California Avocado Society 1953-54 Yearbook 38: 177-188

INORGANIC CONTENT OF PORTIONS OF AVOCADO FRUIT OF SEVERAL VARIETIES GROWN UNDER VARIOUS ORCHARD CONDITIONS

A. R. C. Haas
Plant Physiologist, University of California, Citrus Experiment Station, Riverside
J. N. Brusca
Senior laboratory technician in the same department.

SUMMARY

There is an increasing knowledge of the effects of inorganic deficiencies or accumulations upon the health of the leaves or vegetative portions of avocado trees without a corresponding study of how far such conditions may affect the reproductive phase of growth, namely the flowers and fruit.

Collections of fruit of several varieties were made from healthy trees and from trees grown in saline areas in order to observe possible chemical differences.

Fuerte avocado fruit from the Escondido area contained very low concentrations of calcium in the pulp and a magnesium content roughly four times that of calcium. The percentage of potassium in the dry matter of the tip portion of the pulp was nearly double that found in the stem portion. The dry matter of the fruit buttons contained considerable chlorine whereas very little was found in the dry matter of the pulp. The percentage of potassium in the dry matter of the skin of the fruit from Escondido was very high, especially as compared with that in the pulp or seed. The dry matter of the skin of the Vista fruit (table 2) contained a high percentage of sodium.

The skin of Hass avocado fruit from Riverside (table 3) and of the Fuerte avocado fruit from Vista, contained high percentages of potassium in their dry matter. The dry matter of the skin of fruit from Vista and N. Whittier Heights contained appreciable percentages of chlorine.

High total S (as SO_4) percentages were found in the dry matter of the pulp of fruit from the San Luis Rey Heights area (table 4) where saline conditions occurred. High sulfate percentages in the dry matter of avocado leaves can result in severe leaf injury.

The dry matter of the pulp of the Nabal (Guat.) avocado fruit, obtained from a saline orchard area, contained very low percentages of calcium (table 5), lower even than that found in the dry matter of the fruit skin.

In table 6 it was shown with Anaheim (Guat.) fruit from the saline area near Carlsbad that in either case, whether thin cross-sections of pulp were obtained from the stem and tip portions, or whether only the pulp immediately next to the skin at the stem and tip ends of the fruit was used, the final result was the same, namely, that the percentage of potassium in the dry matter of the pulp from the tip end exceeded that from the stem

end. The dry matter of the buttons of the Anaheim avocado fruit obtained from the saline area near Carlsbad contained the highest percentages of chlorine found in the dry matter of any part of the fruit pulp, skin, or seed.

In the MacArthur fruit from Santa Paula (table 7), a high total chlorine percentage was found in the dry matter of the buttons. High sodium and total chlorine percentages were found (table 7) in the dry matter of the skins of fruit collected from a saline area near Goleta.

The percentage of total chlorine in the dry matter of the buttons of the off-bloom MacArthur fruit was approximately the same as that found in the burned avocado leaves from the same trees. Dead flowers (including the flower stalks or pedicels) contained 635 per cent of sodium in their dry matter which is very high. Dry, checkered bark also contained a high sodium content in its dry matter (.625 per cent).

When certain elements such as calcium and magnesium are in short supply for the leaves, the result may be that the fruit produced may be of small size in order to survive and reach maturity.

When excessive concentrations of elements such as chlorine, sulfate, and sodium occur, they appear able to accumulate in the fruit stalk (pedicel), button, or peel with, in many cases, little or no accumulation taking place in the pulp.

Avocado leaves can maintain their turgidity and provide for the water loss of transpiration by the withdrawal of water from the avocado fruit.

As the inorganic composition of avocado trees is better understood, there is a greater awareness of the injurious effects that the excessive accumulation of certain elements such as chlorine, sulfate, sodium and other additional inorganic constituents can have upon the health of the leaves. Often such accumulations occur with or without a deficiency of certain desirable elements. Little is known as to the degree that such effects on the vegetative portions of an avocado tree are carried over as also to affect in some way the fruit or reproductive portion of the tree. The many fruit varieties and root stock combinations add to the scope of any study which is here initiated.

