moisture, was fed to six Jersey cattle in the Florida Experiment Station herd by Scott (19). He concluded the dried feed had merit and thought further work was justified. California dairymen located near orange by-products factories fed fresh orange pulp as early as 1922.

Digestion trials using dried orange pulp were conducted at the California station in 1926, with five wethers (12). Results show that it yielded 6.0 percent digestible protein and 78.3 percent TDN. The Florida station conducted similar trials with dried grapefruit pulp with steers (15). The results obtained were in close agreement with those of the California station.

Regan and Mead (18) compared the value of dried orange pulp to that of dried beet pulp, since these feeds had very similar chemical analyses. The feeds had essentially the same feeding value when fed with alfalfa hay and a grain mixture of ground barley, ground corn, and dried beet pulp. Becker _et al_ (3) illustrated the bulkiness of the dried citrus meal when ground by a hammer mill. This feed had a density of 0.97 pounds per quart as compared to 0.6 pounds for beet pulp, dried brewer's grains, and alfalfa meal; 1.5 for cottonseed meal and 1.5 to 2.0 for farm grown grains It was also noted that the dried grapefruit meal was hygroscopic on contact with water or digestive juices. The feed was considered palatable when 30 out of 31 cows ate all or part of their feeding of this dried product following their regular, full feeding of the grain mixture in six consecutive days.

Neal _et al_ (15) conducted feeding trials with growing native and grade Hereford heifers. The ration consisted of 30 pounds of sugar cane silage, 15 pounds of dried grapefruit meal, and five pounds of cottonseed meal per one thousand pounds of live weight. This ration was very palatable and the bitter taste caused by the naringin content did not detract from the palatability. The animals appeared thrifty and had a glossy hair coat.

Results reported by Arnold et al (1), also Regan and Mead (18) indicate that dried citrus meal and dried beet pulp are approximately equal in value as a feed for dairy cows. Copeland and Shepardson (6) stated that dried citrus pulp proved to be a satisfactory carbohydrate feed for dairy cows. There was no significant difference in production when seven cows were fed dried citrus meal constituting half the grain mixture as compared to corn-and-cob meal. They also found it had a beneficial effect on the appetite of the animals when fed moderately, in extremely hot weather. No noticeable effects were observed on the flavor and aroma of the milk produced when as much as eight pounds were fed per cow per day. They also reported that the animals had a slightly glossier hair coat when dried citrus meal was fed. Davis and Kemmerer (7) showed that this by-product feed contained an unknown lactating factor which produced a stimulus to milk production following prolonged feeding of alfalfa hay alone. Cows fed a ration, which had a substitution of two pounds of dried citrus meal for a similar amount of grain, produced essentially as much milk as those fed the regular herd ration.

PART I. Dried Citrus Meal as a Substitute for Regular Grain Mixtures in the Rations of Older Calves.

III. EXPERIMENTAL

Dried citrus meal was used as the sole source of concentrate for calves of the Guernsey, Holstein, and Jersey breeds. Thirty-three female calves - 8, 16, and 9, of the respective breeds, were fed two pounds of dried citrus meal in place of the regular calf grain mixture from the time they were six months old until they reached one year of age. The control group consisted of thirty-one female calves - 9, 13, and 9, of the respective breeds. The animals were placed on the experiment when they were six months old. Calves were placed in the respective pairs as each reached the proper age. The two groups were uniform in numbers, sizes, and breeds at a given time throughout the various seasons of the year.

A. Rations for Calves. Alfalfa hay was the only source of roughage. Salt was provided each group *ad libitum* throughout the experiment. The citrus group was fed two pounds of dried citrus meal per calf per day and the control group received two pounds of a calf grain mixture containing 70 parts of rolled barley, 70 parts of whole oats, 50 parts wheat bran, and 15 parts of cottonseed meal.

