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Citrus Feeds for Beef Cattle[1]

H.L. Chapman, Jr., C.B. Ammerman, F.S. Baker, Jr., J.F. Hentges, B.W. Hayes, and T.J. Cunha[2]

A number of residue materials are produced when fresh citrus is processed into juice, and canned fruit. These include peel, rag, and seeds. The volume of these residue has increased as the Florida citrus industry has grown (37)[3]. Studies have been by researchers of the Florida Agricultural Experiment Stations for 60 years[4] (15, 30, to evaluate the various materials as feeds for livestock. Early work emphasized the use of citrus pulp for livestock feeds (36), and for the first few decades considerable quantities of material were dumped on the ground and fed wet to cattle as a supplement to pasture, range, dairy feeds. The high moisture content of the fresh pulp limited the distance it could be transported, and there were variations in palatability of pulp from varius citrus (10, 14) .These problems led to the developement of dried citrus pulp during the 1930's, today most citrus pulp is used in the dry form. When the citrus pulp is dried, other citrus such as molasses and citrus meal are produced.

The chemical composition and physical appearance of these citrus feeds varies a great deal, on the kind of citrus fruit being processed and the procedures used at various plants. For example, some citrus pulp will have the juice pressed out before drying some will be dried without this being done; some pulp contains considerable seeds and some very little seed; and some will have more fine particles than others. These factors emphasize the that may occur between citrus pulp and the importance of properly evaluating the material being fed. In addition, citrus pulp is often pelleted to reduce hauling and storage and this has brought about another important change in processing citrus by-products.

Approximately 672,000 tons of citrus by-product feeds were produced in Florida during 1969-70 .This included about 588,000 tons of dried citrus pulp, 68,000 tons of citrus molasses, and 16,000 tons of dried citrus meal. These feeds provide the Florida beef cattleman with sources of high energy feeds for beef cattle rations. The purpose of this bulletin is to summarize current knowledge and recommendations for the use of these materials in beef cattle feeding.

Types Of Citrus Feeds

Citrus feeds include dried citrus pulp, citrus molasses, citrus meal, citrus seed meal, and wet pulp. The relationship of the various feeds is presented in Figure 1. Considerable variation may occur in citrus feeds, and it is very important to properly evaluate the material fed. The types of citrus by-product feeds are listed in Table 1 in order to indicate some of the

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2. H.L. Chapman, Jr., former professor, C.B. Ammerman, former professor, F.S. Baker, Jr., former professor, J.F. Hentges, former professor, B.W. Hayes, former professor, and T.J. Cunha, former professor; Department of Animal Science, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

variations that may occur. Detailed information about more descriptive nomenclature for by-products and a glossary of feed terms are presented in Appendix A and B.

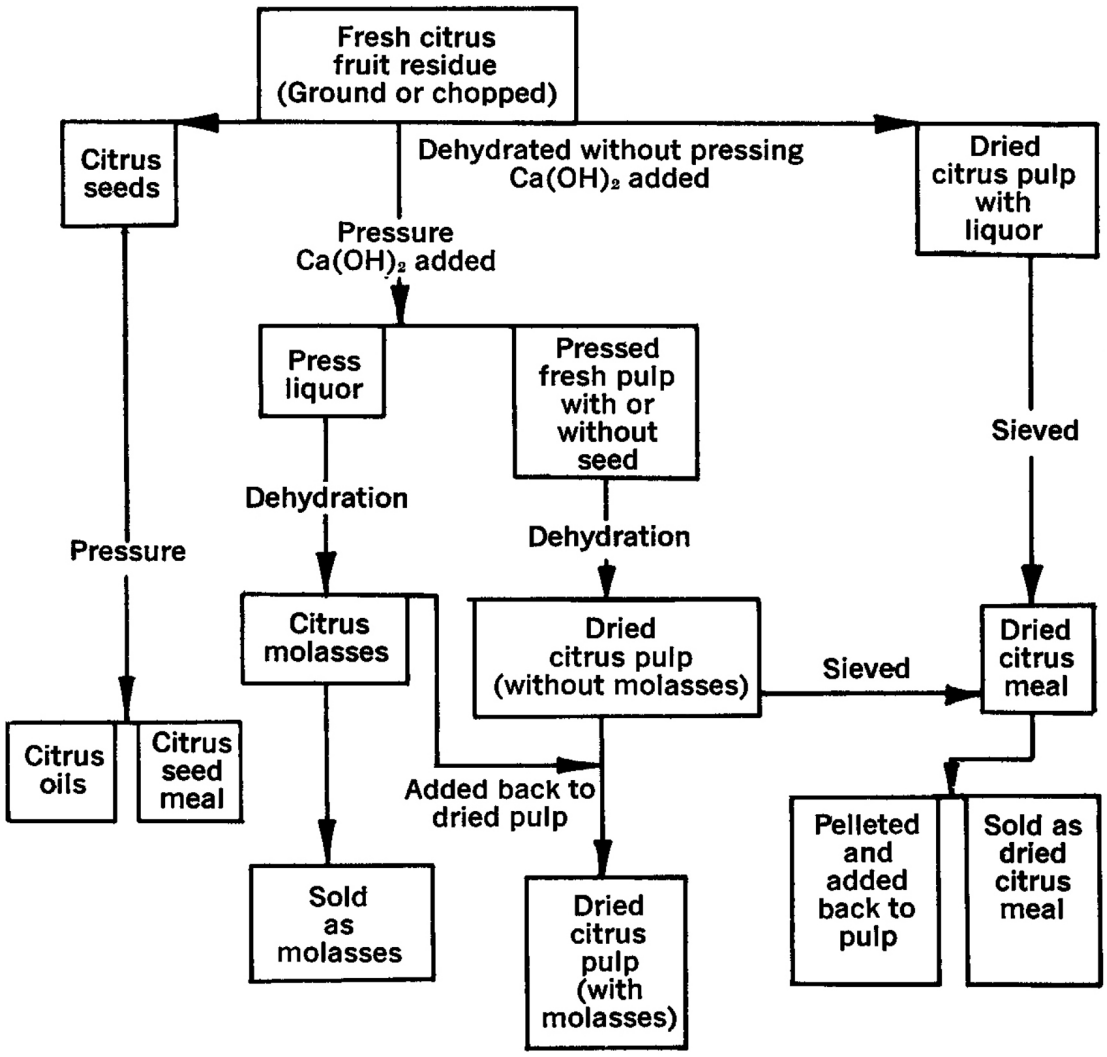

Figure 1. Schematic presentation of citrus by-products.