Collections[1] of the fruit of several varieties were made from trees growing in various saline areas as well as from trees in healthy orchards. In an avocado fruit, the appearance of the fruit skin and the condition of the button are external factors that affect consumer appeal. Among the factors that make for certain impressions once the fruit is cut open, are: the quality and oil content of the pulp, the size of the seed, and the looseness of the seed coats. Upon securing chemical data for samples of avocado fruit, the results were placed in table form in order to permit of their ready inspection.

In table 1, a comparison is made of the chemical analysis of the skin of Fuerte avocado fruits obtained from two orchards near Escondido. Separated by a road, the one orchard was located on a gentle slope (A) covered with grass at the time of fruit collection. Below orchard (A) on a fairly level area under non-cultivation was orchard (B). In the fruit from the higher-situated orchard (A), the dry matter of the fruit skin contained slightly higher percentages of potassium and a minimum of sodium, whereas in the dry matter of the fruit skins of comparable fruit from the lower-situated orchard (B), the sodium percentage was considerably higher.

In Fuerte avocado fruit principally from the Escondido area (table 2) the dry matter of the stem and tip portions of the pulp contained very low percentages of calcium and a magnesium content about four times that of calcium, whereas the percentage of potassium in the dry matter of the tip portion was approximately double that occurring in the stem portion. Although the percentage of chlorine is very low in the dry matter of the pulp, it is considerably higher in the dry matter of the fruit buttons. The seeds contain considerable potassium. Note the high potassium content in the dry matter of the skin of the fruit obtained at Escondido, much higher than in that of the pulp or seed. Noteworthy also is the high sodium content in the skin of the fruit from Vista.

High percentages of potassium were found in the dry matter of the skin of Hass avocado fruit from Riverside and of the Fuerte avocado fruit from Vista (table 3). The dry matter of the skin of fruit from Vista and N. Whittier Heights contained appreciable percentages of chlorine. In the Elsie fruit, the potassium percentages were greatest in the dry matter of the tip portion of the pulp and lowest in the dry matter of the stem portion of the fruit skin.

Fruits were collected about a month apart from a supposedly saline area in San Luis Rey Heights and their composition is given in table 4. A slight decrease in the percentages of calcium and a slight increase in those of magnesium occurred in the dry matter of the pulp during the interval between fruit collections. Note the increased percentages of potassium and the decreased percentages of sodium in the dry matter of the pulp. High concentrations of sulfate (total S as SO_4) in avocado leaves can result in leaf injury and it is of interest to find such high values in the dry matter of the pulp.

Fruit of the Guatemalan variety were obtained from a saline area in an orchard near Carlsbad. Note in table 5 the extremely low calcium content in the dry matter of the pulp, especially in that of the Nabal variety, in which the percentage was less than that found in the dry matter of the fruit skin. The dry matter of the middle sections of the pulp of the Nabal fruit contained high percentages of potassium and sodium, but on account of the small samples, the values will require confirmation. The percentage of total chlorine in the dry matter of the buttons of the Nabal (Guat.) avocado fruit exceeded that found in the buttons of the Dickinson (Guat.) fruit collected from the same orchard.

Anaheim (Guat.) fruit were also collected from the saline area in the orchard near Carlsbad. The percentage of potassium in the dry matter of the tip portion of the pulp exceeded that of the stem portion. The pulp of avocado fruit is much greener next to the fruit skin than farther away in the interior of the pulp. Instead, therefore, of taking pulp samples in the form of thin sections across the stem-end to tip-end axis, samples of pulp in this one case were taken only from next to the fruit skin near both ends of the fruit. Even so, as shown in table 6, the percentage of potassium was greatest in the dry matter of the pulp taken in this manner from the tip portion, thus agreeing with the results obtained when thin cross-sections of pulp were taken.

