HAWAII AGRICULTURAL EXPERIMENT STATION.

J. G. SMITH, SPECIAL AGENT IN CHARGE.

BULLETIN No. 14.

Marketing Hawaiian Fruits

BY

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UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. Department of Agriculture.

HONOLULU:
HAWAIIAN GAZETTE COMPANY, LTD.
1907.

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

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LETTER OF TRANSMITTAL.

Honolulu, T. H., May 6, 1907.

SIR:—I transmit herewith, and recommend for publication, as Bulletin No. 14, a report on the marketing of Hawaiian fruits, by Mr. J. E. Higgins, the station horticulturist.

Yours truly,

JARED G. SMITH,
Special Agent in Charge.

Dr. A. C. True, Director Office Experiment Stations.

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

JAMES WILSON, *Secretary.*

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INTRODUCTION.

There are probably no products of the American farm that have passed so rapidly from the realm of luxuries to that of necessities as have fruits. More fruits are being used each year. The great middle class is rapidly becoming a fruit consuming people. Not only has demand for temperate zone fruits increased, but at the same time there has been an enormous development of the semi-tropical and tropical fruit markets. While the people have been learning to regard as necessities the apple, pear and plum, the consumption of bananas has increased and continues to increase at the rate of about one million dollars in value each year. Twenty years ago the banana was an unfamiliar fruit to many in America. Today several of the Pacific Coast markets with their abundant supply of temperate and sub-tropical fruits, consume a car load each of bananas per day. A few years ago the pomelo, or grape fruit, was practically unknown. Today it is everywhere in America and its increasing consumption is surprising even the wholesale dealers.

This development which has been witnessed will certainly be repeated in the case of many tropical fruits now unknown on the mainland of the United States. The pineapple has only begun to gain in popularity. The avocado is a rarity in a few markets and never reaches most of the large cities. The mango is not known. All these and a number of other tropical fruits will certainly make a large place for themselves in the American markets.

Where will these fruits be produced? The eastern markets will be supplied by Porto Rico, Cuba, and the tropical portions of the mainland. There is no place better suited to supply the Western markets than Hawaii. The pineapple business is already assuming large proportions here. With this outlook the Hawaii Experiment Station has undertaken experiments to determine what fruits can be successfully shipped and further to investigate methods of packing and shipment. The experiments also serve to introduce new kinds of fruit in the markets. Experiments have been conducted in a small way for several years, which led to the shipment of several tons of fruit in charge of the Horticulturist of the Station. This shipment was made in August, 1906. The plan and results of the experiments are noted herein.

PINEAPPLES.

EXPERIMENTS IN SHIPPING.

For many years very heavy losses have been experienced in the shipping of pines from Hawaii. Recently these losses have greatly increased and there has been a growing tendency to can the greater part of the crop. Some companies have given up the shipping of the fresh fruits and others have been seriously considering the same step. The Station has undertaken a study of the causes of these losses and has sought remedies.

An experiment was undertaken in shipping the fruits packed according to different methods, treated in various ways, and subjected to the same conditions as other fruits in transit. The stock was purchased from two of the leading growers, part of it coming from the lower or dark colored soils of the Wahiawa region and the remainder from the higher lands which are red in color. The fruit was under the careful supervision of the Station from the time of gathering in the field to unpacking at its destination, with the exception of lot 565-569, the packing of which was supervised by Mr. Byron O. Clark, a well known and very careful grower and packer. The fruits of this lot were gathered on July 29, placed on their crowns in the packing-house and packed July 30. All the other fruits were gathered July 29, packed the same day and on the following morning were shipped to Honolulu. Nearly half of the shipment as indicated in tables I and VI was taken to the U. S. Quarantine Wharf and there subjected to fumigation with formaldehyde gas. On July 31 all crates were placed on board the S. S. Alameda in various decks as also indicated in tables I and VI. The ship sailed on the morning of August 1 and arrived in San Francisco on the afternoon of August 7. The fruit was immediately removed from the ship, taken to the ferry and shipped by rail to Portland, Oregon. As this route leads through the Sacramento Valley and the weather was exceedingly warm, the test for the fruit was a most severe one. The shipment arrived in Portland August 9 and an examination was begun at once.

The Causes of Loss.

It is not to be supposed that any single cause is wholly responsible for the heavy losses which the pineapple shippers have experienced, but rather there are a combination of causes, some of which must be removed by the growers and shippers, and some by the steamship companies if the highest success in shipping is to be attained. In June, 1906, the writer visited the plantations at Wahiawa to determine if possible some of these causes. It was discovered that pineapples were decaying while still green and unfit for use, the probable cause being the presence of a parasitic fungus. Specimens were submitted to Dr. N. A. Cobb who made a study of them and found them infested with a fungus which is common upon cane in these Islands and which gives rise to the disease known as the "Pineapple disease" of sugar-cane.[1] This fungus, *Thielaviopsis ethaceticus* Went, was afterward repeatedly found upon fermenting pines. (Plate I.) It should be said in passing, that this disease appears to have received its name not from having been first discovered on pines but from the fact of its producing in cane an odor of decaying pineapples.

Since this is in all probability a very potent cause of loss in the shipping of fresh pineapples, it was determined that methods should be sought to bring early relief to the shippers by devising methods to prevent the progress of the disease in the fruit while in transit. Other methods should be sought to stay the progress of the trouble in the field, but methods for treatment of the fruit to destroy the fungus spores have demanded first consideration. The use of a 3 per cent. solution of commercial formalin (=40 per cent. formaldehyde) as a medium in which various kinds of fruits might be dipped to delay decay has been suggested and tried at least in laboratory experiments at Kew[1] and is reported to have been quite successful in the case of some fruits. Preliminary experiments with this solution for pineapples were tried at the Hawaii Station but the results were not satisfactory. This treatment resulted in a shrinkage of the segments of the fruit or the "eyes" as they are commonly called, which deformed the fruit more or less. It was conceived that fumigation with formal-

[1] J. G. Smith, Press Bulletin, No. 9, Hawaii Experiment Station.

[1] Journ. Bd. Agr. (London), 12 (1905) No. 5, p. 305.

