COMPARATIVE UTILIZATION OF CALCIUM CARBONATE AND CALCIUM CHLORIDE IN LIQUID FEED SUPPLEMENTS FOR FEEDLOT CATTLE

by

Royce D. Teague

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Approved by:

Leniel H. Harbers

Major Professor

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INTRODUCTION

Increased economic pressure in the beef cattle industry in recent years has caused researchers in the field to emphasize studies on efficiency of production. One possible area in which cost of production of beef cattle can be reduced is in the formulation of rations. The advantages of liquid feed supplementation, which have been listed by many sources to include lowered cost of ingredients and lowered mixing and handling costs, make it a practice which merits careful consideration.

Although other advantages, such as better distribution of nutrients, improved palatability, reduced dust problem, and better utilization of certain mineral sources (particularly phosphoric acid) have been cited in the literature, the major advantage of liquid feed supplements appears to be economical. However, this economic advantage must be scrutinized. Most commercial sources base their claims of lowered ingredient cost on prices of ingredients, such as urea, which are first manufactured as a liquid, then dried, and savings are based on reduced manufacturing cost by eliminating the drying process, however many liquid supplements are prepared by redissolving previously dried urea into a liquid, if this is done the advantage of reduced cost of urea is lost. Also, increased freight costs must be noted, even if the product is bought in the original liquid state.

The advantage of liquid supplementation are therefore limited to an area or even an individual basis. It appears that in certain areas where liquid ingredients are available at reduced cost that liquid supplementation of beef cattle rations can be an economically sound practice.

Liquid feed supplements have been used for wintering beef cattle for many years. Most of these supplements have been used in conjunction with some type of grazing program. Forages contain more calcium than grains, so the addition of calcium to these liquid formulations has been minimal. Now that the use of liquid feed supplements in high concentrate finishing rations is becoming more popular, higher levels of calcium need to be added.

Calcium carbonate, or ground limestone, is the most widely used source of supplemental calcium in meal mixtures. When calcium carbonate is added to liquid feed supplements however, it tends to flocculate and settle to the bottom forming a thick, solid mass. Even with incorporation of attapulgite clay to aid in suspension, formulations using calcium carbonate cannot be used effectively in automated feeding systems. Calcium chloride is a calcium source which has been reported to remain in solution indefinitely, and therefore is at least one possible solution to the problem of incorporation of supplemental calcium into liquid feed supplements.

The objective of this study was to compare the performance of beef steers finished on high concentrate rations supplemented with liquid feed supplements using either calcium carbonate or calcium chloride as supplemental calcium sources and thereby make some evaluation as to the feasability of the use of calcium chloride as the only source of supplemental calcium in beef finishing rations. A balance and digestibility study was also included to arrive at some estimation as to the relative utilization of the two calcium sources. Liquid feed supplements were sampled at various intervals to obtain information concerning their relative stability upon storage for extended periods of time.

Review of Literature

Although liquid feed supplements have been in use for many years in grazing programs for growing beef cattle, only recently has interest in using liquid feed supplements in high concentrate finishing rations been expressed.

As the calcium requirement for growing steers as recommended by N.R.C. (1970) is .36% of the ration and most forages used in grazing programs exceed this level, incorporation of calcium into liquid feed supplements has not been necessary. With finishing steers the N.R.C. (1970) recommended calcium level is only .27% of the ration. However, with the much lower calcium content of most feed grains used in high concentrate finishing rations, incorporation of supplemental calcium into liquid feed supplements to be used in finishing rations is desirable.

Grosso and Nelson (1973) have shown that by proper handling and mixing, as much as five percent calcium from calcium chloride can be added to molasses based liquid feed supplements with no problems concerning stability or precipitation of the resulting solution.

Calcium chloride has been used successfully in beef cattle rations to prevent urinary calculi by Brethour and Duitsman (1970, 1972). Efficacy of calcium chloride in preventing urinary calculi has also been demonstrated in sheep by Hoar, Emerick, and Embry (1970), Bushman, Embry, and Emerick (1967), and Emerick and Embry (1963).

Brethour and Duitsman (1970) found no adverse effect on growth rate of feed efficiency when calcium chloride was incorporated into the finishing ration of beef steers to prevent urinary calculi.