Morrison (13) showed dried citrus pulp contained 2.5 percent digestible protein and 74.4 percent TDN. The calf grain mixture contained 12.6 percent digestible protein and 72.4 percent TDN.

B. Nutrient Requirements. The approximate values of digestible protein, total digestible nutrients, and the net energy of the experimental and control rations were tabulated (Table 2). The requirements for growth for these animals were based on the average size, of the nine month old female of each breed. In all cases, sufficient digestible protein, total digestible nutrients, and net energy were provided to meet the requirements set forth by Morrison (13). Dried citrus meal was a good carbohydrate feed which supplemented the protein supplied in good quality alfalfa hay to balance the ration in this feeding trial.

C. Growth Determinations. Each animal was weighed monthly and her height at the withers was measured at the same time. The measuring device consisted of an upright measuring scale with a tightly fitting crossarm. A level was built into the crossarm to facilitate accuracy in designating when the exact height was obtained. The instrument was read to the nearest one-quarter of an inch.

Table 2. The nutrient requirements of the calves of the various breeds and the feeds used to supply those nutrients for growth.

		Dig. Prot. lbs.	T.D.N. lbs.	Net Energy therms
	2 lbs. grain	0.25	1.45	1.48
	2 lbs. dried citrus pulp	0.02	1.52	1.50
Guernsey	requirement for growth	0.86	6.90	6.22
	12 lbs. alfalfa hay	1.40	6.18	5.06
390	Total: hay and grain	1.66	7.63	6.54
lbs.	hay and citrus	1.42	7.70	6.56
Holstein	requirement for growth	0.92	8.20	7.28
	15 lbs. alfalfa hay	1.76	7.73	6.33
510	Total: hay and grain	2.01	9.18	7.81
lbs.	hay and citrus	1.78	9.25	7.83
Jersey	requirement for growth	0.83	6.60	5.98
	11 lbs. alfalfa hay	1.29	5.67	4.64
360	Total: hay and grain	1.54	7.11	6.12
lbs.	hay and citrus	1.31	7.18	6.15

IV. RESULTS

A. Height and Weight Data. The data on the heights and weights of the calves are presented in tabular form (Tables 3,4) and graphically (Figures 2,3,and 4) by breeds. The height of the animal is represented on the horizontal axis and the weight is shown on the vertical. The average height and weight are shown for each group. In addition, the standard growth curve at the corresponding ages is also shown for each breed. It can be noted that both the experimental and control groups had more rapid growth rates than the standard for these breeds, as shown by Ragsdale (17).

The dried citrus pulp group made essentially the same growth as the control. This may have been due, in part, to the fact that nearly all their nutritional requirements were supplied by the high quality alfalfa hay. The supplementary feeds may have been incidental to their growth.

B. Statistical Analyses of Height and Weight Data. Statistical analyses of the data with the mean of the growth for the various groups, as indicated by the pounds gained in weight over the six month experimental period, are shown (Table 5).

The mean value was calculated by formula (a) below. The mean (M) equals the summation (S) of each individual

Table 3. Height of the experimental and control groups of Guernsey, Holstein, and Jersey calves from six to twelve months of age, as compared with the standards.

	Guernsey			Holstein			Jersey		
	Standard 1/	citrus	control	standard 1/	citrus	control	standard 1/	citrus	control
6 mo.	36.9"	38.1	38.6	39.7"	40.4	40.6	36.2"	36.7	36.4
7 mo.	38.4	38.8	39.6	41.1	41.8	42.0	37.7	38.2	37.7
8 mo.	39.9	39.6	40.7	42.3	42.8	43.5	39.0	39.1	38.3
9 mo.	40.9	40.7	41.9	43.5	44.0	44.5	40.1	39.9	39.5
10 mo.	41.7	41.2	42.3	44.4	45.0	45.2	40.9	40.7	40.2
11 mo.	42.6	41.8	42.7	45.3	46.1	46.3	41.7	41.7	41.1
12 mo.	43.3	42.6	43.5	46.0	47.3	47.4	42.2	42.4	41.5

1/ Standard for the breed from Ragsdale (17).