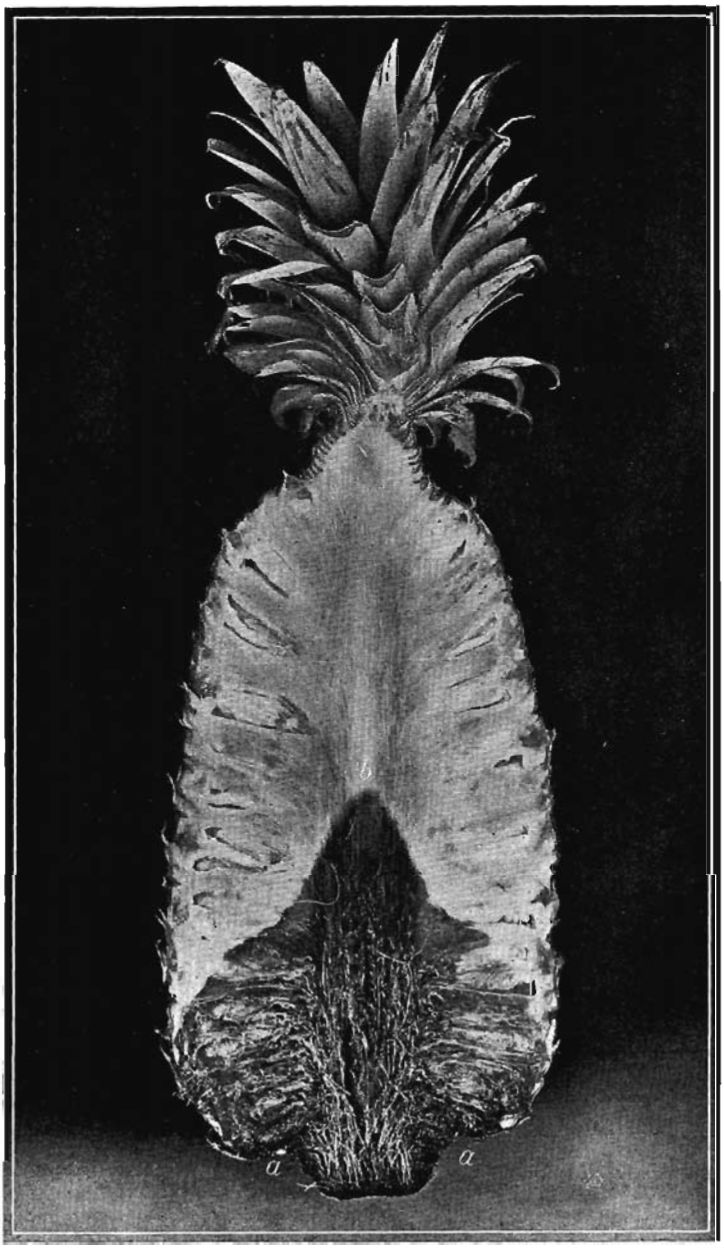

Plate I.—Pineapple destroyed by Thielaviopsis ethaceticus Went. Photo. by Dr. N. A. Cobb.

dehyde gas might be equally or more effective and could be applied much more economically. Some preliminary experiments with this method of treatment were carried on through the coöperation of the U. S. Public Health and Marine Hospital Service, since there was no equipment at the station for carrying on this work. These experiments though on a very small scale, resulted in considerably prolonging the life of the fruit and led to further experiments on a much larger scale.

With this fungus as a probable cause of severe losses, any practices which would tend to spread the spores or make inviting points of entrance for the same on the fruits would greatly increase the difficulty. It is customary with some of the shippers to pull off the bracts which subtend the fruits, in preparing them for shipment. This produces slight abrasions at the base of the pineapple which make a means of entrance into the fruit for the fungus spores. Experiments were therefore tried to determine whether this really occurs. A number of packages of fruit marked 500 to 509 as indicated in table I were prepared by cutting the bracts at a considerable distance from the fruit instead of pulling them off. Otherwise the packing and treatment was the same as that given to lot 545 to 554.

A large proportion of the decay and fermentation appears to have its origin at the base of the fruit (Plate I) and may result from the spores having found entrance through the stem where it has been cut. These cut surfaces often keep moist for many days and in some cases never become dry. The stems which are cut long appear to dry more readily than those cut short. Fifteen small crates of fruit were gathered and packed with their stems cut 2½ to 3 inches from the fruit. These are marked 510 to 524 in table I. Otherwise they received the same treatment as lot 545 to 554. The length of stem in ordinary practice is about 1¼ inches. It has been suggested that fruits be placed on their crowns and allowed to cure for a day or two before packing. This matter also was tested by allowing those designated lots 565 to 569 in table I, to remain as indicated in the packing-house for about 24 hours. If other lots could have been left two and three days respectively a better test of the advantages of this method might have been made. Otherwise the treatment and packing were the same as lot 545 to 554, used as a standard of comparison.

The use of paper as wrapping material for fruit of all kinds has become very common, in fact is of almost universal application. Pineapples are shipped from Florida with a wrapping of heavy paper, although this practice has not as yet been followed in Hawaii. There are several advantages which may be claimed for it. It tends to prevent a free distribution of the spores of any fungus from fruit to fruit and prevents slight moisture from one fruit getting to the adjacent one. In the case of pineapples, a further advantage is in the much brighter and more attractive color attained by wrapped fruit. Certain packages therefore were wrapped in paper, being closed at the base and pressed as close as possible to the crown. Since the fumigating could not be done at the plantation, certain other packages, marked 535 to 544 in table I, were wrapped in paper, but the ends were left open that there might be thus a freer access of the fumes of formaldehyde in treatment. Otherwise both of these lots were as lot 545 to 554.

The relative merits of hay and excelsior as a packing material have been somewhat in dispute. The packages indicated in table I were packed with hay which is gathered in the neighborhood of the plantations and which is commonly used in packing. The same number of crates was packed in an exactly similar manner except that excelsior was used instead of hay. These are marked 545 to 554 in table I and represent in other respects also the methods in common use at the plantation where the fruit was obtained, and may therefore be taken as a check or standard of comparison for the other methods of packing and treatment. Hay is the packing material in general use in shipping Hawaiian pineapples.

Since a considerable part of the losses of the past appear to have been due to the shipping facilities, a test was made of the different decks of the ship to determine where the fruit carries best. In this work we had the careful coöperation of the Oceanic Steamship Company and the captain and officers of the steamship Alameda. Fruits were stored on the main deck, in the 'tween decks and in the orlop deck as indicated below. (Tables I and IV).

The detailed results of the examination of the fruit from the lower fields are indicated in table I.