Dried Citrus Pulp

Research at the Florida Agricultural Experiment Stations in 1911 suggested that dried citrus pulp potential value as a feed for cattle (15, 38). During the early 1930's dried citrus pulp began to produced commercially and since then has become an important feedstuff in cattle rations. It been estimated that approximately 20% of the annual production of pulp is fed to beef cattle 80% to dairy cattle. Greater quantities of pulp will become available for feeding beef cattle if increases in citrus production occur.

Physical Characteristics and Nutrient Composition

Dried citrus pulp is comprised primarily of grapefruit and oranges, but may also contain the residue of lemons, limes, and tangerines. As shown in Figure 1, the basic procedure for producing dried citrus pulp consists of grinding or chopping and then dehydrating the fresh fruit residue. The residue may be pressed, to remove the press liquor, and the remaining pulp then dried; or, it may be dried without removing the press liquor. If it is pressed, molasses is produced

from the press liquor. Molasses is sometimes added back to the pulp during the drying process. The finer particles of the dried pulp are often removed by sieving and either sold as citrus meal or pelleted and added back to the pulp. The pulp may or may not contain large amounts of seeds. These differences in processing, in source and variety of fruit, and in type of canning operation from which the fruit residue is obtained, are responsible for the variation that may occur in the physical characteristics and nutrient content of dried citrus pulp.

The physical characteristics of 24 commercial samples of dried citrus pulp collected in mid-season are shown in Table 2. The average density (weight of a cubic foot of pulp) for all samples was 18.70 pounds. Each sample was separated into two fractions using a Number 10 sieve. The material that passed through the sieve was approximately equivalent to commercial citrus meal. The fraction retained by the sieve was separated further into pellets, seeds, and peel pulp. The pulps contained an average of 45.63% of fine and 54.37% coarse material. As shown in Table 2, considerable variation existed in the amounts of peel, pulp, seeds, and pellets.

The average nutrient composition of the component fractions of citrus pulp is shown in Table 3. Seeds were considerably higher in protein and ether extract and lower in ash, crude fiber, and nitrogen-free extract than the other fractions. The pelleted and unpelleted fines were higher calcium, phosphorus, ether extract, and protein than was the peel plus pulp fraction.

The average nutrient composition of 1728 citrus pulp samples, analyzed over a 5-year period, is shown in Table 4. The moisture content of the pulp varied from 3.5 to 13.7% with an average of 8.58%. Expressed on an air-dry basis, the citrus pulps had an average of 6.16% crude protein, 12.28% crude fiber, 64.56% nitrogen-free-extract (N.F.E.), and 4.6% ash. Nutrient composition of the pulp varied only slightly from year to year. Mineral analyses performed on a limited number of samples (Table 4) , indicate that dried citrus pulp is higher in calcium and potassium than are most grains, but lower in phosphorus and in micro minerals except for iron.

As mentioned earlier, major factors influencing the nutrient composition of citrus pulp include amount of seeds and molasses remaining with the pulp. Citrus pulp with large amounts of seeds will contain more protein and fat than pulp without seeds, and citrus pulp from which molasses has been removed will be higher in fiber and lower in nitrogen-free extract than pulp that contains molasses.

Feeding Value of Dried Citrus Pulp

Good quality dried citrus pulp is highly palatable. It is sometimes referred to as a "bulky concentrate feed" since it is bulky in nature but also relatively high in digestible energy. It is low in digestible protein and is primarily an energy feedstuff having certain "roughage properties." These physical and nutrient characteristics must be considered when rations with citrus pulp are formulated. Average coefficients of digestibility for the nutrients in good quality pulp are: protein, 51% ; fat (ether extract), 85% ; fiber, 68%; and nitrogen-free extract, 89%.These values represent determinations obtained in five studies (1,8, 25, 31, 34) using different types of animals and rations, and different citrus pulps. When these data were applied to the average composition values for pulp (Table 3) , an average total digestible nutrient (TDN) value of 76 was obtained. The TDN value would be lower for poorer quality citrus pulp. Dried citrus pulp has an estimated net energy value for full fed finishing cattle of 68 to 73 megacalories per 100 pounds (32) .When fed at levels of no more than 40% of the ration, good quality citrus pulp is considered to be equal in feeding value to ground snapped corn and to a value 85% to 90% of that for shelled corn (32) .

Extremely high dehydrating temperatures can result in a dried pulp which is dark in color and which contains considerable quantities of charred material. Such pulp is less palatable and has less nutritional value due to a reduced digestibility of protein and energy (3).

Feeding Value in Drylot

Citrus pulp has compared favorably with corn meal and ground snapped corn in feedlot rations for yearling steers (35) when fed at 70% of the concentrate, or 46% of the total ration (Table 5).

During later studies various levels of citrus pulp were added to cattle finishing rations (5,7). Data in Table 6 shows that steers receiving 22% and 44% of citrus pulp in their rations gained more than steers receiving no citrus pulp. Steers receiving citrus pulp also had a higher carcass grade, higher dressing per cent, and more fat over the rib eye. The ruminal papillae of those steers fed 22% citrus pulp were normal, but there were several parakeratotic rumens in the steers fed the two higher levels of pulp. This condition did not appear to influence the performance of steers.

Feeding Value on Pasture

Studies have been conducted concerning the use of dried citrus pulp as a supplement for finishing steers on pasture (19). Crossbred steers grazing St. Augustine pasture were fed either ground snapped corn, dried citrus pulp, cane molasses, or citrus molasses (Table 7, Experiment 1) .The steers gained average of 1.08 to 1.16 pounds per head daily, and the slight differences between supplements were not significant. In a similar study (Table 7, Experiment 2) 6 pounds of several different feeds were fed per head daily to grade Brahman steers grazing St. Augustine pasture. Those steers fed citrus pulp gained faster and had a slightly higher dressing per cent than steers fed other feeds.

Feeding Pelleted Citrus Pulp

There have been economic limitations on the transportation of dried citrus pulp because of its relative bulkiness. When pelleted, its bulk is greatly reduced, resulting in a substantial reduction in transportation and storage costs. Pelleting also increases handling efficiency, decreases dustiness, and decreases bridging in storage bins. To determine the nutritional value of pelleted citrus pulp, an experiment was conducted to compare the feeding value of pelleted and non-pelleted dried citrus pulp, fed at different levels to steers in drylot. The experimental design and results are shown in Table 8. Steers fed the control rations containing no citrus pulp gained an average of 2.84 pounds daily. Those steers fed the three levels of regular pulp gained an average of 2.89 pounds and those fed pelleted pulp gained 2.98 pounds per day. Steers fed 66% regular pulp gained 2.61 pounds and those fed 66% pelleted pulp gained 3.04 pounds per head daily. Feed intake was greater throughout the feeding period for those steers fed pelleted pulp. The difference in feed consumption may have been due in part to the difference in ration density (weight per cubic foot). The concentrate containing 66% pelleted pulp had a density more than twice that of the concentrate containing 66% non-pelleted pulp. Pelleting the citrus pulp increased its density from 13.0 to 41.6 pounds per cubic foot. The decrease in bulkiness and particle size may cause the pelleted pulp to lose some of the "roughage properties" generally attributed to non-pelleted citrus pulp. Other studies (24) have suggested that the utilization of urea nitrogen may be improved by incorporating the urea into a citrus pulp pellet. More information is needed concerning the effect of pelleting on nutritional value of citrus pulp.

