Fluoride Injury to Citrus

effect of air pollutant investigated to learn extent of contamination by component of smog

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The fluorine investigations referred to in the following progress report were initiated by the late J. C. Kaudy and continued by the authors.

The effect of fluoride on the growth of citrus and other plants as a result of air pollution—smog—is under extensive investigation following reports of fluoride damage.

Fluoride is a natural constituent of soils and of plant material, but the amounts of fluoride originating from the soil that are found in citrus leaves are normally low. High or elevated fluoride values were not associated in this study with any visible damage to citrus, but the physiological effects—tree behavior, yield, sizes, and so forth—of accumulations must be determined by controlled experiments. Such experiments will be started when facilities, now under construction, are completed.

Foliage from approximately 130 citrus groves was sampled for fluoride analyses. The samples represented groves in areas far removed from air pollution—to serve as a basis for comparison—and groves in industrial areas where air pollution does occur.

In areas considerably removed from industrial centers—Coachella Valley, San Diego County, Santa Clara Valley of Ventura County, and Tulare County—the citrus leaf samples were low in fluoride concentrations. The maximum level found in most of these areas was 1 ppm F—one part per million of fluoride—except in the Simi Valley, where levels up to 7 ppm F were found. The average value for citrus in the Simi Valley was 3 ppm F.

Two general areas—Los Angeles and Fontana—have considerably elevated concentrations of fluorides in the foliage of citrus. In the Los Angeles area, a gradual increase in leaf fluoride concentrations takes place with the approach to the heavily industrialized district in and around Santa Fe Springs, Whittier, and San Gabriel. Fluoride levels as high as 57 ppm F were found.

In the San Juan Capistrano-Irvine region south of the Los Angeles basin, relatively little fluoride buildup was detected. To the north of the manufacturing district of Los Angeles in the vicinity of Canoga Park and Chatsworth, similar low levels of fluoride were found in foliage of citrus trees. Approximately 5 ppm F is associated with citrus of this area. However, in the neighborhood of Fontana, San Bernardino Valley, where a steel plant is located, much higher quantities of fluoride were noted.

PPM F in Citrus Spring Cycle Leaves Sampled Through the Year (July 1952 to March 1953)

Location	PPM fluoride				
	July	Sept.	Oct.	Jan.	Mar.
Highgrove	3	12	10	13	13
Redlands	4	4	4	8	9
Fontana	73	142	145	171	185
Rialto	41	40	64	82	119
Highland	12	10	12	11	14
Greenspot	2	9	6	8	8
Corona	3	3	6	10	9
Arlington	2	..	5	6	11
Etiwanda	40	105	90	129	123
Alta Loma	16	29	24	37	45
Chino	3	9	12	61	63
Cucamonga	14	25	30	23	32

Fluorine Content of Citrus Spring-Cycle Leaf in the Major Citrus Areas of California.

Location	No. of sites	Fluorine content of leaf ppm F		
		Max.	Min.	Av.
Coachella Valley				
Mecca-Indio-Valerie	5	1	1*	1*
San Diego Co.				
Fallbrook-Escondido-Rancho Santa Fe	7	1	1*	1*
Ventura Co.				
Santa Clara Valley	7	1	1*	1*
Camarillo-Simi Valley	8	7	1*	3
Tulare Co.				
Terra Bella-Ivanhoe	6	1*	1*	1*
Orange Co.				
San Juan Capistrano-Irvine	6	6	1*	3
Tustin-Buena Park	4	16	4	12
La Habra-Yorba Linda	5	12	7	9
Los Angeles Co.				
Sunland-San Fernando	4	19	5	12
Whittier-Santa Fe Springs	2	24	21	23
S. San Gabriel-Covina	3	57	24	37
Pomona-Claremont	2	16	13	15
San Bernardino Co.				
Etiwanda-Cucamonga-Upland	12	100	12	41
Fontana	12	211	39	95
Rialto	6	41	20	27
Bloomington-Crestmore	3	12	1	7
Highlands-Del Rosa	7	18	5	10
Highgrove-Loma Linda-Redlands	18	8	2	4
Yucaipa	2	3	1	2
Riverside Co.				
Moreno-Riverside	5	7	1	3
Arlington-Corona	3	3	2	2

* = Less than.

A maximum of 211 ppm F was observed in one grove, and the average content of a dozen groves in the vicinity of Fontana was 95 ppm F. Examination of areas west of Fontana disclosed a gradual tapering off of fluoride in citrus foliage to a concentration of about 25 ppm F in the vicinity of Covina and Arcadia, some 20 miles distant. To the east, elevated amounts were noted to be present in citrus in the Rialto district. Citrus of the Del Rosa and Highlands districts, in general, has a concentration of 10 ppm F. The eastern end of the valley is comparatively free from fluoride pollutants since little buildup was found in the Yucaipa, Redlands, and Loma Linda areas. Eighteen groves examined in this area contain an average of 4 ppm F. Similar levels of fluoride were noted in the citrus areas of Colton, Highgrove, Riverside, and Corona.