TABLE I. *Detailed results with fruit from lower fields.*

No. on Package	Style of Package[1]	MANNER OF PACKING, ETC.	Fumigated[2]	Location in Ship[3]	RESULTS ON EXAMINATION IN PORTLAND			
					GREEN		RIPE	
					Sound	Unsound	Sound	Unsound
500	8/30	Bracts cut, not pulled	F.	T. D.	3	....	5	....
501	"	" " " "	"	M. D.	3	....	5	....
502	"	" " " "	"	"	3	.....	5	....
503	"	" " " "	"	"	3	....	5	....
504	"	" " " "	"	"	2	....	5	1
505	"	" " " "	N.	T. D.	1	....	6	1
506	"	" " " "	"	M. D.	....	....	7	1
507	"	" " " "	"	"	5	....	1	2
508	"	" " " "	"	"	1	....	7	....
509	"	" " " "	"	"	1	....	7	....
510	6/30	Long stems	F.	T. D.	....	....	4	2
511	"	" "	"	M. D.	1	....	4	1
512	"	" "	"	"	....	....	6	....
513	"	" "	"	"	2	....	4	....
514	"	" "	"	"	2	1	2	1
515	"	" "	"	"	1	....	5	....
516	"	" "	"	"	....	....	6	....
517	"	" "	"	"	1	....	5	1
518	"	" "	N.	T. D.	1	....	2	3
519	"	" "	"	M. D.	2	....	2	2
520	6/25	" "	"	"	3	....	3	....
521	"	" "	"	"	1	....	4	1
522	"	" "	"	"	1	....	4	1
523	"	" "	"	"	2	....	4	....
524	"	" "	"	"	4	....	2	....
525	"	In paper, ends closed	F.	T. D.	....	....	2	4
526	"	" " " "	"	M. D.	1	....	4	1
527	"	" " " "	"	"	....	....	4	2
528	"	" " " "	"	"	1	....	5	....
529	"	" " " "	"	"	....	....	5	1
530	"	" " " "	N.	T. D.	....	....	4	2
531	"	" " " "	"	M. D.	....	....	4	2
532	"	" " " "	"	"	1	....	2	3
533	"	" " " "	"	"	....	....	5	1
534	"	" " " "	"	"	1	....	3	2
535	"	In paper, ends open	F.	T. D.	....	....	4	2
536	"	" " " "	"	M. D.	....	....	4	2
537	"	" " " "	"	"	....	....	6	....
538	"	" " " "	"	"	....	....	5	1
539	"	" " " "	"	M. D.	1	....	5	....
540	"	" " " "	N.	T. D.	1	....	3	2
541	"	" " " "	"	M. D.	....	....	5	1
542	"	" " " "	"	"	1	....	4	1
543	"	" " " "	"	"	3	1	....	2
544	"	" " " "	"	"	....	1	3	2

[1] The first number in the expression "8/30" represents the number of fruits in the crate; the second figure, the approximate weight of the fruit. Thus 8/30, indicates that there are eight fruits whose combined weight approximates 30 pounds. The individual fruits therefore weighed a little less than 4 lbs.

[2] Those marked "F" received the formaldehyde fumigation. Those marked "N" did not.

[3] T. D. 'tween decks. M. D. main deck.

TABLE I—*Continued.*

No. on Package	Style of Package[1]	MANNER OF PACKING, ETC.	Fumigated[2]	Location in Ship[3]	RESULTS ON EXAMINATION IN PORTLAND			
					GREEN		RIPE	
					Sound	Unsound	Sound	Unsound
545	6/25	As usual, with excelsior	F.	T. D.	....	....	4	2
546	"	" " " "	"	M. D.	....	....	1	5
547	"	" " " "	"	"	1	....	3	2
548	"	" " " "	"	"	3	....	2	1
549	"	" " " "	"	"	1	....	2	3
550	"	" " " "	N.	T. D.	....	....	2	4
551	"	" " " "	"	M. D.	2	....	4	....
552	"	" " " "	"	"	1	....	2	3
553	"	" " " "	"	"	....	....	3	3
554	"	" " " "	"	"	1	....	3	2
555	"	" " " hay	F.	T. D.	....	....	5	3
556	"	" " " "	"	M. D.	....	....	7	1
557	"	" " " "	"	"	1	....	6	1
558	"	" " " "	"	"	1	....	5	2
559	"	" " " "	"	"	1	....	3	2
560	"	" " " "	N.	T. D.	1	....	1	6
561	"	" " " "	"	M. D.	6	....	2	....
562	"	" " " "	"	"	....	....	4	4
563	"	" " " "	"	"	3	....	5	....
564	"	" " " "	"	"	1	....	4	3
565	"	Excelsior, cured one day	"	T. D.	1	....	5	2
566	"	" " " "	"	"	2	....	2	4
567	"	" " " "	"	M. D.	2	....	2	4
568	"	" " " "	"	"	....	....	4	4
569	"	" " " "	"	"	1	....	4	3

These results have been brought together in more concise form in the following table:

TABLE II. *Summary of results with fruits from lower fields.*

Lot No.	MANNER OF HANDLING AND PNCKJNG	Fumigated	Sound	Unsound	Total	Loss, %	Difference in favor of Fumigation, %	Loss Reduced, %
500 to 504.	Bracts cut, not pulled	F. [1]	39	1	40	2.5	7.5	75.
505 to 509.	" " " "	N. [2]	36	4	40	10.		
510 to 517.	Long stems	F.	43	6	49	12.2	4.4	26.6
518 to 524.	" "	N.	35	7	42	16.6		
525 to 529.	In paper, ends closed	F.	22	8	30	26.6	6.7	20.2
530 to 534.	" " " "	N.	20	10	30	33.3		
535 to 539.	In paper, ends open	F.	25	5	30	16.6	16.7	50.2
540 to 544.	" " " "	N.	20	10	30	33.3		
545 to 549.	As usual, with excelsior	F.	17	13	30	43.3		
550 to 554.	" " " "	N.	18	12	30	40.	-3.3	-8.2
555 to 559.	As usual, with hay	F.	29	9	38	23.1	9.4	29.
560 to 564.	" " " "	N.	27	13	40	32.5		
	Totals for fumigated stock		175	42	217	19.3	7.1	26 9
	" " unfumigated stock		156	56	212	26.4		
565 to 569.	Cured one day		23	17	40	42.5		

[1] F.=fumigated stock.

[2] N.= stock not fumigated.