Hansard, Crowder, and Lyke (1957) have shown, using radioisotopes, that calcium from calcium chloride is absorbed slightly more than calcium from calcium carbonate but less than that from bonemeal.

No work has been reported concerning the effect on feedlot performance or carcass quality of steers fed rations containing calcium chloride as the only source of supplemental calcium.

Materials and Methods

Feeding trial. A feeding trial was conducted using 42 steers of mixed breeding averaging 355 kg. weight. Steers were divided into six lots of seven animals according to breed and weight. Steers were then fed identical rations *ad libitum*, except three randomly selected lots received a liquid feed supplement containing calcium carbonate and the remaining three lots received a liquid feed supplement containing calcium chloride. Each animal was fed 908 grams of the specified liquid feed supplement daily plus a starter ration of 60% roughage, (as fed basis) divided into morning and evening portions. Animals were gradually changed to a high concentrate (28% roughage, as fed basis) ration over a period of 28 days and maintained on this ration for 84 days. Ration composition for last 84 days on feed and composition of liquid feed supplements are shown in tables 1 and 2.

Liquid feed supplements were prepared by Simonsen Mill, Quimby Iowa, and shipped to the experiment station in 20 liter buckets. Individual buckets were mixed thoroughly prior to each feeding. A bucket of supplement was used for each three feedings so that any residual loss would have no untoward affect on growth or performance of the animals.

Steers were fasted overnight for initial and final weights. Monthly weights were taken prior to the morning feeding.

Animals were slaughtered at a commercial plant that allowed collection of appropriate carcass data and sampling of kidneys. Hot carcass weight was determined immediately after slaughter, and remaining carcass data was determined the following day after cooling the carcasses overnight. Loin eye area and backfat were determined by direct measurement. Grade and percent kidney and pelvic fat were estimated from visual inspection.

Five kidneys taken at random from each treatment group were removed from the carcasses and taken to the laboratory and frozen. Upon thawing, kidneys were dissected and inspected visually for abnormalities or indications of calculi formation.

Supplement stability. Barrels containing 200 liters of liquid feed supplement containing either calcium carbonate or calcium chloride were sampled at the top and bottom of the liquid layers by way of a siphoning tube, without disturbing precipitated residues, at arrival, then two and four weeks later. After four months the 200 liter barrels were sampled at ten centimeter intervals from top to bottom, including residue samples. All liquid feed supplement samples were then analyzed for phosphorus, calcium, sodium, potassium, magnesium, iron, manganese, zinc, and copper.

Residue present in 20 liter buckets was determined at various times throughout the experiment by simply weighing a bucket of the supplement, then pouring off the liquid portion and weighing the remaining residue. The pH of the supplements was determined at various times throughout the trial period. The pH was determined using a Corning Model 10 pH meter equipped with a Corning number 476022 silver/silver chloride triple purpose electrode on 200 ml. samples immediately after collection.

Samples of residues present in the two supplements were collected and precipitates were washed with distilled water. Washed residues were mounted on aluminum stubs with double stick scotch tape. Mounted samples were then coated with 150 Å of gold palladium and observed with an Ethec Antoscan scanning electron miscroscope at an accelerating voltage 20Kv. Polaroid PN55 film was used to photograph the scanned image.

Balance study. Four steers averaging 414 kg. were confined individually in metabolism stalls to facilitate total collection of urine and feces. Rations fed during the balance study were the same as those fed in the feeding trial with two steers receiving each of the two liquid feed supplements. Steers from the feeding trial were used to alleviate any residue problems from feed changeover. Each steer was fed four kilograms of his respective ration twice daily.

Urine was collected in 20 liter containers with 100 ml. 6N HCl. Five percent samples were collected daily and kept refrigerated until analyzed for nitrogen.

Fecal samples (five percent of total) were collected daily and kept frozen until the end of the experiment, then dried in a forced air oven (65^{o}C.) with random feed samples taken daily throughout the trial.

A seven day collection period was used preceeded by a five day period to allow the animals to become accustomed to the metabolism stalls.

Analysis of samples. All feed and feces samples were dried in a forced air oven to determine air-dry matter content. Dried samples were then ground in a Christy-Noris laboratory mill equipped with a 8mm screen and then analyzed for proximate components using A.O.A.C. methods (1970).