Table 4. Weight of the experimental and control groups of Guernsey, Holstein, and Jersey calves from six to twelve months of age, as compared with the standards.

	Guernsey			Holstein			Jersey		
	standard 1/	citrus	control	standard 1/	citrus	control	standard 1/	citrus	control
birth weight	65#	59	63	90#	91	91	53#	51	53
6 mo.	260	290	324	355	397	403	243	279	268
7 mo.	305	323	375	410	456	435	286	317	309
8 mo.	350	358	439	462	499	510	324	344	341
9 mo.	389	405	477	509	564	576	360	395	377
10 mo.	427	430	501	552	620	637	393	436	406
11 mo.	459	469	559	593	659	673	420	471	449
12 mo.	490	524	608	632	714	727	450	508	499

1/ Standard for the breed from Ragsdale (17).

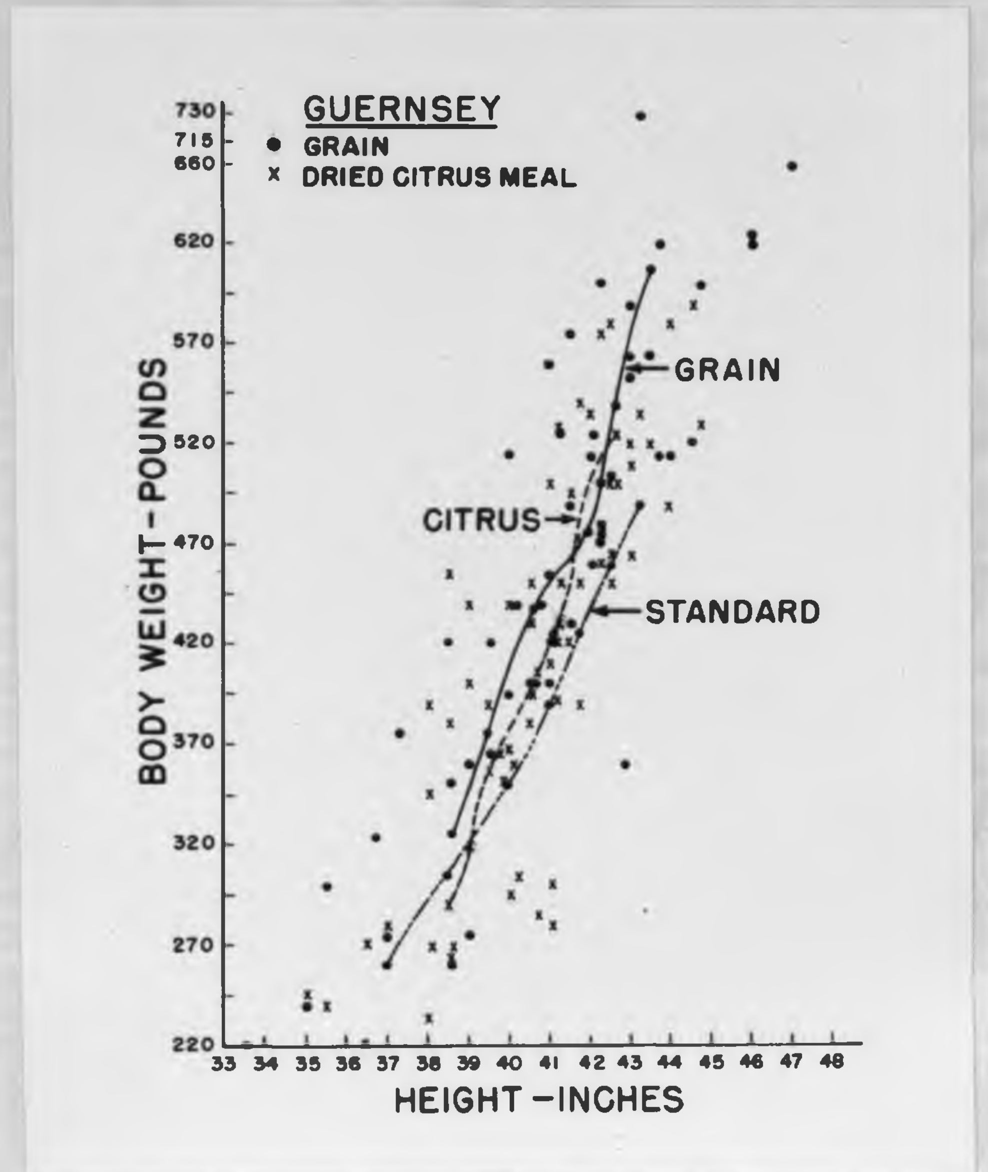

Figure 2. Height and weight data for Guernsey calves

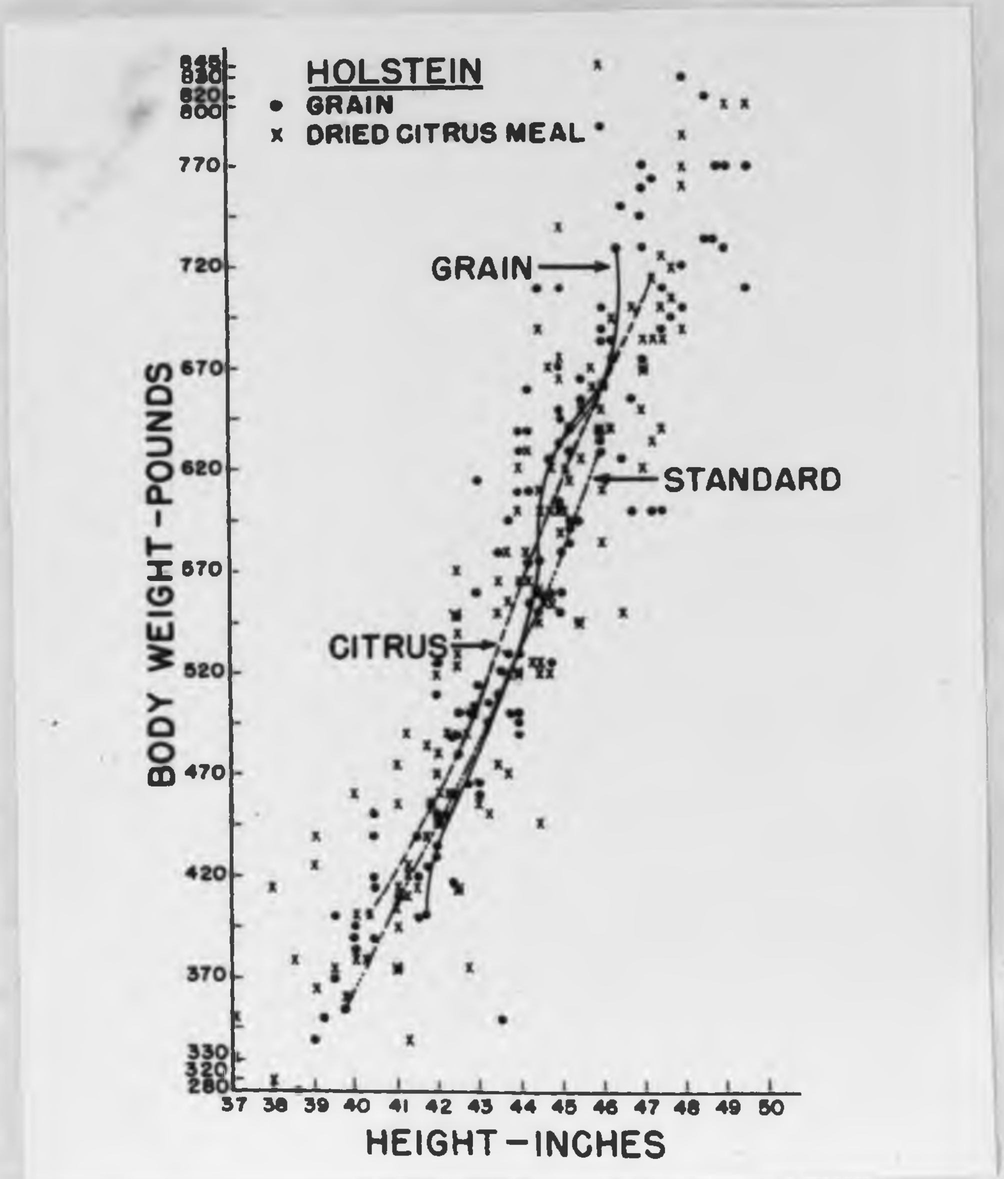

Figure 3. Height and weight data for Holstein calves

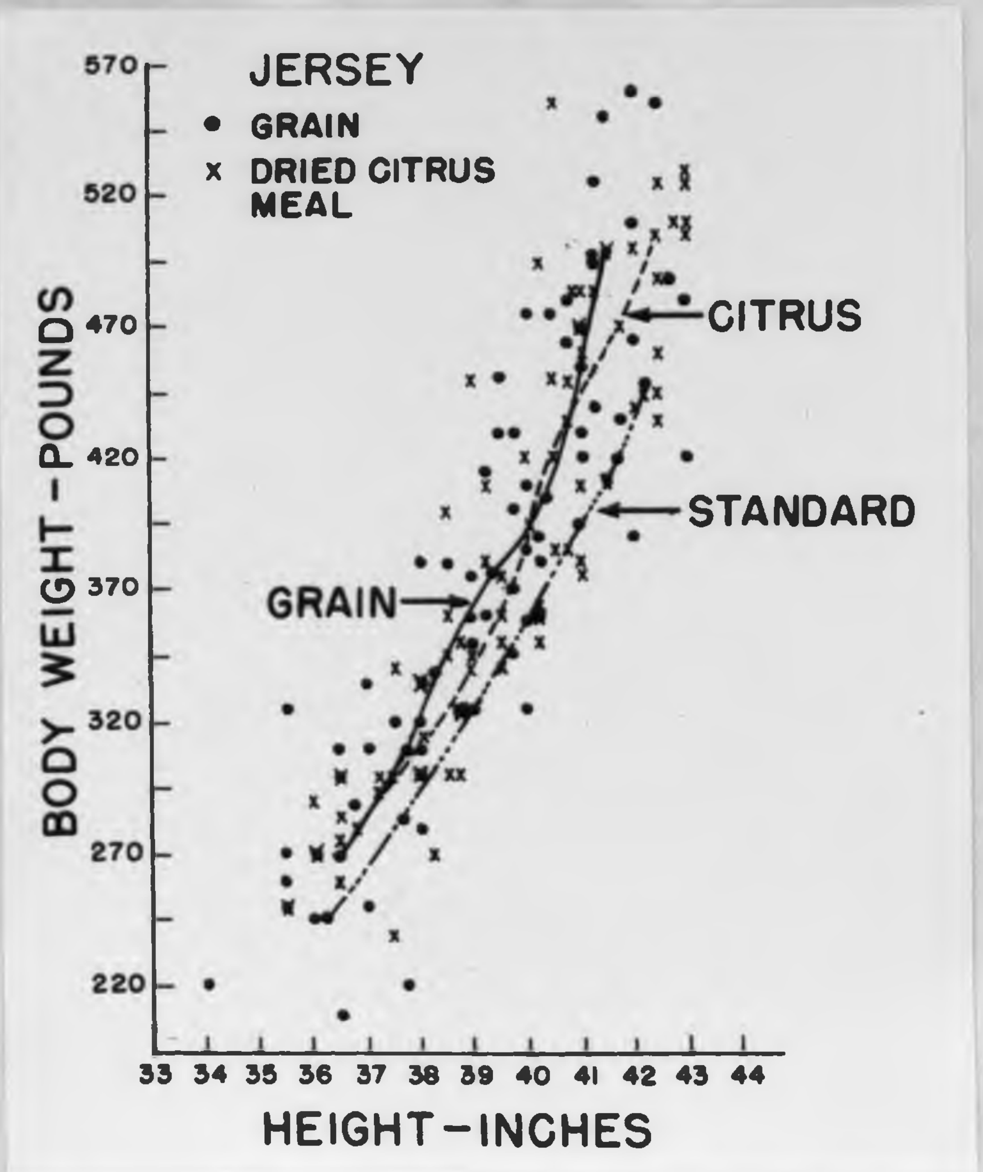

Figure 4. Height and weight data for Jersey calves