Feeding Recommendations

Good quality dried citrus pulp is an excellent, high-energy feed that can be used in rations for finishing cattle in drylot, or on pasture. Concentrate mixtures can contain 40% dried citrus pulp with excellent results. Higher levels can be used by experienced feeders. If more than 60% of the concentrate is citrus pulp, rumen parakeratosis may occur in cattle being full-fed in drylot. However, straight citrus pulp can be limited fed on pasture with excellent results and will produce no harmful effects.

It is important to properly evaluate dried citrus pulp. Dark pulps may have been overheated and charred during the dehydrating process and will have less digestible energy and protein than good-quality pulp. When citrus pulp is used in concentrate feeds, special attention should be taken to be sure the rest of the diet includes adequate protein, fiber, and phosphorus.

Pelleted citrus pulp can be used in finishing rations. However, more information is needed concerning the level that is best to use in beef cattle ration formulation.

Dried Citrus Meal

Dried citrus meal consists of small particles of peel, pulp, and seed that pass through sieves during the processing of citrus waste into dried citrus pulp. The average annual production of dried citrus meal in Florida during 1964 to 1969 was 12,800 tons (37).

The average nutrient composition of dried citrus meal is shown in Table 9. The appearance and composition of commercial sources of dried citrus meal may vary widely, depending upon the kind of drying equipment and sieves used to process the citrus residue and the kind of fruit being processed. Steam drying methods can produce a better quality citrus meal than direct fire driers, as there is less charring of the citrus residue. The color of dried citrus meal may vary from golden yellow to black depending on the degree of charring during drying. Charred, black citrus meals and citrus mill dust have a lower nutritional value for livestock. Every effort should be made to eliminate charring. The seed particles in dried citrus meal impart some of its golden color and much of its protein and fat content.

Feeding Value of Dried Citrus Meal

Research (27) has shown that high quality citrus meal may contain as much as 6.46% crude protein and 70% to 72% TDN, about equal to dried citrus pulp. The digestibility of nutrients in dried citrus meal and dried citrus pulp by cattle has been reported to be similar (25, 31, 33, 34) .In a feeding trial (12) yearling steers ate high quality citrus meal more readily than citrus pulp and gained slightly more weight. It was concluded that either citrus meal or pulp was a satisfactory substitute for one-third of the ground snapped corn in a ration containing up to 40% citrus molasses.

Other research (23) showed that corn meal could be replaced in pelleted, high concentrate rations by high quality steam-dried citrus meal plus sources of phosphorus and protein. Five lots of yearling steers were self-fed diets which contained 0, 15.8%, 31.6%, 47.4%, or 63.2% of steam-dried citrus meal. Weight gains among lots at the end of the 142trial were similar, except the lot which received the ration containing 63.2% dried citrus meal had more variability in gains. Steers fed rations containing 0, 15.8%, and 31.6% dried citrus meal had almost equal feed efficiency, but feed efficiency was reduced when rations contained 47.4%, and 63.2% of dried citrus meal. Decreased efficiency of feed conversion was correlated with an increased acetic acid and decreased propionic acid level in rumen fluid.

The two higher levels produced an apparently harmful alteration of the rumen mucosa: papillae were darker. smaller, and more irregular in shape; papillae were partially coated or encrusted and showed a high incidence of regression. As the percent of dried citrus meal in the diet increased, the dressing percentage, carcass grade, marbling score, and backthickness decreased, but the carcass yield grade and estimated yield of rib, loin, round, and rump increased. All rations produced steaks of excellent and equal tenderness and juiciness. The percentage saturated fatty acid composition of backfat was increased by the addition of steam dried citrus meal to the ration.

Feeding Recommendations

The appearance, composition, and feed value may be different for dried citrus meals obtained from different processors; therefore, the meals should be inspected and valued accordingly. Dried citrus meal which is bright and golden in color should be used in preference to one that is charred or dark in color. It should be bulky and preferably not be of a fine sand-like consistency. The same precautions should be taken as with citrus pulp, to see that protein, fiber, and phosphorus levels are properly balanced. High quality steam-dried citrus meal, properly supplemented, can replace up to about 60% of corn meal and comprise up to about 40% of formulas for finishing yearling cattle. A decrease in feed conversion efficiency may be experienced with each increase in dried citrus meal above 40%. Rations to be creep-fed to suckling calves should be formulated to contain no more than 40% of the highest quality citrus meal. Dried citrus meal can be fed free choice in conjunction with good pasture.

Citrus Seed Meal

The availability of citrus seed meal depends on whether citrus seeds can be separated profitably from citrus pulp. Current annual production is about 3,000 tons and may increase in the future. Dried citrus pulp has been reported to contain from 1.83% to 8.27% seeds with an average seed content of 4.75% (2) .There has been some interest expressed in separating the seeds providing a suitable and profitable market for citrus seed oil develops. If this occurs, the remaining citrus seed meal would be available for animal feeding.

Citrus seed meal is left after the oil has been extracted from the citrus seed. It varies in protein content, but its average value Is 23.2% .If the hulls are removed from the seeds, the protein level is increased from 14.6% to 17.6%, if the fat is not extracted. If the fat is first extracted, the protein level will vary from 26.5% to 43.0% depending on whether a complete ether extraction occurs.

Feeding Value of Citrus Seed Meal

A trial in 1950 (20) showed that citrus seed meal, containing 35% protein, was equal in value to cottonseed meal as the sole source of supplemental protein for finishing steers. No significant differences were found between the steers fed citrus seed meal or cottonseed meal with regard to weight gain, feed efficiency shrinkage in transit to market, carcass yield and grade, or in general appearance. During the same study citrus seed meal was fed to two steers for a year to determine if the material was toxic to cattle. No evidence of toxicity occurred in the performance of the animals, and none was observed in gross pathology examination at slaughter.

A digestion trial with lambs (6) showed that the protein in citrus seed meal, when supplied at a level of 88% of the total protein in the ration, was equal in digestibility and biological value to the protein from two samples of soybean meal. The average digestibility of the protein in the citrus seed meal and soybean meal rations was 64% and 61%, respectively.

