



Evaluation of computer-formulated least-cost concentrate mixes for dairy cows

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The same milk production was obtained in these tests from cows fed computer-formulated least-cost concentrate mixes as from cows fed mixes formulated by hand. An average price reduction of \$3.10 per ton resulted from feeding the least-cost mixes to 295 cows in five feeding trials.

ELECTRONIC COMPUTERS have been used for several years to formulate rations for different types of animals, especially for poultry. Recently the University of California became interested in further developing this program for dairy and beef cattle as part of an overall farm management program.

Many combinations of feed ingredients will fulfill a specified set of nutrient requirements for a ration. Linear programming techniques on computers make it possible to rapidly test all combinations of feed ingredients that will fulfill the specified nutrient requirements and select the formula meeting these requirements at the lowest cost. Thus the name, "least-cost" formulation. Maximum limitations on individual ingredients and certain combinations of ingredients are assigned to decrease the likelihood of palatability problems caused by excessively high levels of certain ingredients within the mix.

Five feeding trials with 295 cows were conducted at four cooperating commercial dairies in California to compare the performance of cows fed standard commercial concentrate mixes with cows fed least-cost concentrate mixes. The trials were conducted at La Sierra College, Riverside County; Deuel Vocational Institution, San Joaquin County; Shady Grove Dairy, San Bernardino County; and Bar 20 Dairy, Fresno County. The least-cost formulas were based upon prices of feed ingredients at the beginning of the trials and the formulas were held constant during the trials. Only feeds readily available in California and acceptable to the coop-

erating dairymen were considered in the least-cost formulations.

In each of three double-reversal trials, 60 to 70 cows were paired according to age, stage of lactation, and previous milk production. One member of each pair was allotted randomly to one of two groups. One group was fed the least-cost mix during the first period, the control mix during the second period, and the least-cost mix during the third. The other group started on the control mix, was switched to the least-cost mix during the second period, and returned to the control mix during the third period. No digestive, physiological or palatability problems were noticed when the cows were switched abruptly from one mix to the other.

La Sierra College

A 300-day trial was conducted at La Sierra College using the same two concentrate mixes as had been used there for a double-reversal trial. Sixty-two cows used in this study were paired and allotted to treatment groups as described above. When cows went dry and subsequently re-freshened, they returned to the same treatment. The same procedure was used at Bar 20 with 22 pairs of cows in a 305-day trial. In this trial the protein content of the computer formulated mix was lower than that of the control mix.

The concentrate mixes fed at the dairies prior to the trials served as the control mixes. Minimum nutrient specifications (TDN, crude protein and phosphorus) for the computer-formulated mixes, shown in table 1, were calculated from the formulas of the control mixes. Except for the protein content of the mixes in the Bar 20 trial, the minimum content of these three nutrients in both mixes of each trial was identical within the accuracy possible when average values are used as the basis for calculating nutrient content. The type and amount of feed ingredients used in each trial varied according to the nutrient specifications and feed prices in each case.

In the La Sierra trials the concentrate mix was fed free-choice to all cows while they were in the milking parlor. The cows consumed an average of 15.4 lbs in the double-reversal and 16.5 lbs per day in the 300-day trial. Concentrate mix allowances in the Deuel trial were varied during each period according to milk production. Both members of each pair received the same amount based upon the production of the higher-producing member. Average intake was 18.7 lbs per day. A constant amount was fed to all cows in the Shady Grove trial, averaging 12 lbs per day. Cows were fed according to production at Bar 20, averaging 13.6 lbs per day. The type of roughage fed varied among trials, but was identical for both groups within a trial. In all five cases, alfalfa hay made up a major portion of the roughage allowance. Other kinds of roughage fed when available included corn silage, oat hay, and soilage made from barley, oats, alfalfa and sorghum.