In table 6 the percentage of calcium in the dry matter of the pulp is very low. The fruit skins contained an increased sodium and a decreased potassium content in the fruit sample that was latest picked. The fruit skins also contained appreciable chlorine. The dry matter of the fruit buttons contained the highest percentages of chlorine found in the dry matter of any part of the fruit pulp, skin or seed.

In the off-bloom MacArthur avocado fruit collected on May 20, 1952, the per cent of water in the fresh pulp was found to increase from the stem to the tip end of the fruit (see footnote in table 7). The potassium percentage in the dry matter of each MacArthur fruit sample appeared to be somewhat low. In the off-bloom fruit, the total chlorine percentage was greatest in the stem portion of the fruit. Note the high percentage of sulfate (total S as SO_4) in the seed of the fruit collected from a saline area near Goleta and the high percentages of total chlorine in the dry matter of the buttons of the off-bloom MacArthur avocado fruit from Santa Paula. In the skin of this off-bloom fruit, the total chlorine percentage in the dry matter of the stem half of skin exceeded that of the tip half. Note the high sodium and total chlorine percentages in the dry matter of the skins of fruit from the saline area near Goleta.

Table 7 shows the total chlorine content of the MacArthur avocado fruit buttons as being 447 per cent in the dry matter. Leaves seriously affected with tip burn and collected from these trees contained an average of .475 per cent of total chlorine in their dry matter, which differs but little from the percentage found in the dry matter of the fruit buttons. Some of the blossoms and flower stalks or pedicels that had died were tested and their dry matter contained .152 per cent of total chlorine which is not extremely high. However, analysis showed the dry matter of these flower portions as containing: sodium, .635; calcium, .805; magnesium, .435; and potassium, .910 per cent, respectively, the sodium content being very high. The bark of some of these MacArthur avocado trees showed a severe checking and drying out of the bark and upon analysis, the dry matter of this bark was found to contain : total chlorine, 027; sodium, .625; calcium, 1.381; magnesium, .512; and potassium, .856 per cent, respectively, the sodium value again being quite high. Such trees, when supplied with high calcium phosphate concentrations, usually respond with considerable growth, probably from the effects of both the calcium and the phosphate. Later, however, as the leaves mature and as the sodium accumulates in the tissue, injury again frequently occurs.

In some avocado areas there is little doubt but that the supply of calcium, magnesium, or both are in short supply as is evidenced both by the leaf appearance and the chemical content. The leaves may have large numbers of tiny brown (rust-like) spots as were found in leaf samples obtained from the La Mesa area. The data in table 8 indicate that the calcium and magnesium percentages are only about half the values usually found for these elements in healthy leaves. The composition of the fruit (table 8) suggests very little outside of the high total sulfur content. A more important suggestion obtained from the La Mesa samples is that with calcium and magnesium in short supply for the leaves, the trees produced small fruit such as those used in table 8, in which less total calcium and magnesium would be required and still permit the fruit to reach maturity.

Leaves like those from La Mesa were also obtained from the Hemet area and as shown in table 8, these leaves contained only about half the percentage of magnesium that is usually found in the dry matter of healthy avocado leaves. From the El Toro area, avocado leaves of good size were obtained which showed no burned spots but which had the oak leaf pattern suggestive of magnesium deficiency. The dry matter of these leaves contained adequate calcium and a below-normal content of magnesium. If avocado fruits are not supplied very early in their development with adequate amounts of the inorganic elements necessary to easily reach maturity, then, if the fruits are to survive, an adequate supply of a necessary element possibly must result in the production of smaller fruits than otherwise would be the case.

From the data, it appears that certain elements such as chlorine, sulfate, sodium and possibly other inorganic elements can quite readily move into the fruit stalk (pedicel), the button and into the skin when the supply of such elements is excessive and it is rather unlikely that such excesses move with much facility into the pulp once the fruit has reached a certain stage in its development.