Samples in the solid state (dried feed and feces) were ashed overnight in a muffle furnace (650^{o}C.) and remaining residues were then dissolved in acid solution for specific mineral analysis. Samples in the liquid state (supplements and urine) were ashed using the perchloric acid wet ashing procedure prescribed by A.O.A.C. (1970). Phosphorus content of ashed samples was determined by the colorimetric procedure described by Fiske and Subbarow (1925). Calcium, sodium, potassium, magnesium, iron, manganese, zinc, and copper analysis were conducted using a Jarrell-Ash flame emission-atomic absorption spectrophotometer (Atomic Absorption Methods, Jarrell-Ash Company).

Analysis of data. Statistical analysis were carried out using least squares analysis of variance as modified for computer (Kemp, 1972). The model used was $Y=\mu+ax_1+bx_2+cx_3$, where the descrete variables were x_1=treatment and x_2=breed, and the continuous variable x_3= initial weight. Analysis of binomial variable (condemned livers) was carried out using the chi-square procedure outlined by Snedecor and Cochran (1973).

Results

Feeding trial. A summary of animal performance and carcass information is given in tables 3 and 4. Calcium source did not affect gain ($p>.65$) as animals receiving the calcium carbonate supplement gained 1.10 kg. per day while those receiving the calcium chloride supplement gained 1.06 kg. per day. Slightly more dry matter consumption was observed with the calcium carbonate fed steers (8.73 vs. 8.37) but the difference was not significant ($p>.15$) and failed to influence daily gain appreciably. Calcium chloride fed steers gained slightly more efficiently (7.77 vs. 8.06), but this difference was also insignificant ($p>.59$).

Carcass data tends to favor the calcium carbonate fed steers, however the differences are not significant ($p>.30$) and are most probably due to the slightly heavier carcass weight of the carbonate fed steers. More condemned livers were observed in the calcium carbonate fed cattle (3 vs. 1) but again the difference was not significant ($p>.75$). There were no abnormalities or indications of calculi formation in any of the sampled kidneys.

Of the characteristics measured breed had a significant effect only on backfat ($p < .04$).

Balance Study. Results of the balance study are summarized in tables 5 and 6. Results were very simular for the two calcium sources in digestibility of dry matter, organic matter, and crude protein. ($p > .05$) Improvement was noted in digestibility of ether extract and crude fiber for the calcium chloride treatment, however data was highly variable and the differences were therefore insignificant ($p > .05$).

Nitrogen retention data tended to favor the calcium chloride group but this was also highly variable and insignificant ($p > .05$). Apparent phosphorus absorption data favors the calcium carbonate group ($p < .05$), which could suggest that phosphorus absorption was impaired by the calcium chloride. Phosphorus retention data however, showed no significant difference ($p > .05$) between the two treatment groups.

There was no significant difference noted between the two treatments in apparent absorption or retention of calcium. ($p > .05$)

A plot of grams nitrogen retained vs. grams nitrogen absorbed showed a positive linear relationship: nitrogen retention increased as nitrogen absorption increased, which adds evidence to our conclusion that there was no significant difference between treatment groups.

Supplement Stability. Residue and pH of liquid feed supplements as determined at time of arrival, and two, four, and eight weeks later are given in table 7. Considerable residue (3-4%) was present in the calcium carbonate supplement and difficulty was encountered in resuspending this portion. There was much less residue present in the calcium chloride supplement (0.5-1.0%) and what residue there was was much easier to resuspend prior to feeding.

The pH of the calcium chloride supplement was consistantly about one unit below that of the calcium carbonate supplement. (4.29 vs. 5.26) There was no evidence of fermentation or gelling of either of the two supplements.

Changes in macromineral content of the liquid feed supplements with respect to time are summarized in table 8. These samples, taken from the 200 liter barrels at zero, two, and four weeks, did not include the precipitated residue, but only the liquid portion of the supplements, which would most likely be used under practical conditions using bulk tanks. In the calcium carbonate supplement, calcium, phosphorus, and magnesium, which were present in the upper layer upon arrival, were lost by the second week. Zinc, iron, and manganese (table 9) were also drastically reduced by the second week in the upper layer of the carbonate supplement. Concomitant increases in these minerals in the calcium chloride supplement after four weeks. Sodium, potassium, and copper remained in homogeneous solution in both supplements.