Fluorides accumulating in the spring cycle leaves were followed for eight months in 12 groves, some in areas little affected by fluoric air contaminants and others in industrial areas. All 12 groves manifested an increase in fluoride levels with time. There was a greater increase in fluoride during the July to October interval than from January to March. Foliar concentrations of fluoride increased very little once the winter rains began.

Because relatively little fluoride appears to be translocated from the soil to the foliage, and because of the small quantities of fluorine detected in citrus away from industrial centers, elevated levels of fluoride, found in certain areas of Los Angeles and San Bernardino counties, are ascribed to air-borne fluorides emitted by certain industries.

The largest source of air-borne fluorides affecting vegetation in the San Bernardino Valley appears to be a steel plant, judging by the fluoride distribution pattern manifested by citrus groves in the valley. Industries concerned with the production of aluminum, ceramics, phosphates, and miscellaneous chemicals are other possible contributors of fluoride to the atmosphere.

Interpretation of elevated tissue concentrations of fluoride—in terms of im-

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Safflower Meal Digestion Tests

lambs used in digestion trials with decorticated seed meal to test product as feed for livestock

Harold Goss and K. K. Otagaki

Safflower oil-cake meal—a high-protein meal that is a promising source of protein for laying hens—was tested as a possible livestock feed in digestion trials with wether lambs.

In 1953, the safflower acreage in California had increased—from less than 100 experimental acres in 1948–49—to 45,000 with a seed yield of about 28,000 tons.

Safflower oil is one of the oils of commerce, available in large quantities on a year-round basis. It is a semidrying oil, used industrially as a raw material for production of protective coverings, ink vehicles, putty, and linoleums.

The oil-cake meal resulting from pressing the oil from the seed is being offered as a feed for livestock under the name whole pressed safflower seed meal. Machines are able to remove most of the hull from the seed before the oil is expressed. The oil-cake meal obtained from this process of decortication may have twice the percentage of protein and one half as much fiber as the whole pressed seed, though processing to remove the hull adds considerably to the cost. The hull removed is about one half crude fiber, but oil from unseparated seeds may still amount to 4% to 5%. The hull has less ash than the whole pressed seed.

Chemical Composition of Safflower Products.
(Average)

	Moisture %	Crude protein %	Ether extract %	Crude fiber %	Ash %	N.F.E. %
Decorticated meal	8.0	36.0	7.6	17.5	7.4	23.5
Whole pressed seed	8.0	19.0	6.0	33.0	4.0	30.0
Hulls	8.7	3.8	4.7	53.1	1.4	28.3

The average chemical compositions of decorticated meal, whole pressed seed, and hulls are given in the two-column table on this page.

The digestion trial at Davis was made with decorticated safflower meal of 36% protein content, as shown in the table. The meal was made of about equal proportions of two varieties—N6 and N852—of seed from the 1952 harvest. The seeds were decorticated before pressing, with the result that the crude fiber content was reduced to 17.5%.

Four wether lambs were tested on levels of 0%, 25%, 50%, and 75% of the safflower meal added to the basal ration of ground alfalfa hay with 20% molasses. The molasses was added to increase palatability to insure daily cleanup of rations. Each animal was fed for a preliminary period of one week on each of the four rations. Coefficients of digestibility were calculated from the results of these sixteen trials. The results are summarized in the following table.

Average Coefficients of Digestibility Decorticated Safflower Meal.

Crude protein	88
Ether extract	89
Crude fiber	23
Nitrogen free extract	63
Total digestible protein	32%
Total digestible nutrients	66%

Earlier, a similar digestion trial was run on a sample of whole pressed safflower seed. Unfortunately, it was learned after the trial was completed that the sample was faulty—the oil had apparently oxidized or polymerized. This lowered the coefficients of digestibility of most of the constituents, so that the total digestible nutrients—T.D.N.—were only 36%. However, the digestibility of the crude fiber was 26%. No other sample of whole pressed seed in which the oil content was impaired has been encountered.

If the average coefficients obtained with the decorticated meal are applied to the composition of whole pressed seed, the figure for total digestible protein should be 16% and that for T.D.N. approximately 54%.

Further digestion trials are under way with sheep on a ration containing 50% of the high fiber hulls, listed in the larger table, mixed with a basal feed of alfalfa hay, barley and molasses. Information from these trials will be used to help interpret feeding trials with steers which have been carried out in the Sutter Basin.

A duplicate trial is also underway on a market grade whole pressed seed of 19% protein content.

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All vaccines are not manufactured from the same strain of infectious bronchitis virus. Some manufacturers suggest that their products are safe to use on laying birds, and other manufacturers emphasize that their product may have an adverse effect on egg production. There has not been time to test the products beyond their effect on growing chickens. No tests have been conducted with laying hens.

Tests of the new vaccines conducted in the laboratories of the School of Veterinary Medicine are concerned with one thing—the protection of the California poultry industry—and until further tests can be made, they have been concerned thus far with the type of reaction and mortality which can be expected when the vaccine is applied to growing chickens, and the nature of the virus used in the vaccine.

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paired fruit production or damage—will be attempted when facilities for controlled fluorine fumigation experiments are completed. Thus far, there is no field evidence of leaf scorch or burn in citrus attributable to fluorine.

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