Table 5. The mean, standard error of the mean, and the "t" value of significance of the experimental and control groups of the calves.

Breed	Group	Mean	Standard error of the mean	"t" value
Guernsey	Dried Citrus	234	14.4	1.49
	Grain (Control)	278	25.8	
Holstein	Dried Citrus	314	25.3	0.41
	Grain (Control)	307	12.6	
Jersey	Dried Citrus	218	15.9	1.02
	Grain (Control)	237	9.7	

item (X) representing the gain in weight over the experimental period, divided by the number of items (N) in the sample. The standard error of the mean (θ) was calculated by the machine method of Snedecor (25) as set forth in formula (b). The "t" value of significance was calculated by use of formula (c). These "t" values show there was no significant difference in the rate of growth between the Guernseys, Holsteins, and Jerseys in the experimental and control groups at the five percent level with 7, 12, and 8 degrees of freedom, respectively.

formula (a) $$M = \frac{SX}{N}$$

formula (b) $$\theta = \sqrt{\frac{S(X)^2 - \frac{(SX)^2}{N}}{N(N-1)}}$$

formula (c) $$"t" = \frac{M_1 - M_2}{\sqrt{\theta_1^2 + \theta_1^2}}$$

C. <u>Breeding Efficiency of Experimental Animals with Statistical Analyses</u>. The greatest discrepancy in breeding efficiency was among the Guernsey heifers (Table 6). These animals required 2.43 services per conception for the citrus group as compared to 1.60 for the animals in the control. This discrepancy was treated statistically, showing a "t" value of 1.81 which indicated no significant difference at

Table 6. Services required per conception for the experimental and control groups.

Citrus Group

	Guernsey	Holstein	Jersey
Animals	7	13	8
Pregnancies	7	23	15
Services	17	30	23
Conception Rate 1:	2.43	1.30	1.53

Control Group

	Guernsey	Holstein	Jersey
Animals	6	12	8
Pregnancies	10	24	17
Services	16	32	23
Conception Rate 1:	1.60	1.33	1.35

the five percent level with five degrees of freedom (25). The mean of the services per conception was 1.56 ± .086 and 1.39 ± .105 for the entire citrus and control groups, respectively. Trimberger and Davis (28) state that the conception rate of 22,684 cows studied was 1.79 from natural services and 1.63 for 5,539 cows conceived from artificial services. The conception rate of animals in this study was, therefore, in agreement with other work having larger sampling.

V. SUMMARY AND CONCLUSIONS

A. Dried Citrus Pulp as a Substitute for a Regular Grain Mixture in the Rations of Dairy Calves. Thirty-three calves of the Guernsey, Holstein, and Jersey breeds were fed dried citrus meal as a substitute for the regular calf grain mixture. This was fed from six months of age until they became one year old. Liberal amounts of alfalfa hay were fed at all times as the only source of roughage for both groups. The thirty-one calves in the control group showed slightly larger growth as evidenced by the slightly higher gains in body weight as compared to the citrus calves However, a statistical analysis of the data shows no significant difference in growth. No apparent differences were noted in the glossiness of the hair where dried citrus meal was fed.