Milk production results of the three double-reversal trials are shown in table 2. Cows fed the control mix in the La Sierra trial produced an average of 0.04 lb per day more milk with 0.06 per cent more milk fat, but neither difference was statistically significant. In the Deuel

TABLE 1. MINIMUM NUTRIENT PERCENTAGES FOR CONCENTRATE MIXES

Nutrient	La Sierra	Deuel	Shady Grove	Bar 20
	%	%	%	%
TDN	76.3	71.4	74.8	73.8
Crude Protein	12.2	14.7	11.4	11.0
Phosphorus	0.6	0.8	0.5	0.4

TABLE 2. DAILY MILK PRODUCTION (DOUBLE-REVERSAL TRIALS)

Trial	Average	Difference
		(Control minus least-cost)
La Sierra (67 cows)		
Milk	59.2 lbs	0.04 lb
Milk fat	3.33%	0.06%
Deuel (60 cows)		
Milk	53.5 lbs	1.47 lbs
Milk fat	3.38%	0.0 %
Shady Grove (62 cows)		
Milk	52.5 lbs	-2.88 lbs*
Milk fat	3.53%	0.13%†

* Statistically significant ($p < 0.01$).

† Statistically significant ($p < 0.05$).

trial, the control mix resulted in a non-significant advantage of 1.47 lbs per day in milk production and showed no difference in fat test. An increase of 2.88 lbs per day in milk and a decrease in fat test of 0.13 per cent resulted from feeding the least-cost mix in the Shady Grove trial. The increase in milk was statistically significant at the 1 per cent level, and the decrease in fat test was significant at the 5 per cent level.

Results of the 300 and 305-day trials at La Sierra and Bar 20 are shown in table 3. Cows fed the control mix at La Sierra produced 14,709 lbs of milk testing 3.75 per cent milk fat compared with 15,239 lbs of milk testing 3.66 per cent milk fat from the least-cost mix during the 300-day trial. Neither difference was statistically significant.

Bar 20 trial

In the Bar 20 trial, the control mix contained 14.4 per cent crude protein whereas the computer mix was 11.0 per cent crude protein. Cows fed the control mix produced an average of 14,514 lbs of milk with 3.37 per cent fat in 305 days. This compared with 14,897 lbs of milk testing 3.32 per cent fat from the cows fed the least-cost concentrate. Again, neither of these differences was statistically significant.

The fact that there was an offsetting, highly significant increase in milk and the significant decrease in fat test in one trial and no significant differences in the other four trials would indicate that approximately equal milk production can be expected from computer-formulated or conventionally formulated mixes when fed to dairy cows. The small differences observed in the five trials probably were the result of variations in feed ingredients in the mixes. It is well known that feed ingredients vary considerably depending on variety, climate, fertilization, and other factors.

The prices of the least-cost mixes were \$4.07, \$0.96, \$2.71 and \$4.67 per ton less than the control mixes at La Sierra, Deuel, Shady Grove and Bar 20, respectively (table 4). The results of these trials indicate that this saving in feed cost from least-cost mixes can be made while equal milk production is maintained, provided ingredient constraints similar to those in the present program are used.

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R. N. Eide, and J. C. Oliver are farm advisors—Riverside, San Joaquin, San Bernardino, and Fresno counties respectively. James Quick and J. M. Rible of the Agricultural Extension Service Regional Laboratories, Davis and Riverside, made the chemical analyses of the feed samples. T. M. Little, Extension Biometrician, and J. A. Shockley, Extension Programmer, did the statistical analyses; and R. C. Laben, Director, University of California Computer Center, Davis, assisted in adapting the computer for the least-cost ration formulations.

TABLE 3. AVERAGE MILK PRODUCTION (FULL LACTATION TRIALS)

Item	La Sierra		Bar 20	
	Control	Least-cost	Control	Least-cost
Number of days	300	300	305	305
Number of cows	31	31	22	22
Milk (lbs)*	14,709	15,239	14,514	14,897
Milk fat (%)*	3.75	3.66	3.37	3.32

* Differences not statistically significant at $p < 0.05$.

TABLE 4. CONCENTRATE MIX PRICES

	La Sierra*	Deuel†	Shady Grove†	Bar 20*
	Control	\$61.25	\$52.03	\$51.19
Least-cost	57.18	51.07	48.48	58.16
Difference	4.07	0.96	2.71	4.67

* Delivered price.

† Ingredient cost only.

D. L. Bath, Extension Dairy Nutritionist, checks a ration formula as it comes off the computer printer at University of California, Davis.