Data showing stratification of minerals after four months standing are shown in tables 10 and 11. As the tables indicate, the calcium carbonate supplement had settled into three distinct layers, an upper layer that appeared to contain mostly soluable material, a middle layer that contained suspended flocculate material, and a solid residue layer on the bottom. The calcium chloride supplement contained the upper two layers but the solid residue layer on the bottom was not distinguishable. Most of the calcium, phosphorus, magnesium, iron, zinc, and manganese were lost from the upper 20 centimeters of the carbonate supplement. Some of the calcium, phosphorus, iron, manganese, and copper was lost from the top of the chloride supplement, however, no losses of these minerals were noted at the ten centimeter depth in the chloride supplement. In the middle layer of the carbonate supplement, concentrations of calcium, phosphorus, iron, zinc, and manganese increased with depth. Samples taken from the bottom of this layer contained higher concentrations of calcium, phosphorus, and zinc than did samples taken from the residue layer. Magnesium, iron, manganese, and copper were concentrated in the thick compacted residue. Only sodium and potassium were found to be constant at all depths in the carbonate supplement.

Except for the aforementioned reduction in concentration of calcium, phosphorus, iron, manganese, and copper in the top layer, no differences were noted among depths in the supplement containing calcium chloride.

Scanning electron photomicrographs of residual minerals (figures 1 and 2) show that precipitates from both supplements were conglomerates. Individual granules from the calcium carbonate supplement were much smaller but more numerous than those found in the calcium chloride supplement.

Discussion

Calcium from calcium chloride was found to be equally as available as that from calcium carbonate. This agrees with the work of Hansard, Crowder, and Lyke (1957). Calcium chloride also had no adverse effect on feedlot performance or carcass quality of steers. It is also evident that liquid feed supplements containing calcium chloride as the supplemental calcium source can be stored for periods of up to four months without encountering any problem concerning stability of precipitation of minerals.

With these results, it can be safely concluded that the mechanical problems of feeding liquid feed supplements to feedlot cattle are satisfactorily worked out. This is not to suggest however, that there are no remaining problems in the use of liquid feed supplements. The major problem, that of economics, is still very real, and is not only a problem, but is apt to prove an insurmountable barrier to the widespread use of liquid feed supplements in areas where liquid ingredients are not locally available.

While liquid supplements are discussed a great deal in trade magazines most of the articles are commercially inclined and present little or no data to support their views. Most of the work that has been done on the use of liquid feed supplements has been supported by commercial interest to work out the mechanics of the use of liquid feed supplements and not to compare liquid feed supplements with comparable dry supplements. This study shares this fault and could have been improved had a control ration of all dry ingredients been used.

TABLE 1. COMPOSITION OF RATION (DRY MATTER BASIS)

Ingredient	%
Cracked sorghum grain	79
Corn silage	13
Liquid feed supplement	8

TABLE 2. INGREDIENT COMPOSITION OF LIQUID FEED SUPPLEMENTS

Ingredients	$CaCO_3$,%	$CaCl_2$,%
Water	5.00	5.00
Minugel clay	1.50	-----
Urea, 50% solution	18.50	18.50
Powdered limestone	6.10	-----
Calcium chloride[a]	-----	8.34
$(NH_4)_2SO_4$	1.80	1.80
NACl	2.00	2.00
Trace Minerals	0.40	0.40
Vitamins A-D-E[b]	0.02	0.02
Ammonium Polyphosphate (10-34-0)	3.40	3.40
Cane Molasses	61.25	61.00

[a]Dowflake,[R] Dow Chemical Co., Midlan, Michigan.

[b]454 g of supplement: 30,000 I.U. vitamin A; 3,000U.S.P.