Segregating the fumigated and unfumigated stock for purposes of comparing the relative advantages of the different types of packing and previous treatment, and placing first the lot which may be regarded as exemplifying the methods which have been pursued in common practice, we have the following table:

TABLE III. *Comparison of methods of packing.*

STYLE OF PACKING	FUMIGATED		UNFUMIGATED	
	Loss %	Loss Reduced %	Loss %	Loss Reduced %
As usual, in excelsior	43.3	....	40.	.....
" " " hay	23.1	46.7	32.5	18.8
" " but bracts cut	2.5	94.3	10.	75.
" " " long stems	12.2	71.9	16.6	58.5
" " in paper with ends closed	26.6	38.6	33.3	16.8
" " " " " " open	16.6	64.	33.3	16.8
" " cured one day	....	....	42.5	—6 2

COMPARISON OF RESULTS.

It must be noted in the above table that the results recorded in the second, third and following lots are not comparable with each other, but only with the first lot. Each lot was packed like the first lot except in the one particular indicated. Therefore all comparisons are made with the first or check lot.

Excelsior versus hay as a medium for packing. The experiments show quite unexpected results in respect to the relative value of hay and excelsior for packing material. It will be noticed by reference to table III that both the fumigated and unfumigated stock carried much better in hay than in excelsior. In the case of the fumigated lots as high as 46.7 per cent. of the loss in excelsior was saved in the fruit packed in hay and in the unfumigated lots 18.8 per cent. Why this should be is not clear. Excelsior is clean and might be expected to be as free from infection as any packing material which could be procured. It has been used in the packing of apples in the East for trans-Atlantic shipment and no evil results have been reported. It is possible that the much larger quantity which is used may be the cause of the apparent advantages of hay. The hay being much cheaper the packers use it very freely, filling all spaces between the fruits. In using excelsior the packing is not so tight but it is not at all impossible that the excelsior is in itself injurious as the above results would appear to indicate. The results of the experiment, however, are suf-

ficiently marked to suggest the importance of further experiments in the use of these two packing materials.

Cutting the Bracts. The results here are most pronounced. It will be noticed that in the fumigated stock, the very heavy loss of 43.3 per cent. in the check lot was reduced to 2.5 per cent. in the lot which had exactly the same packing and treatment in every respect except in the matter of the removal of the bracts subtending the fruits. This represents a difference of 94.3 per cent. of the total loss of the standard check lot. In the unfumigated stock the loss was 10 per cent., this being, 75 per cent. less than that of the check. In both fumigated and unfumigated stock therefore the results are very marked against the practice of pulling off the bracts.

Long Stems. Here there appears to have been a marked difference in favor of the fruits which were cut with long stems. This appears perfectly reasonable and might be expected since the moist surface near the base of the fruit, when the stem is cut short, would furnish a most inviting medium for the propagation of the fungus which destroys the pineapple. It will be claimed by the packers that long stems are inconvenient in packing and that a much larger crate would be required, nevertheless the primary aim must not be convenience in packing, or even economy of space, but rather to get the fruit to the market in good condition. Hence if future results should be at all commensurate with those of the present experiments the saving would abundantly justify very great increase in the cost of packing. As a matter of fact, however, the size of the crate need not be greatly increased, not more than two or three inches being added to one dimension.

Wrapping in Paper. The fruits wrapped in paper with the ends closed and those with the ends open, carried with identically the same percentage of loss in the case of unfumigated stock, namely 33 1-3 per cent. In this there was a reduction in the loss from that of the check lot of 16.8 per cent., due apparently to the use of wrapping. Referring to the fumigated stock it will be observed that the loss was much greater in the case of the fruits wrapped with paper with the ends closed than with those having the ends open. Though the fumes of formalin are exceedingly penetrating it is reasonable to suppose that there would be freer access to the fruit when the ends of the wrapping are left open and particularly so when the fumigation is continued for only a short time. The results therefore indicate that if fruits are to be wrapped, it should be

after the fumigating process is completed. In the case of both fumigated and unfumigated stock the figures indicated a very appreciable advantage in favor of wrapped fruit. Another advantage which is not indicated in the figures, lies in the very much better color attained by the wrapped fruit. The paper used should be quite heavy; a light thin paper breaks too easily. The Florida packers use a glazed paper rather than one of rough finish.[1] Wrapping also protects the fruit from infection with spores from other pineapples or which may be lingering about the decks of the ship.

Curing the Fruit. The cured fruits which remained twenty-four hours in the packing-house previous to packing, appear to have shown a very slight disadvantage in this method of packing. So far as the fungus is the cause of the losses it is to be supposed that the drying of the stems would lessen the opportunities for the progress of the disease. If however the drying or curing process proceeds in the packing-house which has not been fumigated, it may offer the best possible opportunity for infection from the spores which would be numerous in an unfumigated packing room. While this experiment can be regarded in no sense as conclusive proof of the disadvantage of curing, it is certainly safe to say in view of our present knowledge of the cause of decay that if curing is to result in any gain it must be carried on in a scrupulously clean packing room or in the open sunlight. It would be interesting and profitable to carry this experiment further by allowing separate lots to remain two or three days respectively. Such tests should be carried on in connection with the experiments in fumigation.

RESULTS OF FUMIGATION.

Referring now to table II it will be observed that approximately half of each lot packed in a given manner was subjected to the process of fumigation with formaldehyde; therefore lot 500 to 504 is comparable with lot 505 to 509; lot 510 to 517 with lot 518 to 524 and so on. In every instance except lots 545 to 554, it will be noticed that there has been a very considerable reduction in the loss in the case of fumigated fruit, varying from 20.2 per cent. to 75 per cent. in the different lots. Comparing lot 545 to 549 with lot 550 to 554, the results are practically negative and may be regarded as one of the exceptions which almost always occur in a series of tests.

[1] H. H. Hume, Florida Agricultural Experiment Station, Bulletin No. 84.

With a very pronounced advantage in favor of fumigation in the case of all the other lots the evidence is very strong that the progress of the development of the fungus was arrested by this process. The large saving in the loss cannot be regarded as incidental. The evidence is the more strong because of at least two unavoidable factors which would tend to minimize the results. First the fumigation was not performed until after the fruits had been gathered 24 to 30 hours, thus affording spores of the fungus an opportunity to germinate and send mycelia[1] into the tissue of the fruit before treatment.

FRUITS FROM THE UPPER OR RED SOILS.