The data offered in the tables are necessarily preliminary to an understanding of the accumulation of inorganic elements in avocado fruits. In fact, it is advisable that we also understand more about the water relation of avocado leaves and fruits. Even though inorganic elements presumably are transported while in solution within the tree, it does not preclude the movement of water independently of the movement of inorganic elements.

The following test should make it clear that water can be withdrawn from avocado fruits and be transported for use by the leaves in supplying their water loss (transpiration). At 10 A.M. on November 20, 1953, the stalks of two terminal leafy-twigs, each bearing five mature leaves, were stood upright and supported in empty glass cylinders, whereas a similar pair of cuttings, each with a nearly mature avocado fruit attached, were likewise supported by the stalk in cylinders, the fruits resting on the open ends of other cylinders. The leafy-twig cuttings and fruit were obtained from R19 T4 in the Citrus Experiment Station orchard and were from a (Klein) Fuerte avocado tree.on Ganter rootstock. At 8:45 A.M. on November 23, 1953, a photograph (fig. 1) was made to show the appearance of the leaves. The leaves of shoots bearing no fruit were badly wilted whereas those of shoots bearing a fruit were turgid and healthy in appearance. The test was terminated at 10 A.M. on November 25, 1953, at which time the leaves of the cuttings bearing no fruit were quite dry and brittle whereas the leaves, on shoots bearing a fruit each, were turgid. At the start of the test, the fruits were hard, whereas at the end of the test, the skins of the fruits were darkening and the pulp was fairly soft.

Leaves, stalk, and fruit were obtained as controls fresh from the orchard and their water contents were determined. In this operation, the fruits were finely cut and both the fruits and the leaves were dried to constant weight in a ventilated oven maintained at 65° C. At the end of the test the leaves, stalks, and fruits were handled as were the controls in ascertaining their water content. The water content of the controls as percentages of the fresh weights were: leaves, 66.08; stalk, 74.18; fruit, 73.31 per cent, respectively. At the end of the test, the water contents of the cuttings bearing no fruit were: leaves, 12.40; stalk, 44.73 per cent, respectively, whereas with a fruit attached, the water contents were: leaves, 65.32 and 56.18, or an average of 60.75; stalks, 74.66 and 68.95, or an average of 71.81; and fruits, 68.21 and 64.00, or an average of 66.11 per cent, respectively. Both from the appearance of the leaves and fruit and the determination of the water content, it could be concluded that the leaves can withdraw water from an avocado fruit. An observation of interest was made in that when control fruits were cut open (and it had rained during the very early morning hours, shortly before the samples were taken) an appreciable amount of liquid was seen in the seed cavity near the base of the seed.

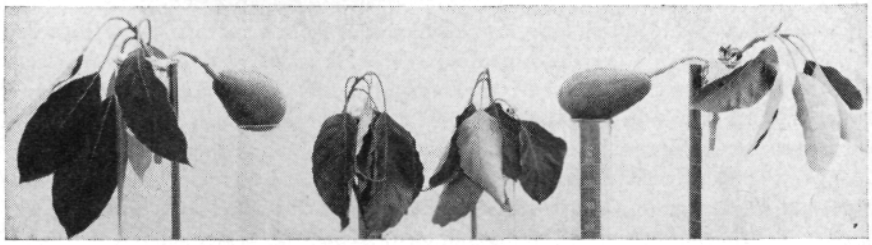

Fig. 1. *Experimental proof to show that avocado leaves can withdraw water from the fruit to maintain leaf turgidity and to provide for the water lost in the transpiration process. The leaves of leafy (Klein) Fuerte shoots, without an attached fruit, appeared severely wilted after three days in the warm headhouse, whereas with an attached fruit (extreme left and right in photo) wilting did not occur after five days.*

Table 1

Fuerte avocado fruit from Escondido area

A. Grass-covered gentle slope (5 applications of 4 lbs. each of 13-13-13 fertilizer, per tree per year.)
Six fruit picked February 4, 1953; lost 18.86 per cent fresh wt. when soft.