Feeding Recommendations

Citrus seed meal can be used in beef cattle rations as a substitute for protein supplements such as cottonseed meal and soybean meal. Limited research data indicate citrus seed meal can be substituted entirely for other protein supplements; however, it is recommended that citrus seed meal not replace more than one half cottonseed meal or soybean meal in beef cattle rations, especially with young calves.

Citrus Molasses

Citrus molasses is manufactured from the bound juice released from limed, cured, and pressed orange and grapefruit peel residues. For example, after the juice is extracted from 1,000 boxes (85,000 pounds) of fresh grapefruit, approximately 3,215 pounds of citrus molasses may be produced from press liquor obtained from the cured peel and pulp residue (22) .

Commercial production of citrus molasses was begun during the 1941season with an output of 2,500 tons. Annual production rose rapidly to 58,000 tons in 1946-47 with little increase thereafter (21,37) .Although production of dried citrus pulp continued to increase after 1946-47, the practice of blending the molasses with citrus pulp limited the output of citrus molasses until the early 1960's. As mentioned earlier, some producers of citrus feeds have recently installed equipment which will dry citrus peel residue including liquids, thereby eliminating the separate production of citrus molasses. This development will undoubtedly reduce production of citrus molasses somewhat. However, information from citrus processors indicates that a considerable tonnage of molasses will continue to be available in the future.[5]

Citrus molasses in Florida is required to have 45% total sugar, have a Brix of 71°, and weigh approximately 11.3 pounds per gallon. It resembles blackstrap molasses but has less dry matter (Table 10) to insure proper viscosity that is sometimes a problem due to insoluble suspended material (21). Typical analyses of Florida citrus molasses are presented below (22, 27) :

pH 5.00

Brix 72°

Total sugars, % 45

Crude protein, % 4.1 - 6.1

Dry matter, % 64 - 71

Crude fiber, % 0

Ash, % 4.3 - 4.7

Calcium, % 0.80

Phosphorus, % 0.06

Total digestible nutrient, % 51.8 - 56.7

The total digestible nutrient content of citrus molasses has been fairly uniform when considered on a dry matter basis (16, 27). It is estimated to have 70% to 85% the value of No.2 corn if fed at less than 35% of the concentrate, and 40% to 45% if fed at higher levels (32).

Comparitive Composition of Citrus and Blackstrap Molasses

Considerable variation exists in molasses composition. Typical compositions for Florida-produced mill run blackstrap, cane, and citrus molasses are presented in Table 10. Citrus molasses is slightly lower than the other two molasses in dry matter, crude protein, and total sugars. When used as a supplement to permanent pasture grasses, citrus molasses would have about 95% the feed value of cane molasses and 85% the value of millrun blackstrap molasses for beef cattle on a fresh wet basis.

Feeding Value in the Feedlot

In early studies, citrus molasses was tried in relatively high roughage (40%) finishing rations, without stilbestrol, with a resultant 7.5% increase in feed intake, 25% increase in rate of gain and 12.8% improvement in feed efficiency. In these studies citrus molasses replaced half of the ground snapped corn in a high roughage ration that produced a low level of performance and feed conversion with feedlot steers (11). Citrus molasses was superior to blackstrap at this high level of molasses intake (13). Other feedlot trials indicated that citrus and blackstrap molasses had a similar feeding value. (29).

In later studies with lower roughage rations, and added stilbestrol, cattle performance was better and the degree of response to citrus molasses was not as great as with the earlier less efficient rations (11) .However, as shown in Table 11, adding citrus molasses to either a ground snapped corn or ground shelled corn ration improved feed efficiency. Similarly, as shown in Table 12, adding citrus molasses has improved gain and feed efficiency with high moisture corn as well as with dry corn.

Feeding Recommendations for Feedlot Cattle

Citrus molasses can be included in beef cattle finishing rations up to a level of 10% to 20% of the concentrate. It can be substituted for corn or other cereal grains. Larger quantities of citrus molasses may be used if grain is high priced and molasses is relatively cheap. Do not feed enough molasses to restrict total feed intake. There is much variation in the composition of citrus molasses, and there appears to be some difference in the amount of molasses that different groups of cattle will readily consume. If a high level of citrus pulp is fed, the amount of citrus molasses should be limited. A maximum of 40% of the combined citrus molasses and pulp will probably give best results. Citrus molasses may be fed satisfactorily to finishing cattle by mixing with the feed, by pumping in the trough between layers of dry feed, or by pouring it on top of the dry feed in the trough without mixing, or by self-feeding.

Feeding Value on Pasture

In a series of trials at the Agricultural Research and Education Center, Belle Glade, corn, citrus pulp, cane molasses, and citrus molasses were compared as supplements to pasture for finishing steers (19) . As shown in Table 7, weight gains were similar with the various supplements, but feed conversion was less efficient than with the other supplements.

Feeding Recommendations for Pasture Cattle

1. Citrus molasses can be used very satisfactorily as a supplement to permanent pasture. It is a high energy feed, relatively low in crude protein and phosphorus. If it is used as the principal supplemental feed, extra protein and phosphorus should be provided for cattle, unless the forage contains enough of these nutrients.

2. Use the kind of molasses that is the most economical in cost, based on its relative feeding value.

3. Voluntary intake of citrus molasses will be more than that of blackstrap molasses. The maximum recommended amount is usually 6 pounds per animal daily. If the intake is to be kept at 6 pounds, it may be necessary to limit the amount fed.

Wet Citrus Pulp

Wet citrus pulp is the residue from fresh fruit after the juice or pulp are removed. As with dried citrus pulp, its composition will vary considerably (22) depending upon the variety of citrus pulp involved, percentage of seed, and manufacturing processes used. Typically it will contain approximately 18% to 25% dry matter, 1.2% to 2.2% crude protein, 2.2% to 4.6% crude fiber, 12% to 18% nitrogen free extract, 1.2% to 2.7% ether extract, and 0.7% to 1.5% ash.

Utilization of citrus residue has been of concern to the Florida citrus industry since 1911 (38). For the first few decades the fresh residue was dumped on the ground and cattle were allowed to help themselves. This practice has not been widely followed during the past 25 years, except when residue production exceeded the drying capacity of a citrus processing plant or when an occasional load of cull fruit was dumped on a pasture.

Early studies indicated that the fresh citrus residue was an acceptable livestock feed but that better utilization could be made of the feed when it was dried. However, there may still be instances when the fresh citrus residue can be used economically in feeding programs.