The fruits from the upper or red soils were gathered the same day and under conditions similar to those under which the pines from the lower fields were gathered. The details of packing, treatment, location in ship and the results of examination are indicated in the following table:

TABLE IV. *Detailed results with fruits from upper or red soils.*

No. of Package	Date of Packing	MANNER OF PACKING	Fumigation	Location	GREEN		RIPE	
					Sound	Unsound.	Sound	Unsound.
650	7/29/06	Grass in bottom only. Paper on each fruit. Headed under pressure	N.	O. D.[2]	..	..	38	2
651	"	Grass in bottom only. Paper on each fruit. Headed under pressure	F.	O. D.	2	...	35	2
652	"	As usual. *Much grass* around each fruit	N.	O. D.	1	..	28	1
653	"	As usual. *Much grass* around each fruit	F.	O. D.	1	..	28	1
654	"	In grass	N.	M.D.[3]	..	..	5	1
655	"	" "	"	"	1	..	4	1
656	"	" "	"	"	..	..	5	1
657	"	" "	F.	"	4	..	2	..
658	"	" "	"	"	4	..	1	1
659	"	" "	,,	"	..	..	5	1

[1] The vegetative part of the fungus.
[2] Orlop Deck. [3] Main Deck.

The details of the above are brought together in more concise form for study in the following table:

TABLE V. *Summary of results with fruits from upper or red soils.*

Lof No.....	MANNER OF PACKING, ETC.	Location in Ship...	Fumigation.....	Sound.....	Unsound.....	Total.....	Percentage of Loss.	Difference in Favor of Fumigation...	Loss Reduced, %..
651	Large crate. Fruits wrapped in paper, hay in bottom only. Headed tight against fruit	O. D.[1]	F.[2]	37	2	39	5.1	....	....
650	Large crate. Fruits wrapped in paper, hay in bottom only. Headed tight against fruit	"	N.[3]	38	2	40	5.	—.1	....
653	No paper. Much hay. Each fruit wrapped in hay	O. D.	F.	29	1	30	3.3	....	....
652	No paper. Much hay. Each fruit wrapped in hay	"	N.	29	1	30	3.3	....	....
657 to 659	Small crates. In hay in usual manner	M. D.	F.	16	2	18	11.1	5.5	33.2
654 to 656	Small crates. In hay in usual manner	"	N.	15	3	18	16.6	....	....

[1] Orlop deck.
[2] Fumigated.
[3] Not fumigated.

Formaldehyde Fumigation. Comparing 650 with 651; 652 with 653 and so on, it will be observed that in the first two instances the results of the formaldehyde treatment were practically negative. The loss, however, was extremely light both on treated and untreated fruit for reasons to which there will be occasion to refer below. Comparing lots 654 to 656 with lots 657 to 659, a marked diminution in the loss is observable in the case of the fumigated lots, confirming the results as found on the pineapples from the lower or dark colored soils.

Dark soils vs. red soils. A just comparison of the fruits from the two kinds of soils can be made only between lots 657 to 659, (Table V) and lots 555 to 559 (Table II) all of which were fumigated; and further between lots 654 to 656 (Table V) and lots 560 to 564 (Table II) which were not fumigated. In the first instance the fumigated fruit from the red soils shows a loss of 11.1 per cent. while that from the dark soils is 23.1 per cent. The unfumigated fruit from the red soil shows 16.6 per cent. loss in contrast with 32.5 per cent. on the fruit from the lower tract or dark soils. While the extent of the experiments is entirely too limited to justify any conclusions the results suggest that the fruits from the lower fields may be more subject to decay than those from the upper fields. If such is the case, it is probably due to a greater prevalence of the fungus *Thielaviopsis ethaceticus* Went, at least on the fields from which the fruits for these experiments were taken. The dark soils are unusually high in manganese, which may or may not be a contributing cause.

Grass as a packing material vs. paper wrapping only. The fruits wrapped in hay, which was also packed tightly in the intervening spaces, carried with slightly less loss than those wrapped in paper only, the difference being about 1.7 per cent. of the whole. Against this, must be reckoned the additional expense for crates and the extra freight charges for the more bulky method of packing. The crates carry approximately 30 five-pound pines or 150 lbs. of fruit if the hay is used. The hay being omitted, about ten more fruits can be placed in the same crate or about 50 lbs. additional. This means that to carry a given weight of pineapples packed with hay in the usual manner, will require one-third more crates than would be necessary were the hay eliminated except a thin layer in the bottom and at the top. This increase of 33 1-3 per cent. in the

bills for crates, involves also an increase of 33 1-3 per cent. in freights since these charges are calculated per ton measurement. Roughly, it may be said that it costs about $6. more per ton (weight) to ship pineapples in hay, than it would without it. The cost of the paper could not greatly exceed that of the hay since the total cost per crate for paper need not be greater than 10 cents. The Florida packers pay from $1.00 to $1.45 per 1000 sheets according to quality, which would be less than 6 cents for the paper for 40 fruits. The sheets for Hawaiian pines, however, would require to be larger.

Clearly, the free use of hay involves large expense. Can it be eliminated? The indications of the present experiments are that it can and with financial gain to the packers. If the results of these limited trials shall be confirmed by future experiments, very little hay should be used in packing. This would add much also to the attractiveness of the package.

The size of crate. It is not to be expected, however, that 200 lbs. of pineapples can be a desirable size of package. Even 150 lbs. is too great. The other crate which has been used extensively by at least one company and which carried the greater portion of fruit in these experiments will contain from 30 lbs. to 40 lbs. It holds from six to eight fruits in a single layer.

None of these crates appear to exactly fulfill the requirements. The amount of fruit in the small crate is desirable and the package is neat and attractive in appearance. The objection lies in the difficulty experienced in making a tight pack. There being but one layer of fruit it must be of uniform diameter to fit the crate. The problem of crates for pineapples is yet unsolved and some medium ground between these two extremes must be sought or a more careful grading of the fruit must be made for the single layer package. Possibly a crimped or corrugated straw-board such as was used in the papaia shipping experiments (see p. 34) could be successfully used with pineapples for fancy packages.

MERITS OF DIFFERENT PARTS OF SHIP.

By reference to table I, it will be observed that one fumigated and one unfumigated package from each lot were located in the "'tween" decks of the ship as indicated by the letters "T. D." All the other crates containing pineapples from the lower or dark lands were placed on the main deck as indicated by the letters "M. D." The results are brought together in the following table:

TABLE VI. *Results on different decks.*

FUMIGATED STOCK

Lot	'TWEEN DECKS				MAIN DECK				
	Sound	Unsound	Total	Loss, per cent.	Sound	Unsound	Total	Loss, per cent.	Reduction in Loss, per cent.
500 to 504....	8	....	8	....	31	1	32	....	....
510 to 517....	4	2	6	....	39	4	43	....	....
525 to 529....	2	4	6	....	20	4	24	....	....
535 to 539....	4	2	6	....	21	3	24	....	....
545 to 549....	4	2	6	....	13	11	24	....	....
555 to 559....	5	3	8	....	24	6	30	....	....
Totals	27	13	40	32.5	148	29	177	16.3	53.