TABLE 3. PERFORMANCE DATA FOR FEEDING TRIAL

Item	$CaCO_3$	$CaCl_2$
Number of animals fed	21	21
Initial weight, kg	359±4.9[a]	351±5.1
Final weight, kg	479±7.2	474±7.5
Daily gain, kg	1.10±.06	1.06±.07
Dry matter intake, kg/day	8.73±.14	8.37±.14
Feed efficiency, feed/gain	8.05±.35	7.77±.35

[a] Standard error of treatment

TABLE 4. CARCASS DATA FOR FEEDING TRIAL

Item	$CaCO_3$	$CaCl_2$
Number of animals slaughtered	19	20
Hor carcass weight, kg	277.4±16.1[a]	273.7±16.8
Yield grade [b]	2.53±.21	2.55±.23
Grade[c]	3.03±.31	3.46±.32
Loin-eye area, cm_2	69.57±5.06	74.79±5.29
Kidney and pelvic fat, %	2.5±.2	2.8±.2
Backfat, cm	.965±.108	.969±.113
Condemned livers	3	1

[a]Standard error

[b]Yield grade - most desirable = 1 to least desirable= 5

[c]grade - high choice = 1 to low good = 6

TABLE 5. DIGESTIBILITY AND NITROGEN BALANCE DATA FOR STEERS CONFINED IN METABOLISM CRATES AND FED EITHER $CaCO_3$ or $CaCl_2$

Nutrient	$CaCO_3$	$CaCl_2$
DIGESTIBILITY, %		
Dry matter	81 ± 3.9[a]	$81 \pm .2$
Organic matter	82 ± 3.8	$82 \pm .2$
Crude fiber	39 ± 2.6	49 ± 5.1
Crude protein	69 ± 9.7	$71 \pm .5$
NITROGEN BALANCE		
Intake, g/day	95.6 ± 12.1	94.9 ± 12.7
Feces, g/day	29.6 ± 13.0	27.7 ± 3.2
Urine, g/day	53.4 ± 4.0	46.9 ± 16.4
Apparently absorbed, g/day	$66.0 \pm .8$	67.2 ± 9.5
Apparently absorbed of intake, %	69.7 ± 9.7	$70.8 \pm .5$
Retained, g/day	12.6 ± 3.1	20.3 ± 26.0
Retained of intake, %	13.2 ± 1.6	21.4 ± 24.7

[a]Standard deviation

TABLE 6. CALCIUM AND PHOSPHORUS BALANCE DATA FOR STEERS CONFINED IN METABOLISM CRATES AND FED EITHER $CaCO_3$ or $CaCl_2$

CALCIUM BALANCE		
Intake, g/day	16.0±2.1	14.6±1.9
Feces, g/day	9.2±.4	9.1±2.3
Urine, g/day	2.1±1.4	1.8±0.1
Apparently absorbed, g/day	6.8±1.7	5.5±.4
Apparently absorbed of intake, %	42.4±5.2	38.1±7.8
Retained, g/day	4.8±3.1	3.7±.2
Retained of intake, %	28.8±15.8	25.9±5.1
PHOSPHORUS BALANCE		
Intake, g/day	17.2±2.2	14.4±1.9
Feces, g/day	5.5±2.3	10.1±1.8
Urine g/day	7.8±1.2	2.6±1.2
Apparently absorbed, g/day	11.8±.1	4.3±.1
Apparently absorbed of intake, %	68.3±9.3	29.8±3.4
Retained, g/day	4.0±1.1	1.7±1.3
Retained of intake, %	23.1±3.5	11.7±7.5

[a] Standard deviation

TABLE 7. RESIDUE AND pH OF LIQUID FEED SUPPLEMENTS MAINTAINED IN 20 1 CONTAINERS

	$CaCO_3$		$CaCl_2$	
Time, weeks	% residue	pH	% residue	pH
0	3.65	5.22	0.48	4.15
2	3.56	5.20	0.51	4.15
4	3.08	5.30	0.50	4.30
8	4.07	5.30	1.02	4.55

TABLE 8. MACROMINERAL CONTENT LIQUID FEED SUPPLEMENTS CONTAINING EITHER $CaCO_3$ OR $CaCl_2$ AFTER 0,2,&4 WKS. STANDING IN 200 1 BARRELS, %