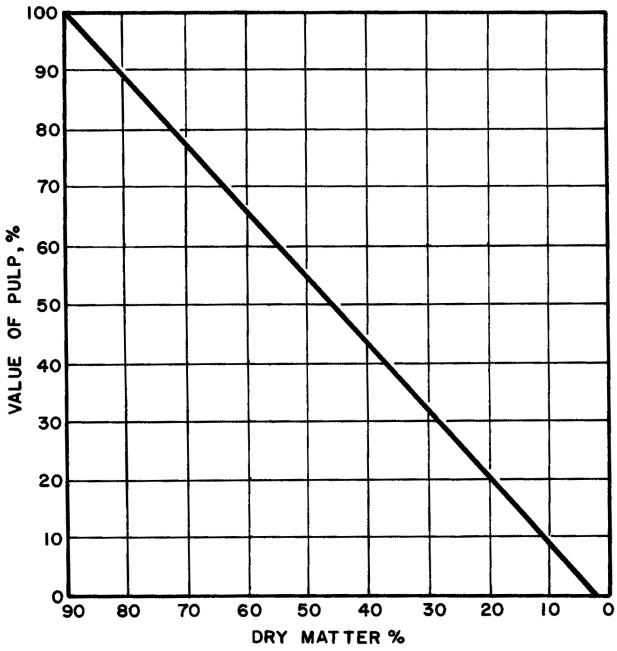

Figure 2. Nutritional or economic value of citrus pulp in relation to its dry matter content. Regular pulp is assumed to contain 90% dry matter.

Fresh Wet Citrus Pulp

Work in California in the 1920's (36) indicated that fresh orange pulp could be used successfully in dairy rations if mixed with other ingredients to make it more palatable. Fresh grapefruit was fed routinely by Florida dairymen before dried citrus pulp became widely accepted (10) , and fresh pulp was also used as a supplement to native range pasture forage for beef cattle (26) .A later report (14) indicated that fresh citrus pulp could be used as a winter supplement to pasture if transportation costs were not excessive and substantiated that fresh grapefruit was more palatable than fresh orange pulp. The value of various citrus by-products for beef cattle has been reviewed earlier (27) , and feeding recommendations have been made for feeding cull grapefruit and oranges, dried citrus pulp, citrus meal, and citrus molasses to beef cattle.

Feeding studies with beef cattle (28) indicate that rate of weight gain will be directly related to the level of TDN intake. Fresh grapefruit was again shown to be more palatable than fresh orange pulp. The palatability of orange pulp was improved by removing essential oils from the skin of the fruit, but this operation was not considered to be economically feasible. These studies revealed that fresh citrus pulp

was a good feed for cattle if intake could be increased and the moisture content reduced. As shown in Figure 2, the greater the water content of the fresh fruit the lower the nutritional value of fresh pulp.

Wet Citrus Pulp Silage

The fresh residue is relatively high in moisture, and if ensiled there will be considerable loss of moisture and water soluble nutrients. Several feeding studies with citrus pulp silage were conducted during the early 1940's (17) . Citrus pulp lost 21% in weight when ensiled in a trench silo, with most of the losses being soluble carbohydrates. The inclusion of hay or sugarcane improved the silage quality and increased efficiency of preservation. Plain citrus pulp silage was less palatable than citrus silage made in combination with hay or sugarcane, but it was readily eaten after beef cattle became accustomed to it.

Recent investigations[6] have been conducted in which fresh citrus pulp was ensiled in combination with whole corn and soybean meal. After being ensiled for 3 weeks, the mixture was palatable and was readily eaten by steers. However, the fresh citrus pulp mixed with whole corn and soybean meal produced plastic-like mixture that could not be handled easily. More study is needed regarding the type of equipment that will be needed to handle this type of mixture. When stored in a sealed container, there was no spoilage after three weeks. The mixture that was stored in the open with no cover developed a hard, foul smelling crust on top. When this crust was removed, the silage mixture underneath was readily consumed.

The inclusion of other feeds with fresh citrus pulp will reduce the water content of fresh pulp and increase total digestible nutrients and crude protein content. The resulting mixture can be ensiled or fed fresh. Cattle may have to be taught to eat the mixture, but after they are accustomed to it they will consume it readily.

Feeding Recommendations

The extent to which fresh or ensiled wet citrus pulp is fed will depend on the relative cost of nutrients in the pulp as compared to nutrients in other available feed ingredients and upon localized conditions where cull citrus fruit is available or where fresh pulp production exceeds the drying capacity of a fruit processing plant. When this occurs, the wet pulp may be fed to cattle, thus helping defray disposal costs by converting a potential waste product to a useful product.

Wet citrus pulp is a carbohydrate feed low in both crude protein and crude fiber and relatively high in moisture. If fed in drylot, it should be fed in combination with a protein supplement, a dry carbohydrate material, a source of roughage, vitamin A, and a well balanced mineral supplement if the diet is to be nutritionally well balanced. When fed as a supplement to pasture, it should be fed in combination with protein and minerals.

Summary and Discussion

The results of research to determine. the feeding value of dried citrus pulp, citrus meal, citrus seed meal, citrus molasses, and wet citrus pulp have been presented. These are excellent beef cattle feeds if used properly. The nutrient composition of the various feeds will vary considerably and should be properly evaluated before using them in beef cattle diets. They are all excellent sources of digestible energy. Dried citrus pulp is high in calcium and digestible energy, but low in digestible protein and phosphorus. If properly supplemented with protein and phosphorus, it can be used to furnish 40% of feedlot rations, with excellent results. Pelleted citrus pulp is well utilized in the feedlot, but it loses some of its "roughage property," and this should be considered when using the pelleted material.

Citrus meal should be used with care, as it varies greatly in chemical and physical properties. Good quality dried citrus meal, if properly supplemented, can replace up to 60% of corn meal and be used to a maximum of 40% of the total ration. It is also high in calcium and digestible energy and low in protein and phosphorus and should be properly supplemented with needed nutrients.

Citrus seed meal contains variable protein level, but will average around 28%. It is low in fiber, and variable in fat content, crude fiber and nitrogen-free extract. It can be used as a substitute for other plant protein supplements in beef cattle rations.

Citrus molasses has been successfully used both on pasture and in the feedlot. It can be fed at the 10% to 20% level in feedlot rations quite successfully, and at higher levels if the price of other feedstuffs warrant. It has been used successfully as the total supplement for cattle on pasture and its use for this program should be based on cost relative to other feedstuffs. A maximum of 6 pounds per animal daily on pasture is usually recommended.