STOCK NOT FUMIGATED

505 to 509....	7	1	8	....	29	3	32	....	....
518 to 524....	3	3	6	....	32	4	36	....	....
530 to 534....	4	2	6	....	16	8	24	....	....
540 to 544....	4	2	6	....	16	8	24	....	....
550 to 554....	2	4	6	....	16	8	24	....	....
560 to 564...	2	6	8	....	25	7	32	....	....
565 to 569....	10	6	16	....	13	11	24	....	....
Totals	32	24	56	42.8	147	49	196	25.	41 6.

By reference to the above table it will be seen that even in the case of the fumigated stock the loss was extremely heavy in the "'Tween decks," *amounting to 32.5 per cent.* On the Main deck the loss falls to 16.3 per cent. representing a reduction in the loss of 53 per cent. In the case of the unfumigated stock in the 'tween decks, the loss runs up to the alarming proportions of 42.8 per cent. The same kind of fruit with exactly the

same treatment in other respects when placed on the main deck, shows a loss of 25 per cent. This, it will be noted, is a reduction in the loss, of 41.6 per cent. due apparently to better conditions on ship-board. The improved conditions on ship-board together with fumigation brought down the loss to 16.3 per cent. Even a loss of 16.3 per cent., however, is too great and can be avoided.

Referring now to table IV, it will be observed that crates Nos. 650, 651, 652 and 653, were located in the orlop deck while crates Nos. 654 to 659 were placed on the main deck with the fruits from the lower or dark soils. Segregating the results on these two decks we have the following table:

TABLE VII. *Results on main and orlop decks.*

FUMIGATED										NOT FUMIGATED									
ORLOP DECK					MAIN DECK					ORLOP DECK					MAIN DECK				
Lot No.	Sound	Unsound	Total	Loss, per cent.	Lot No.	Sound	Unsound	Total	Loss, per cent.	Lot No.	Sound	Unsound	Total	Loss, per cent.	Lot No.	Sound	Unsound	Total	Loss, per cent.
651	37	2	39	5.1	657 to 659	16	2	18	11.1	650	38	2	40	5.	654 to 656	15	3	18	16 6
653	29	1	30	3.3	.....	....	....	....	.....	652	29	1	30	3.3	.....	....	...	....	.....
Totals	66	3	69	4.3	Totals	....	....	....	11.1	Totals	67	3	70	4.2	Totals	....	....	....	16.6

There is a striking contrast in the above figures, showing a loss of 11.1 per cent. on the main deck and only 4.3 per cent. on the orlop deck with fumigated fruit; and with fruit not fumigated 16.6 per cent. on the main deck in comparison with 4.2 per cent. on the orlop deck. Recalling again the heavy losses in the 'tween decks the question naturally arises what were the conditions prevailing in each of these parts of the ship. The proper conditions on shipboard for the successful shipping of fruit may be enumerated as follows:

1. Ventilation,
2. Dryness,
3. Reasonably low temperatures,
4. Careful handling and steeving.

The conditions were far better on the main deck than in the 'tween decks because of better ventilation and lower temperatures. On account of the calmness of this voyage, the freight port of the main deck could be kept open continuously, affording free circulation of air. The ports of the 'tween decks were of course closed tightly. The temperatures here read as follows: Aug. 2, 82° F.; Aug. 3, 79° F.; Aug. 4, 75° F.; Aug. 5, 75° F.; Aug. 6, 73° F.; Aug. 7, 76° F.

Although these temperatures are not excessively high for the first day or two considering that of the atmosphere, they would have fallen much lower on August 5, 6 and 7, had there been free access for the outside air. The heat in itself, however, though hostile to the keeping of the fruit, is less so than stagnation of warm air. The latter condition with moisture furnishes ideal environment for the growth of fungi which destroy fruit. In 'tween decks, only one of the desirable factors prevailed. It was dry. But it was hot and unventilated. The main deck was cool, well ventilated, but so damp, that the packing material became wet. The orlop deck furnished the best conditions, being fairly dry, cool, and well ventilated by means of a wind-sail. If these conditions could always be maintained in the orlop deck, as they were on this voyage, it would be the most desirable part of the ship which was tested. But unfortunately, this can be done only when the weather is favorable. In case of rain or heavy seas the wind-sail must be taken down and the hatches closed. The temperatures rise, the air becomes stagnant and the orlop deck proves no better than the 'tween decks. Under these weather conditions, the freight ports of the main deck also must be closed and no part

of the ship furnishes suitable conditions for successful shipment of fruit.

Furnishing the requisite conditions. Furnishing mechanically forced draft through all parts of the ship where fruit is carried, is the only possible means of equipping a steamship for this tropical fruit trade so that she can safely carry her cargo. This applies equally to bananas, pineapples or any fruit not carried in the refrigerated compartments. It is gratifying to know that at least one line of boats carrying Hawaiian fruit, is considering the matter of installing mechanically forced draft. The extent of the fruit carrying trade in the near future, will depend in large degree upon the shipping facilities offered.

THE PROCESS OF FORMALDEHYDE FUMIGATION.

The apparatus and material used in formaldehyde fumigation are neither expensive nor difficult to manage. The apparatus ordinarily used consists merely of a small boiler or cylinder into which the materials are poured, and a lamp or stove which burns kerosene under pressure to supply the heat which aids in liberating the formaldehyde gas from its solution. The materials are simply formalin (40 per cent. formaldehyde) and calcium chloride (Ca Cl.) in the proportion of ten gallons of the former to twenty pounds of the latter as the stock solution. The quantity of this stock solution which should be used in fumigating pineapples is as yet wholly undetermined. In the experiments recorded in this bulletin, four quarts of the stock solution were used in a room 18x19x20 feet. The time of exposure was about an hour and a half, after which time the doors and windows were thrown open and the gas allowed to pass out. Further experiments must be carried on to determine more definitely the quantity of the stock solution and the time of exposure which is best adapted for the purpose.

Commercial formalin costs about $1.50 to $2.00 per gallon. Calcium chloride can be purchased for about 20 cents per pound in quantity.