This study has proven conclusively that two pounds of dried citrus meal can replace an equal amount of a regular grain mixture in the ration of six month old calves when good quality alfalfa hay is fed in liberal amounts. The substitution was also shown to be economical, since this is the most economical source of carbohydrate feed available to Arizona dairymen today.

No significant difference was noted in the conception rate between the two groups. A total of fity-one pregnancies resulted from seventy-one services in the experimental group as compared to forty-five pregnancies from sixty services in the control group.

PART II. Dried Citrus Pulp in the Rations of Dairy Cows.

III. EXPERIMENTAL

Five pairs of Holstein cows were grouped in two lots as nearly as possible as to age, weight, stage of lactation, and production. The five pairs were placed on a thirty-day, double-reversal feeding trial to study the effect of dried citrus meal in the grain ration of lactating cows. The animals were weighed at the same time of day on three consecutive days at the start and at the end of each of the three experimental periods.

D. Rations for Cows. The animals were fed all the good quality alfalfa hay they would consume. In addition, they were fed a concentrate mixture at the rate of one pound for each five pounds of milk produced over twenty pounds per day. The experimental group received a ration consisting of dried citrus meal - 2000 pounds, rolled barley - 600 pounds, cottonseed meal - 600 pounds, and wheat bran - 800 pounds. This grain mixture contained essentially the same amounts of digestible protein, total digestible nutrients, and net energy as the control ration. The control ration was composed of cottonseed meal - 223 pounds, rolled barley - 1334 pounds, wheat bran - 889 pounds, rolled hegari - 1110 pounds, and dried beet pulp - 444 pounds. Each group had block salt together with a mixture of loose salt and steamed bonemeal.

IV. RESULTS

D. Milk Production of Experimental and Control Groups. The two groups of five cows each produced a total of 16,593 pounds of milk when fed the dried citrus ration as compared to 17,479 pounds when receiving the control or regular grain ration. The difference between the two groups was not significant. The "t" value was 0.76 at the forty percent level with four degrees of freedom.

E. Hay Consumption. The hay consumption was 2.7 pounds per hundred pounds of body weight for both groups of Holstein cows weighing approximately 1400 pounds.

F. Changes in Body Weight of Experimental Animals. The experimental ration produced a gain in weight of forty-five pounds per animal and twenty-one pounds per animal on the control ration during the ninety-day period.

G. Flavor of the Milk. The flavor of the raw milk was studied regularly throughout the experimental period to detect any off-flavors which might have been produced. No difference was noted in the flavor of the milk from the two groups. These results are in agreement with the work of the Florida workers (1,6,8), and in partial agreement with the work of Tarassuk and Roadhouse (27). The latter investigators state identifiable, but not objectionable flavors were produced when the cows consumed two to four pounds of dried orange pulp one and one-half hours before milking. The flavor scores were lowered with increased amounts of citrus pulp fed. They also report no apparent difference in flavor due to feeding citrus meal produced from lemon, grapefruit, or orange pulp.

V. SUMMARY AND CONCLUSIONS

B. Dried Citrus Pulp for Dairy Cows. Five pairs of Holstein cows were used in a thirty-day, double reversal, feeding trial, to ascertain the value of a grain ration containing fifty percent dried citrus pulp, as compared to a regular grain ration. The two grain concentrate mixtures were approximately equal in digestible protein, total digestible nutrients, and net energy values. The animals fed the citrus ration produced slightly less milk than the control. There was no significant difference, however, in the milk production.

The experimental ration was readily consumed by all the Holstein cows in this project. There was no cow that refused all or part of the experimental ration after a three day transition period from one concentrate to the other. These results indicate that dried citrus pulp can be used to constitute one-half of the grain mixture. It thus reduced materially the feed cost without sacrificing milk production and palatability.

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