	Time, Wks.	$CaCO_3$ TOP	$CaCO_3$ BOT	$CaCl_2$ TOP	$CaCl_2$ BOT
Ca, %	0	1.4	1.7	2.4	2.3
	2	0.2	2.3	2.6	2.5
	4	0.2	2.6	2.5	2.3
P, %	0	0.5	0.6	0.5	0.6
	2	0.2	0.6	0.5	0.5
	4	0.2	0.6	0.5	0.5
Na, %	0	2.0	2.0	1.6	1.6
	2	2.0	2.0	1.6	1.5
	4	2.0	2.1	1.5	1.6
K, %	0	0.1	0.1	0.1	0.1
	2	0.1	0.1	0.1	0.1
	4	0.1	0.1	0.1	0.1
Mg, %	0	0.15	0.14	0.09	0.10
	2	0.06	0.16	0.08	0.09
	4	0.07	0.19	0.10	0.09

TABLE 9. MICROMINERAL CONTENT LIQUID FEED SUPPLEMENTS CONTAINING EITHER $CaCO_3$ OR $CaCl_2$ AFTER 0,2,&4 WKS. STANDING IN 200 l BARRELS, p.p.m.

	Time, Wks.	$CaCO_3$ TOP	$CaCO_3$ BOT	$CaCl_2$ TOP	$CaCl_2$ BOT
Mn, ppm	0	123	138	133	141
	2	6	145	124	133
	4	7	164	127	126
Fe, ppm	0	705	714	495	470
	2	58	830	445	439
	4	67	900	444	411
Zn, ppm	0	285	314	320	314
	2	45	320	271	292
	4	50	348	309	297
Cu, ppm	0	53	68	53	58
	2	48	56	46	51
	4	44	57	52	55

TABLE 10. MACROMINERAL ANALYSIS AT VARIOUS DEPTHS OF 200 l BARRELS CONTAINING LIQUID FEED SUPPLEMENTS CONTAINING EITHER $CaCO_3$ or $CaCl_2$

	Ca, %		P, %		Na, %		K, %		Mg, %	
Sample depth	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$
top	0.07	1.04	.19	.03	1.82	1.65	.62	.89	.04	.07
10 cm	0.07	2.07	.18	.44	1.82	1.58	.59	.88	.04	.09
20 cm	0.07	2.12	.18	.58	2.01	1.62	.60	.91	.04	.09
30 cm	1.61	2.14	.57	.57	1.91	1.62	.63	.93	.18	.09
40 cm	1.79	1.92	.58	.51	1.86	1.57	.62	.89	.18	.09
50 cm	2.00	2.02	.62	.50	1.91	1.42	.68	.95	.18	.09
60 cm	2.04	1.92	.63	.48	2.03	1.38	.71	.81	.17	.09
70 cm	2.87	1.84	.69	.51	2.03	1.48	.80	.82	.18	.10
residue	2.69	1.74	.63	.42	1.48	1.48	.96	.83	.22	.09

TABLE 11. MICROMINERAL ANALYSIS AT VARIOUS DEPTHS OF 200 1 BARRELS CONTAINING LIQUID FEED SUPPLEMENTS CONTAINING EITHER $CaCO_3$ or $CaCl_2$

Sample depth	Fe, ppm		Zn, ppm		Mn, ppm		Cu, ppm	
	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$	$CaCO_3$	$CaCl_2$
top	105	246	22	239	6	39	41	21
10 cm	96	556	22	294	6	171	48	59
20 cm	97	611	20	320	8	191	52	61
30 cm	1018	610	313	327	190	197	70	65
40 cm	1068	558	283	308	193	167	96	82
50 cm	1119	541	293	316	202	179	78	64
60 cm	1170	503	321	302	220	186	85	64
70 cm	1276	567	350	306	254	191	102	41
residue	2011	518	288	293	734	162	250	32