Wet citrus pulp is not widely used because of the economics of transporting and handling a material containing 75% to 85% moisture. However, it is a carbohydrate feed, low in crude fiber, and crude protein and can be used in a cattle feeding program if economics or other conditions warrant. It should be fed in combination with a protein supplement, a dry carbohydrate material, roughage, vitamin A, and a well-balanced mineral supplement.

Much research has been conducted during the past 60 years by the Florida Agricultural Experiment Stations. However, newer technology has created a need for additional research that will provide beef cattlemen with further information that will allow them to better use citrus feeds. For example, citrus feeds need to be standardized so that they will produce a uniform effect when fed to cattle. Processors are encouraged to describe their products so that buyers will know exactly what they are purchasing. More information is needed on what levels of the citrus feeds can best be used as supplements for cows, for developing calves, and for finishing cattle. More citrus pulp is being pelleted each year, and more information is needed on how pelleted citrus pulp can be used in the above programs. Information is needed on how much molasses can be added back to citrus pulp and the effect it has on the feeding value of pulp. More data is needed on the effect of other production variables such as temperature on the feeding value of pulp. If fresh citrus pulp is to be used, more information is needed on the equipment needed to handle the wet product and also on how it can best be incorporated into beef cattle feeding programs.

However, despite the need for additional research data, much information is already available which proves conclusively, that if used properly, citrus feeds can be profitably fed in beef cattle rations.

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Appendix A

Proposed Descriptive Nomenclature for Citrus By-Product Feedstuffs

A nomenclature system[7] for feedstuffs has been proposed which defines more specifically the feed with regard to its origin, part of plant represented, type of processing, and certain other factors. In applying this system to citrus feeds, the following terms are used to describe the feed more accurately. According to this system, citrus meal is referred to as citrus fines and citrus molasses as citrus syrup. The term meal has been reserved for ground ingredients such as soybean meal, and "fines" represent materials resulting from a screening process such as occurs with citrus pulp. Molasses indicates a by-product from refined sugar production, and syrup denotes a secondary product produced during the process of extracting and concentrating the juice of a fruit. The use of this type of system would be of value in establishing more uniform citrus feeds, would assist in marketing, and would aid in the efficient utilization of the materials from a nutritional standpoint. A partial listing of terminology is shown below:

Citrus, pulp, dehydrated

Citrus, pulp, fines, dehydrated

Citrus, pulp, pressed, dehydrated

Citrus, fines, dehydrated

Citrus, fines, pressed, dehydrated

Citrus, syrup, 45% invert sugar, 71 degrees brix

Citrus, seed, mech-extd ground

The above terms can be used, particularly with regard to citrus pulp and citrus fines, to describe more accurately the type of processing which they have undergone. For example, if the fines have been removed, this is indicated for the remaining pulp. The term "pressed" indicates whether this procedure has been used as an aid in dehydration.

Appendix B

Glossary of Feed Terms[8]

The following is a list of terms which are used in the International Feed Names. They describe: (1) the part of the parent material eaten, (2) the process (es) used in its preparation, (3) the physical form of the part as a single ingredient or the form of a mixture of parts prepared for feeding, and (4) other relevant miscellaneous terms.

APPARENT DIGESTIBLE ENERGY (DE).(term) Foodgross energy minus fecal energy. Similar terms: Apparent absorbed energy ; energy of apparently digested food.

DE = (GE of food per unit dry wt x dry wt of food) - (GE of feces per unit dry wt x dry wt of feces)

$$\text{GE digestion coeficient} = \frac{(\text{GE of food per unit dry wt x dry wt of food}) - (\text{GE of feces per unit dry wt x dry wt of feces})}{\text{GE of food per unit dry wt x dry wt of food}} \times 100$$

ASH. (part) Mineral residue remainin after the burning of combustible substances.

BLOWINGS. (part) See Mill dust.

BRIX DEGREE. A measure of the density of concentration of sugar solutions. When applied to molasses or syrup, it is a measure of soluble solids.

BY(part) Another product(s) produced by a process incidental to its primary purpose.

CALORIE. (cal) is the amount of heat required to raise the temperature of 1g water to 15.5 degrees centigrade from 14.5 degrees centigrade.

CANNERY RESIDUE. (part) Edible residue obtained from the preparation of a product for canning.

CITRUS MILL DUST. See mill dust.

DRIED. (process) Water or other liquid removed. (International term: Dehydrated)

DUST. (part) Fine, dry particles of matter usually resulting from the cleaning or grinding of grains or other feedstuffs.

FAT. (part) A substance, solid or plastic at room temperature, composed chiefly of triglycerides of fatty acids.

FEED(S). (term) Edible material(s) which are consumed by animals to contribute energy and/or nutrients to the animal's diet. (Usually refers to animals rather than man.)

FIBER. (part) An elongate tapering plant cell that has at maturity no protoplasm content. It is found in many plant organs that are well developed in the zylem and phloem of t the vascular system. It imparts elasticity, flexibility, and tensile strength to the plant.

FINES. (physical form) Any material which will pass through a screen whose openings are immediately smaller than the specified minimum crumble size or pellet diameter .

FRUIT. (part) The edible, more or less succulent, product of a perennial or woody plant, consisting of the ripened seeds and adjacent or surrounding tissues, or the latter alone.

GROSS ENERGY (GE) (term) The amount of heat, measured in calories, that is released when a substance is completely oxidized in a bomb calorimeter containing 25 to 30 atmospheres of oxygen. Similar term: Heat of combustion.

GROUND. (process) Reduced in particle size by impact, shearing, or attrition.

JOULE (J) .(term) The International System of Weights and Measures is referred to as the Mkgs system, derived from the first three entries of the fundamental units - the meter , the kilogram and the second. Of particular interest to the animal scientist is the derived unit for energy in terms of heat, the joule(J). One calorie is equal to 4.184 joules. At the present time, animal scientists are using the calorie as the unit of measure for heat energy ; however, sometime in the future the joule may be used.

JUICE. (part) The aqueous substance obtainable from biological tissue by pressing or filtering (with or without addition of water).

MEAL. (physical form) An ingredient which has been ground or otherwise reduced in particle size.

MILL DUST. (part) Fine feed particles of undetermined origin resulting from handling and processing feed and feed ingredients.

METABOLIZABLE ENERGY. (ME) (term) is the food intake gross energy minus fecal energy, minus energy in the gaseous products of digestion, minus urinary energy.

MOLASSES. (part) The thick, viscous by-product resulting from refined sugar production or the concentrated, partially dehydrated juices from fruits.

NET ENERGY. (NE) (term) is the difference between metabolizable energy and heat increment, and includes the amount of energy used either for maintenance only or for maintenance plus production. Net energy can also be expressed as the gross energy of the gain in tissue or of the products synthesized plus the energy requirement for maintenance. Below the critical temperature the heat increment is also part of net energy.