	Fruit skin (per cent in dry matter)
K	2.859
Na	.035
Total S as SO_4	.158

Fuerte avocado fruit from same Escondido area

B. On a level area below (A) and separated from (A) by a road; orchard under non-cultivation.
Four fruit picked February 4, 1953; lost 22.81 per cent fresh wt. when soft.

	Fruit skin (per cent in dry matter)
K	2.589
Na	.326

Table 2

Fuerte avocado fruit from Escondido area

Fruit	Pulp		Seed (no	Seed		
Sample No. 1	Stem end	Tip end	seed-coat)	coats	Buttons	Fruit skin
Ca	.028	.028	.041			.174
Mg	.109	.116	.090			.363
K	1.514	2.593	1.187			3.579
Na	.050	.115	.064			.086
Total Cl			.025	.010	.336	
Total S as SO_4			.210			
Fruit Sample No. 2						
Ca	.026	.024	.040			.155
Mg	.112	.105	.084			.307
K	1.323	2.415	1.130			3.544
Na	.148	.011	.049			.219
Total Cl	.025	.018	.021	.010	.328	
Total S as SO_4			.176			
Fuerte avocado fruit from Vista area						
K						2.843
Na						.405
Fuerte avocado fruit from La Habra						
K						2.750
Na						.023

Table 3

	Pulp: Stem end	Pulp: Tip end	Seed (no seed-coat)	Seed-coats	Fruit stalk or pedicel (no button)	Fruit skin	
			Per cent in dry matter				
Hass avocado fruit from tree on Topa Topa rootstock at Citrus Experiment Station, June 27, 1952							
Ca	.025	.027	.030			.096	
Mg	.086	.137	.108			.177	
K	2.269	2.964	1.268			4.731	
Na	.000	.108	.037			.022	
Total Cl	.006	.007	.009			.081	
Total S as SO_4			.120	.008	.060	.277	
Fuerte avocado fruit † from tree at Vista, Jan. 26, 1953							
K						3.844	
Na						.013	
Total Cl						.362	
Total S as SO_4						.235	
Fuerte avocado fruit from tree at N. Whittier Heights, Jan. 28, 1953							
K						2.919	
Na						.000	
Total Cl						.265	
Elsie avocado fruit* from tree at Whittier, June 9, 1952							
						Stem half	Tip half
Ca	.048	.021	.035				
Mg	.078	.102	.092				
K	1.389	2.544	1.129			2.650	2.141
Na	.007	.007	.052			.057	.092
Total Cl	.009	.016	.012	.009		.157	.066
Total S as SO_4			.145			.154	.192

† Buttons: Total Cl, .230

*Middle sections of pulp: Ca, .024; Mg, .087; K, 1.908; Na, .065

* Buttons: Total Cl, .084

Table 4

Fuerte avocado fruit from San Luis Rey Heights area

	Seven fruit picked Dec. 5, 1952 and soft Dec. 18, 1952 Per cent in dry matter of pulp		Six fruit picked Jan. 6, 1953 and soft Jan. 12, 1953 Per cent of dry matter in pulp	
	Stem end	Tip end	Stem end	Tip end
Ca	.081	.047	.061	.037
Mg	.118	.095	.125	.107
K	1.648	2.377	2.021	2.636
Na	.138	.146	.000	.066
Total Cl	.099	.084	.098	.077
Total S as SO_4	.438	.406	.544	.527

Table 5

Avocado fruit from Carlsbad area (Sept. 2, 1952)
(Per cent in dry matter)

	Middle section of pulp	Fruit skin	Buttons	Seed (no seed coats)	Seed coats
	Three Dickinson (Guat.) fruit				
Ca	.041	.085			
Mg	.110	.151			
K	2.761	1.594			
Na	.021	.056			
Total Cl			.112	.027	.018
	Two Nabal (Guat.) fruit				
Ca	.016	.044			
Mg	.109	.092			
K	5.448	2.301			
Na	.679	.087			
Total Cl			.276	.063	.017