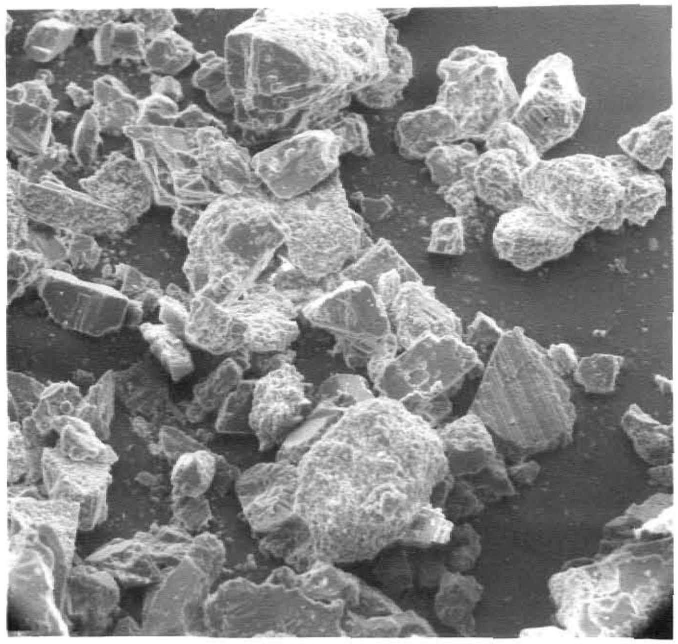

FIGURE 1 - Washed conglomerate crystals from residue of liquid feed supplement containing calcium carbonate (132X).

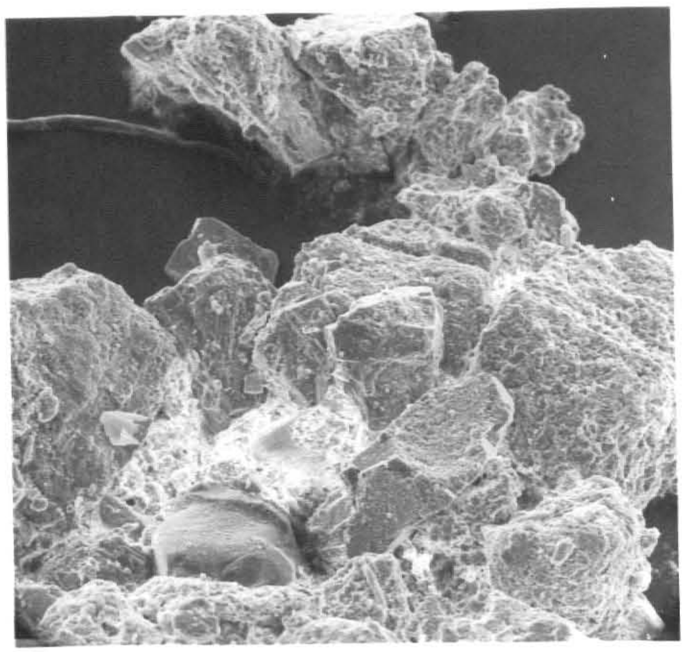

FIGURE 2 - Washed conglomerate crystals from liquid feed supplement containing DOWNFLAKE calcium chloride (120X).

Summary

A feeding and balance study was conducted using 42 steers (initial wt. 355 kg.) to compare the relative utilization of calcium carbonate and calcium chloride when used in liquid feed supplements for feedlot cattle.

Calcium chloride had no adverse effect on performance or carcass quality of feedlot steers. It appeared also to have been equally as available as the calcium carbonate.

Calcium chloride alleviated the problem of precipitation of minerals in the molasses based supplements, as almost all of the supplement containing calcium chloride could be pumped or poured off, while approximately four percent of the supplement containing calcium carbonate became tightly packed in the bottom of the container.

Therefore the use of calcium chloride is at least one solution to the precipitate problems encountered in the incorporation of calcium into liquid feed supplements.

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AN ABSTRACT OF A MASTER'S THESIS

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In the last few years an increase in the use of liquid feed supplements has been noted in the beef cattle industry. The problem of incorporating enough calcium into liquid feed supplements to supplement high concentrate rations has been encountered because of the low solubility of ground limestone. This study was conducted to determine the feasability of substituting calcium chloride, a more soluble calcium source, in liquid feed supplements for feedlot cattle.

Steers fed liquid feed supplements containing calcium chloride did not differ significantly in either feedlot performance or carcass quality from steers fed liquid feed supplements containing calcium carbonate.

Calcium from calcium chloride was equally as available as calcium from calcium carbonate. Calcium chloride did not effect digestibility of proximate principles in steers involved in the balance study.

Calcium, phosphorus, magnesium, manganese, iron, zinc, and copper tended to flocculate and settle out of solution in the liquid feed supplement containing calcium carbonate. Sodium and potassium were the only minerals found to remain in homogeneous solution in the calcium carbonate supplement.

All problems associated with stability or precipitation of minerals were alleviated by using calcium chloride in the formulation of liquid feed supplements.