Fumigate immediately after gathering the fruit. It will be noticed that the fumigating in the above experiments was unavoidably delayed until a day or two after the fruit was gathered. This, however, cannot be recommended. It should be performed as soon as possible after the fruit is gathered in order to destroy the spores of the fungus before they have

germinated and the vegetative organs have penetrated the tissue of the stem or of the fruit.

The room for use in fumigating should be fairly tight and should be constructed of wood. It should not have an iron roof or ceiling which would come in contact with the fumes since the latter destroy iron.

A PROPOSED NEW METHOD OF FORMALDEHYDE FUMIGATION.

The use of formaldehyde as a disinfectant has become increasingly common and several attempts have been made to develop a method of liberating the gas from its aqueous solution without the use of apparatus especially constructed for the purpose. The State Board of Health of Maine report the use of the following method with great success and efficiency.[1]

The rule for ordinary disinfection given by the State Board of Health of Maine is as follows:

For each 1000 cubic feet of room space to be disinfected, use 7½ ounces of the permanganate to one pint of formaline.

The time of exposure which is recommended is four hours. Probably a shorter time would suffice for fruits since the dosage and the time have been worked out for disinfection against infectious diseases where a very large margin of safety must be allowed. This method of liberating formaldehyde is now being used in fumigation experiments by the Hawaii Experiment Station.

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[1] Bulletin, State Board of Health of Maine, Vol. 1, No. 7.

"In carrying out this process of disinfection the requisites are simply the ordinary so-called 40 per cent. formaldehyde solution, commercial permanganate of potassium, and a vessel to mix them in.

"The required quantity of permanganate for each pint of formaldehyde is 7½ ounces. The permanganate is first put into the dish and the formaldehyde is then poured upon it. The permanganate must *go in first.* Before the mixture is made everything must be in readiness, because a rapid flight from the room must be made. Leave the room closed up tightly four hours.

"The vessel in which the permanganate and formaldehyde are to be mixed should be of considerable size, else the vigorous foaming will throw a part of the mixture upon the floor. A flaring ten-quart tin pail is a suitable and large enough vessel unless more than three pints of formaldehyde are to be used, and even then until the disinfector is well acquainted with this process, it would be a safe precaution to set the pail inside of a large pan. In this, as in all methods of chemical disinfection, the disinfectant action is more efficient the warmer the room."

"It is necessary to adjust carefully the relative quantities of permanganate and formaldehyde ————————"

MARKET CONDITIONS.

The study of the markets from Fresno, California, to Vancouver, British Columbia, reveals the unmistakable fact that there is an exceedingly inefficient distribution of pineapples. It was found that even some employees of wholesale fruit houses were quite unacquainted with the pineapple and unfamiliar with the methods of using it for food. In one case it was asked whether it was necessary to cook pineapples before eating them. There is no permanent and reliable supply of pineapples in the large markets throughout Oregon, Washington and British Columbia during the season. The fruits come in spasmodically and the consumer or even the retail dealer never knows when they are available. This is true, only to a less degree in California. These markets are supplied with fruit in this indifferent and uncertain way from Florida and Hawaii. The fruits from Florida come by rail and are packed in crates of smaller size than the standard large sized Hawaiian crate. The pineapples are much smaller than the Hawaiian fruit and are less juicy and therefore less subject to decay. They range in size from 2½ to 4 pounds. The Hawaiian fruit ranges from 4 to 9 pounds, has abundant juice and appears to be more subject to decay. The Florida fruits have been in the market for a long time and the consumers have become accustomed to buying them by the piece or by the dozen, at prices which would be quite low for the much larger sized Hawaiian fruit.

The market demands a fruit of medium size which can be retailed at from thirty to forty cents each. The fruits ranging from 6 to 9 pounds can be sold only in very limited quantities since they must be retailed at from forty to sixty cents and are larger than the average family can consume. There is also a heavier loss in the shipping of these extremely large fruits. The quantity which any of these markets can handle with safety, is determined very largely by the price. It is a well known principle in the handling of all kinds of fruit, that the sales increase in indirect ratio with the price; as the price lowers, the sales become rapid and large quantities of fruit are moved in a very short time. In seeking to build up a market it will be well not to hold the fruit at too high a figure.

THE AVOCADO.

The avocado or "alligator pear" has been shipped to a limited extent. Most shipments which have been made have arrived in such bad condition that little encouragement has been offered to the development of a trans-Pacific trade in these fruits. Honolulu prices have also ruled high. Experiments conducted by this Station in the storing of avocados in refrigeration, led to the belief that with proper handling and care, this fruit should be shipped successfully. Hence, experiments were undertaken as a part of the plan for the shipping of tropical fruits.

The fruit was packed from July 28 to July 31, 1906, was taken on board the steamship Alameda on the afternoon of July 31 and placed in the refrigeration compartment. A few packages were put on the main deck where ventilation was good. The fruits that were picked previous to July 31, were placed in cold storage the day on which they were picked and remained there until the afternoon of July 31.

The steamship Alameda sailed, as stated above, August 1 and arrived in San Francisco, August 7. The fruit was immediately transferred to the railway and carried by express to Portland, Oregon, arriving August 9. It will thus be seen that the fruit was subjected to unusually trying conditions, being taken from cold storage and shipped by ordinary express for nearly two days through a hot section of country. These conditions were more severe than would be considered for any commercial venture in fruit shipping, which fact makes the outcome the more encouraging to those interested in the development of the industry. The results of these experiments indicate that it is possible to ship this fruit to direct markets without greater loss than is experienced in average fruit shipments. The chief points of importance to be considered in shipping avocados, as learned from these experiments and from the principles which have been demonstrated in all fruit shipments, may be summed up in the following paragraphs:

HOW TO SHIP AVOCADOS.

