marked changes in potassium availability. The Davis soils had high potassium levels, while the Dos Palos soils had adequate to marginal levels. Regardless of site or treatment, potassium concentrations tended to decrease with increasing soil depth. Average potassium concentrations were slightly higher in solarized soil than in nonsolarized soil at three of the four sites. These results are consistent with those from earlier studies, which showed that in most soils solarization has little or no effect on the availability of potassium. Soil solarization appears to increase the availability of mineral nutrients adsorbed to organic material, but has less influence on mineral nutrients like potassium, which are associated with clay particles.

Discussion

The evidence obtained in this study supports conclusions from earlier research that the potassium-deficiency problem in California cotton is not due to a lack of available potassium in the soil. In potassium-deficient soils, plants usually develop symptoms first in the lower leaves, but those with the "potassium-deficiency syndrome" first show symptoms in the upper leaves.

Removing the bolls will reduce or eliminate the symptoms, since developing bolls are a strong sink for potassium. It appears that a biological disease agent is causing a major interference in the translocation of needed potassium from roots and lower leaves to younger leaves and developing fruit. Treatments such as soil solarization, which would control a soilborne agent but would have little or no effect on potassium concentrations in soil, thus markedly reduce or eliminate the potassium-deficiency problem in the most severe field situations.

Soil solarization is a feasible control measure for the potassium-deficiency problem, since it also results in excellent control of verticillium wilt and weeds and often gives significant increases in lint yields. However, second-season observations indicate that it is more effective in the first than the second season. The failure of soil fertilization with large amounts of potash to effectively control the potassium-deficiency problem gives added incentive to identify the causal agent that is controlled by soil solarization or soil fumigation.

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Pistachio culls acceptable in livestock feed

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Whole cull pistachio nuts appear to be acceptable to cattle and sheep as part of their daily rations. Research indicates that cattle can be fed up to 20% of the daily ration without refusal, but this may be too high for sheep.

The pistachio industry in California annually produces an estimated 1.5% to 2.5% unmarketable in-shell nuts. These cull nuts are substandard because of insect damage, immaturity, undersize, or general poor quality. This study was designed to evaluate the use of these cull nuts as a livestock feed or supplement.

Pistachios are grown in 32 California counties, but the southern San Joaquin Valley counties of Kern, Tulare, Kings, Fresno, Madera, and Merced have over 93% of the total acreage in the state. In 1987, these counties yielded approximately 96% of the state's total production. Kern and Madera counties contributed 43% and 31%, respectively, of the total production in 1987.

Pistachio trees are alternate-bearing, producing a heavy crop one year followed by a light crop the next (table 1).

The nuts have a high fat content, especially the meats, but even in-shell nuts are high in fat (table 2). The estimated energy content of whole pistachios is also high (digestible energy = 3.72 Mcal/kg) because of the fat content. Protein is high in the meat but low in the whole nuts.

While nutrient analyses suggest that cull, whole pistachios could contribute to livestock rations, the question remains whether the shell-plus-meat cull nuts are acceptable to the animals. Excessive fat content could be a problem, since rations with as little as 20% nuts contain 6.4% fat, well over the suggested limit of 5% added fat (total ration dry matter) recommended by the National Research Council.

TABLE 1. California pistachio production

Year	Salable	Culls (estimated)
	tons	*tons*
1983	13,200	200 - 340
1984	31,000	470 - 795
1985	13,500	205 - 346
1986	37,450	570 - 960
1987	16,500	250 - 425
1988 (projected)	44,000	670 - 1,130

SOURCE: California Pistachio Industry Annual Report - Crop year 1987-88.

Cull in-shell pistachio nuts (left) amounted to an estimated 670 to 1,130 tons in California in 1988. Nutritionally, the whole cull nuts appear to be suitable as part of cattle and sheep rations. This preliminary trial evaluated their acceptability to the animals.

Another factor that might limit intake is the high proportion of unsaturated fatty acids in the fat of the meats (table 3). Over 85% of the fatty acids are mono- and poly-unsaturated. This is important in feeding livestock, because unsaturated fatty acids have been shown to be more harmful to the microbial population in the rumen than saturated fatty acids. Compared with corn oil, pistachio oil is higher in mono-unsaturated fatty acids (C16:1 and C18:1) and lower in poly-unsaturated fatty acids (C18:2 and C18:3). Compared with tallow, pistachio oil is higher in C18:2 and lower in saturated fatty acids (C14, C16, and C18).