Table 6

Anaheim (Guat.) avocado fruit from Carlsbad area

	Per cent in dry matter of cross-section of pulp				Per cent in dry matter of pulp taken only from next to skin (Sept. 20, 1952)	
	Sept. 4, 1952	Sept. 20, 1952	Sept. 20,1952			
	Middle section		stem end section	tip end section	stem end	tip end
Ca	.025	.020	.022	.021	.039	.021
Mg	.102	.078	.089	.082	.140	.126
K	3.236	2.909	2.526	3.433	2.567	2.981
Na	.069	.000	.000	.000	.000	.000
Total Cl		.106	.154	.103		
Total S as SO_4		.236	.327	.111		

Per cent in dry matter

	Fruit skin		Seed (no seed coat)		Seed coats		Buttons	
	Sept. 4 1952	Sept. 20 1952	Sept. 4 1952	Sept. 20 1952	Sept. 4 1952	Sept. 20 1952	Sept. 4 1952	Sept. 20 1952
Ca	.075	.081		.043				
Mg	.167	.178		.134				
K	2.705	2.455		1.523				
Na	.108	.214		.009				
Total Cl		.125	.066	.060	.020	.021	.305	.192
Total S as SO_4		.126		.251				

Table 7

MacArthur (Guat.) fruit from Santa Paula area
(Per cent in dry matter)
Five off-bloom fruit May 20, 1952*

	Pulp: Stem end	Pulp: Middle Section	Pulp: Tip end	Seed (no seed-coat)	Seed-coats	Buttons	Fruit skin
Ca	.073	.055	.046	.049			
Mg	.141	.120	.117	.069			
K	1.299	2.080	2.927	1.052			
Na	.051	.104	.086	.060			
Total Cl	.161	.112	.007	.016	.007	.447	.194 stem half .098 tip half .164 whole
Total S as SO_4	.417	.414	.518	.268			.102 tip half .073 whole
MacArthur (Guat.) fruit from Santa Paula area — Six fruit Sept. 4, 1952 (Better soil in orchard)							
Ca		.057					.200
Mg		.100					.287
K		1.536					1.074
Na		.038					.143
Total Cl				.016	.006	.207	
Six fruit Sept. 4, 1952 (Poorer soil; more salt)							
Ca		.042					.154
Mg		.100					.258
K		1.739					1.247
Na		.024					.074
Total Cl				.014	.006	.140	
Three MacArthur fruit from a Goleta salty area							
Ca	.042		.027	.053			
Mg	.121		.093	.069			
K	1.416		1.900	.919			1.837
Na	.202		.176	.057			.221
Total Cl	.056		.043	.023	.022	.583	.399
Total S as SO_4	.307		.309	.655			

*Per cent water in fresh wt. of pulp: stem end sections 76.94; middle sections 79.90; tip end sections 81.58.

Table 8

Seven Fuerte avocado fruits and a mature leaf sample from La Mesa area.

	Per cent in dry matter of pulp	Leaves with brown, rust-like spots Per cent in dry matter of leaves
Ca	.040	.550
Mg	.101	.310
K	2.477	1.439
Na	.018	.035
Total Cl	.073	
Total S as SO_4	.534	

Fuerte avocado leaves from Hemet area

	Numerous small burned spots over the leaf surface Per cent in dry matter
Ca	1.252
Mg	.338

Fuerte avocado leaves from El Toro area

	No burned spots; magnesium-deficiency in leaf pattern Per cent in dry matter
Ca	2.892
Mg	.514

[1] *Grateful acknowledgment is made of the assistance of Mr. J. J, Coony, formerly Farm Advisor in San Diego County and now County Director of the Agricultural Extension Service in Orange County, of Mr, Allen C. Hardison of Santa Paula, and of Mr. J. S. Shepherd of the Calavo Growers of California and others in securing various samples of fruit.*