When reporting net energy, is should be clearly stated which functions are included. For example, there may be values for net energy for maintenance plus production (NE_{m+p}), net energy for maintenance only (NE_m), or net energy for production only (NE_p). The subscripts are suggested because there is often confusion in the literature concerning which energy fractions are contained in net energy.

NET ENERGY FOR MAINTENANCE (NE_m) (term) is the fraction of net energy expended to keep the animal in energy equilibrium. In this state, there is no net gain or loss of energy producing animal may be different than for a non-producing animal of the same weight. This is due to changes in amounts of hormones produced and to differences in voluntary activity. This difference may be charged to maintenance, but in practice it is usually charged to the production requirement.

NET ENERGY FOR PRODUCTION (NEp) (term) is the fraction of net energy required in addition to that needed for body maintenance that is used for work or for tissue gain (growth and/or fat production) , or for the growth of, for example, a fetus, milk, eggs, or wool. It should always be clearly stated which production fractions are included. For example, there could be:

NE_{egg}; NE_{gain}; NE_{milk}; NE_{preg}; NE_{wool} ; NE_{work}.

PECTIN. (part) Any of the group of colorless amorphous methylated pectic substances occurring in plant tissues or obtained by restricted treatment of protopectin obtained from fruits or succulent vegetables, that yield viscous solutions with water, and which when combined with acid and sugar yield a gel.

PEEL. (part) Skin.

PELLETS. (physical form) Agglomerated feed formed by compacting and forcing through die openings by a mechanical process. Similar terms: Pelleted feed, hard pellet.

POMACE. (part) Pulp, seeds and stems from fruit. (International term: Pulp) .

PROTEIN. (part) Any of a large class of naturallycomplex combinations of amino acids.

PULP. (part) The solid residue (including seeds and skins if present) remaining after extraction of juices from fruits, roots, or stems. Similar terms: Bagasse, pulp from sugar cane; Pomace, pulp from fruits; Marc, pulp from grapes.

PULP. Plant material less juice.

PULP FINES. (part) Fine particles separated by screening from pulp such as citrus pulp.

RESIDUE. (part) Part remaining after the removal of a portion of its original constituents.

SEED. (part) The fertilized and ripened ovule of a plant.

SYRUP BY-PRODUCT. (part) Secondary product produced during the process of extracting and concentrating the juice of a fruit or plant.

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Additional Notes:

3. Numbers in parentheses refer to Literature Cited.

4. Becker, R. B. 1969. Personal communication.

5. Coates, J. L. 1970. Personal communication.

6. Chapman, H. L. 1970. Unpublished data.

7. Unpublished data obtained from L.E. Harris.

8. The terms and definitions in this glossary are taken from Bulletin 479 of the Utah Agricultural Experiment Station, *An International Feed Nomenclature and Methods for Summarizing and Using Feed Data To Calculate Diets*, by Lorin E. Harris, J. Malcolm Asplund, and Earle W. Crampton (Logan, Utah: 1968).

Table 1. Types of citrus feeds.[1,2]

Citrus residue, fresh, not pressed, ensiled or not ensiled
Citrus residue, fresh, pressed, ensiled or not ensiled
Citrus residue, not pressed, dehydrated with fines
Citrus residue, pressed, dehydrated with fines
Citrus residue, not pressed, dehydrated, without fines
Citrus residue, pressed, dehydrated, without fines
Citrus residue, not pressed, dehydrated, with pelleted fines added
Citrus residue, pressed, dehydrated, pelleted fines and molasses added
Dried citrus pulp fines, from pressed citrus residue
Dried citrus pulp fines, from non-pressed citrus residue
Citrus molasses
Citrus seed meal
Citrus mill dust
[1] Feeds in this list, except for citrus seed meal and citrus molasses, will occur with and without seed.
[2] All of the dried citrus products may be sold in pelleted or non-pelleted form.

Table 2. Physical characteristics of 24 dried citrus pulp samples (2).[1]

Characteristic	Average	Range
Density, lb/cu ft.	18.70	12.54 - 22.66
Fine Material[2]		
Unpelletd fines, %	40.31	9.45 - 64.80
Pelleted fines, %[3]	5.32	3.40 - 38.61
Coarse material[2]		
Peel plus pulp, %	49.62	28.50 - 68.71
Seeds, %	4.75	1.83 - 8.27

[1] All values obtained on citrus pulp samples under air-dry conditions.
[2] Dried citrus pulp was seperated using U.S. Bureau of Standards No. 10 sieve. Approximately equivalent to citrus meal. Although pellets were retained, they were considered as part of the material that would pass through a No. 10 sieve.
[3] Only 8 of 24 samples examined conatined pellets. The average pellet content of the 8 samples was 15.96.

Table 3. Average nutrient composition of dried citrus pulp fractions (%) (1).[1]

Nutrient	Fine material		Coarse material	
	Unpelleted	Pelleted	Peel plus pulp	Seeds
Ash	6.55	7.69	5.09	2.97
Ether extract	2.14	2.13	1.78	47.96
Crude protein	7.16	7.44	6.50	17.31
Crude fiber	12.58	12.91	13.79	8.06
Nitrogen-free extract	71.57	69.83	72.84	23.70
Calcium	2.36	2.37	1.68	0.57
Phosphorus	0.11	0.13	0.09	0.30

Table 3. Average nutrient composition of dried citrus pulp fractions (%) (1).[1]

[1] Values expressed on a dry matter basis. Each figure is the average of 24 samples except for the pelleted fines. Only 8 of the 24 samples contained pellets.

Table 4. Average nutrient composition of dried citrus pulp (4).[1,2]

Nutrient	Number of samples analyzed	Content
Moisture, %	1728	8.58
Ash, %	1728	4.68
Ether extract, %	1728	3.74
Crude protein, %	1728	6.16
Crude fiber, %	1728	12.28
N.F.E., %	1728	64.56
Calcium, %	82	1.43
Phosphorus, %	82	0.11
Magnesium, %	82	0.12
Potassium, %	82	1.09
Sodium, %	82	0.096
Sulfur, %	10	0.066
Iron, ppm	35	98.72
Copper, ppm	35	6.19
Zinc, ppm	35	9.94
Manganese, ppm	35	5.70
Cobalt, ppm	10	0.073

[1] Analyses obtained by the Feed Laboratory, Division of Chemistry, Florida Department of Agriculture, Tallahassee.
[2] All mineral values expressed on a dry matter basis.