The acceptability of whole cull pistachio nuts to ruminants was evaluated in a trial at the University of California, Davis. The trial was designed so that all animals received each ration for a 2-week period (Latin square design, 4x4 replicated twice). Test animals were eight yearling Hereford steers, and four Suffolk and four Rambouillet yearling ewes. The rations were fed free-choice to the animals in their individual pens. Ration consumption was determined weekly, as was the amount sorted out (refusals). Animals were weighed at the beginning and end of the 8-week feeding period.

The rations consisted of a base ration and three levels of whole pistachios nuts (table 4). Inclusion of pistachios in the ration did not affect feed intake (table 4), nor did differences among rations differ significantly within species. There were no differences in intake between week 1 and week 2 within rations as the animals readily consumed their assigned diets.

The amount of feed that the sheep sorted out and refused to eat increased as the proportion of pistachios in the ration increased. This refusal at the end of each weekly feeding period was primarily the whole pistachio nut. Refusal of the 20% ration (0.16 kg/day) was significantly higher than that of the 5% ration (0.06 kg/day). Refusal of the 10% ration (0.11 kg/day), however, did not differ significantly from that of either the 5% or the 20% ration.

The sheep had an overall average daily gain of 0.25 kg/day. The Suffolks' average daily gain (0.32 kg/day) was significantly higher than that of the Rambouillets (0.11 kg/day). This difference is as expected, since Suffolk are generally considered to be a better gaining breed than Rambouillet. These figures are within the normal range for sheep (0.11 to 0.32 kg/day).

Average daily gain of the cattle (1.32 kg/day) was also within the normal range (1.1 to 1.8 kg/day) on this type of ration. Since these gains were over the entire 8-week feeding period, the animals did not gain poorly when pistachios nuts were included in the ration.

On the basis of this preliminary trial, it appears that whole cull pistachios could successfully be used in cattle feed. Intake was not decreased and sorting (refusals) was not observed when pistachios were included in the ration. Average daily gain and feed intake were in the normal range.

Feeding whole pistachios to sheep does not appear as promising. Feed intake did not drop when pistachios were added to the ration. The fact that refusals increased with increasing proportions of pistachios, however, suggests that in a more rigorous trial a reduction in intake might become apparent and, ultimately, rate of gain might be changed.

Our results suggest that up to 20% of whole cull pistachio nuts can be fed to cattle and up to 10% to sheep. The most critical restriction is the price of the nuts in relation to other feed ingredients.

TABLE 2. Pistachio composition

Item	Shells	Meats	Shell + meat (as fed)*
	% dry weight		
Crude protein	1.31	24.31	11.44
Ash	1.89	6.91	3.40
Fat	2.59	52.84	25.43
Acid detergent fiber	53.96	3.66	30.54
Neutral detergent fiber	93.68	5.94	53.31
Lignin	10.35	1.52	5.19
Calcium	—	—	0.21
Phosphorus	—	—	0.41

* Pistachios by weight: 45% shells, 55% meats.

TABLE 3. Fatty acid composition of fats from pistachios, corn, and tallow

Fatty acid	Pistachio	Corn	Tallow
		wt%	
C14	—	1.2	3.5
C16	12.4	11.3	25.7
C16:1	1.5	0.5	5.0
C18	0.9	2.2	15.2
C18:1	53.1	26.2	41.0
C18:2	31.3	56.8	8.6
C18:3	0.6	1.8	1.0

TABLE 4. Ingredient composition and analysis of rations and dry matter intake (fed free choice)

Item	Cull pistachios (%) 0	5	10	20	Avg.
			% dry matter		
Ingredient composition:					
Alfalfa hay	48.0	45.5	43.2	38.4	—
Rolled wheat	42.5	40.4	38.3	34.0	—
Cottonseed meal	2.5	2.4	2.3	2.0	—
Molasses	6.0	5.7	5.4	4.8	—
TM salt	0.5	0.5	0.5	0.4	—
Monosodium phosphate	0.5	0.5	0.5	0.4	—
Analysis (as fed):					
Ash	6.93	6.73	6.52	6.26	—
Nitrogen	2.82	2.77	2.78	2.86	—
Ether extract	1.50	2.51	4.65	8.61	—
Neutral detergent fiber	29.40	28.84	28.55	26.39	—
Acid detergent fiber	17.65	18.48	17.58	16.25	—
Dry matter intake:			kg/day		
Sheep	2.04	2.13	2.18	2.24	2.14
Std. deviation	0.63	0.37	0.29	0.24	0.40
Cattle	7.64	8.30	8.48	8.01	8.10
Std. deviation	1.69	1.10	1.02	2.14	1.51

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