Table 5. Average performance of steers fed rations containing citrus pulp, corn meal, or ground snapped corn (35).[1]

	Treatment		
	Citrus pulp	Ground snapped corn	Corn Meal
Initial wt., lb	455	434	434
Final wt., lb	788	779	769
Daily gain, lb	2.38	2.42	2.39
Daily ration, lb			
Concentrate[2]	11.44	12.18	11.43
Pangolagrass hay	3.83	3.61	3.78
Citrus molasses	2.00	2.00	2.00
Minerals	0.14	0.19	0.19
Total	17.41	17.98	17.40
Feed/cwt. gain, lb	735	743	725

[1] Average of three trials of 140 days in drylot.
[2] Concentrate contained 70% citrus pulp, corn meal, or ground snapped corn, 5% 3/4" cut alfalfa and 25% cottonseed meal (41% crude protein).

Table 6. Average performance of steers fed different levels of citrus pulp (7).[1]

	Level of citrus pulp in concentrate, %[2]			
	0	**22**	**44**	**66**
Initial wt., lb	667	685	672	670
Final wt., lb	974	998	1014	975
Daily gain, lb	2.92	2.98	3.26	2.90
Daily ration, lb				
Concentrate	22.05	24.78	23.91	20.92
Bermudagrass hay	2.27	2.27	2.25	2.11
Total	24.32	27.05	26.16	23.03
Feed/cwt. gain, lb	883	908	802	794

[1] Yearling steers fed 105 days in drylot.
[2] Citrus pulp replaced an equal amount of corn meal-cob meal mixture (80% corn meal, 20% cob meal).

Table 7.

Experiment 1 (19)[1]		**Supplement**			
		Citrus pulp	**Ground snapped corn**	**Black-strap molasses**	**Citrus molasses**
Initial wt., lb		663	666	656	658
Final wt., lb		795	808	796	795
Daily gain, lb		1.08	1.16	1.15	1.12
Supp./cwt gain, lb		495	549	682	814
Experiment 2 (18)[2]	**Supplement**				
	None	**Citrus pulp**	**Ground snapped corn**	**Sugarcane molasses**	**Mixed feed**[3]
Supp./cwt gain, lb	0	6	6	6	6
Initial wt., lb	692	692	691	675	692
Final wt., lb	839	931	914	875	923
Daily gain, lb	1.05	1.71	1.59	1.43	1.65
Dressing per cent	54.94	57.82	56.25	56.45	55.84
Cooler shrink, %	1.20	0.76	0.79	0.71	0.58
Supp./cwt gain, lb	0	351	377	420	364

[1] Average of three trials, 119 to 127 days in length.
[2] Steers fed 140 days.
[3] Mixed feed contained 40.0% ground snapped corn, 38.3% dried citrus pulp, 20.0% cottonseed meal, and 1.7% complete mineral mixture.

Table 8. Average performance of steers fed different levels of pelleted and non-pelleted citrus pulp (5).[1]

	Per cent citrus pulp in concentrate mixture[2]							
	Non-pelleted pulp				Pelleted pulp			
	0	**22**	**44**	**66**	**0**	**22**	**44**	**66**
Initial weight, lb	732	738	728	735	742	728	733	732
Final weight, lb	974	1035	1014	986	1046	1022	1055	1024
Total gain, lb	242	297	286	251	304	294	272	292

Table 8. Average performance of steers fed different levels of pelleted and non-pelleted citrus pulp (5).[1]

Daily gain, lb	2.52[4]	3.09	2.98	2.61	3.17	3.06	2.83	3.04
Daily consumption, lb								
Concentrate	22.41	24.50	23.47	22.13	23.70	24.12	23.25	22.80
Bermudagrass hay[5]	3.34	3.47	3.37	3.41	3.50	3.52	3.45	3.36
Total	25.75	27.97	26.84	25.54	27.30	27.64	26.60	26.16
Feed/cwt. gain, lb	1022	964	901	979	858	903	943	861

[1] On feed 96 days.
[2] Dried citrus pulp either regular or pelleted (3/8 inch pellets), was substituted for a corn-cob and shuck mixture (80% cornmeal-20% ground cobs and shucks) in the amounts indicated.
[3] Final weight was determined by shrinking the full weight 3%.
[4] This lot contained a nervous steer which gained only 1.60 pounds per day and which may have influenced performance of all steers in the lot.
[5] After 21 days, 2 pounds of hay feed per steer daily.

Table 9. Average composition of dried citrus meal (%).[1,2]

Moisture	6.01
Ash	6.71
Ether extract	2.62
Crude protein	7.16
Crude fiber	14.32
Nitrogen-free extract	63.18

[1] Feed ingredient analyses for Official Samples from 1962-69. Feed Laboratory, Division of Chemistry, Florida Department of Agriculture, Tallahassee.
[2] Each figure an average of 25 samples.

Table 10. Average composition of millrun blackstrap molasses, cane molasses for feeding and citrus molasses (%).

	Millrun blackstrap molasses[1]	**Cane molasses for feeding**[1]	**Citrus molasses**[2]
Dry matter	81	74	71
Crude protein	8-10	6-7	4
Total sugars	54	48	45
Phosphorus	0.10	0.08	0.06
Calcium	0.90	0.66	0.80
Total digestible nutrients	61	54	51
Digestible protein	4.7	4.3[4]	1.4
Level for fattening ration[3]	0-45	0-45	0-35
Relative value to #2 corn[3]			
Limited fed	78-98	75-95	70-85
Overfed	45-55	40-50	40-45

Table 10. Average composition of millrun blackstrap molasses, cane molasses for feeding and citrus molasses (%).

[1] Date obtained from U.S. Sugar Corporation for molasses produced on muck soil.					
[2] Hendrickson and Kesterson (22)					
[3] Morrison (32)					
[4] Estimated.					

Table 11.

	Ground snapped corn		Ground shelled corn	
	No molasses	Citrus molasses	No molasses	Citrus molasses
Total gain, lb	249	291	266	274
Daily gain, lb	2.28	2.67	2.44	2.51
Daily feed intake, lb:				
Citrus molasses	---	3.61	---	3.61
Remainder of ration	22.55	22.32	23.73	20.47
Feed/100 lbs gain, lb	1007	965	991	949
[1] Average of three trials.				

Table 12. Average gain and feed efficiency of steers receiving citrus molasses with dry and high moisture corn.[1]

	Dry Corn		High moisture corn	
	No molasses	Citrus molasses	No molasses	Citrus molasses
Total gain, lb	246	284	289	328
Daily gain, lb	2.30	2.65	2.70	3.09
Daily feed intake, lb:				
Citrus molasses	---	3.64	---	3.64
Remainder of ration	25.74	23.34	25.80	24.90
Feed/100 lbs gain, lb	1125	998	958	904
[1] Average of two trials.				