Picking. The first step is the proper picking of the fruit. Here is where a great many mistakes have been made. Fruit of any kind carelessly picked cannot be expected to reach its destination in a sound condition. The slightest bruising will certainly show its effects when the fruit becomes ripened,

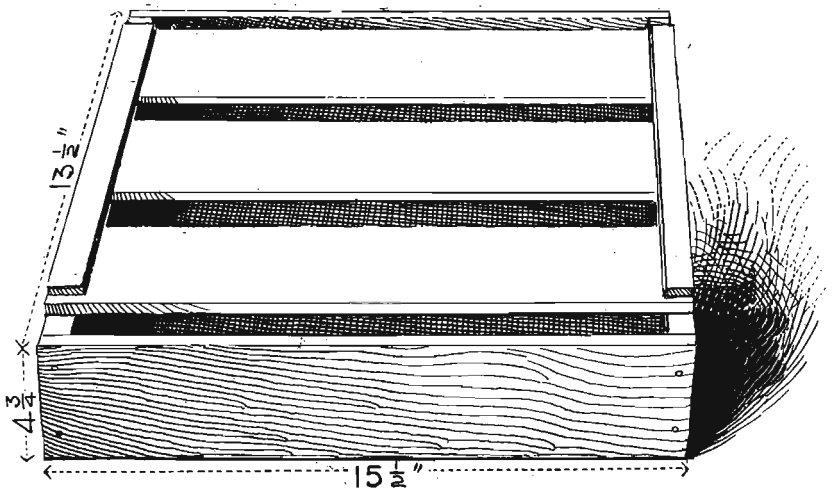

Fig. 1.

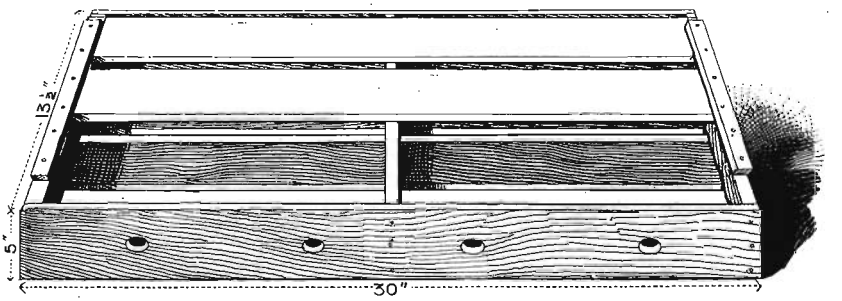

Fig. 2.

Plate II.—Crates for Avocadoes. The measurements are outside dimensions.

though it may be impossible to discover any evidences of it when the fruit is first picked. The fruit must be gathered by hand and the stems should be cut with a pair of shears as oranges are picked. If pulled the stem is likely to pull out from the fruit leaving a place where decay is sure to start. There is also danger of injuring the tree for if the stem is not cut at the proper place the branch may be broken too far back. Therefore, the cut should be made just above the natural joint found between the fruit stem and the branch.

The picking should be done on the day when the steamer is to sail or the day just preceding, if the sailing is in the morning. The experiments made, do not indicate that picking several days previous to sailing and placing in cold-storage is likely to be advisable. The reason for this is not far to seek. Though the fruit may be transferred without delay from cold-storage to the ship, the refrigeration compartments of the ship are open for the reception of freight and are not at a low temperature. The fruit therefore becomes warmed, and nothing will destroy fruit more rapidly than alternating variations in temperature. When the business assumes sufficient proportions to justify a steamship in devoting one compartment exclusively to fruits coming from cold storage, early picking and storing would be feasible.

Grading. Careful grading is important. Nothing detracts more from the appearance or the selling price of good fruit than does poor grading. The few unusually large and fine fruits from a given lot if picked out and packed by themselves will generally sell at a fancy price. If they are put in the same package with average fruit, not only is this special price lost but by contrast they make good average fruit look poor and thus lower its price to that of inferior goods. Fruit that is rather second grade if neatly packed will often bring a reasonable price, but if placed with good specimens will destroy the whole package. As illustrative of this principle the following experience may be related. A grower shipped to Honolulu a small quantity of limes to be sold at the auction rooms. A Honolulu business man realizing the importance of sorting and neatness in packing, purchased these limes at auction paying $1.50 for the lot. He also purchased a few fruit baskets in which to pack them. The limes were washed and sorted into four grades before being placed in the baskets. They were then placed on the market at twenty-five cents per basket, and sold readily. The account as furnished by the gentleman above mentioned stood as follows:

Purchase price of limes	$1.50
Baskets	.25
3 hrs. labor, boy and help	1.00
Total expense	$2.75
Sale of 38 baskets limes at 25c. per basket	$9.50
Deducting costs	2.75
Profit	$6.75

This only illustrates what may be accomplished by proper grading and packing, and what is constantly being lost by careless methods of packing.

The fruits in a package must be uniform in size, form, color, and other characters. Otherwise they will not sell for a good price.

To do the grading and packing properly it is very desirable that there should be a packing house. A room, or even a part of a room, will do where the business is small, but some place properly equipped and of suitable size should be devoted to this work. The chief essentials in the construction or selection of such a room are coolness, good ventilation and convenience of approach. In equipment it is important that everything be arranged systematically so that the packer may have crates, crate covers, wrappers, nails, and all the essentials within easy reach from his position in front of the packing table.

Packages. A second error which has been made, is in the packing. The fruits have been placed in too large boxes. The writer has seen avocados arrive in the San Francisco market in boxes as large as potato crates. This makes too much pressure on the fruit. An unnecessary amount of heat is generated and the fruit begins to ripen before it can be cooled in the refrigeration. A crate which was found to be very satisfactory for medium sized fruit was of the following dimensions: 13 inches by 14 inches by 3¾ inches, inside measurement. Such a crate (Plate II, Fig. 1) requires the following materials:

2 pieces ¾″ by 3¾″ by 13″ for ends,
2 pieces ¼″ by 3¾″ by 15½″ for sides.
6 pieces ¼″ by 3″ by 15½″ for tops and bottoms,
2 or 4 pieces ¼″ by ¾″ by 11¼″ for cleats.

The cleats may be put on the top and bottom, or on the top only. This crate holds about one dozen avocados of average size. A convenient crate of double this capacity (Plate II, Fig. 2) is made of the following materials:

2 pieces ¾″ by 3¾″ by 13″ for ends,
2 pieces ¼″ by 3¾″ by 30″ for sides,
6 pieces ¼″ by 3″ by 30″ for tops and bottoms,
1 piece ½″ by 3¾″ by 13″ for partition,
3 or 6 pieces ¼″ by ¾″ by 11¼″ for cleats.

The advantage of the cleats is in providing an air space between the boxes. They also aid in holding on the slats. Both of these crates, it will be seen, take only a single layer of fruit. For large sized fruit the depth must be increased to at least four inches. A slight adjustment to the depth of the crate can sometimes be made by tilting the pear and supporting it in this position by the adjacent fruit.

Wrapping and Packing Materials. Each fruit should be carefully wrapped in a piece of paper large enough to make a single covering and which has not been used for other purposes. Old newspapers and second-hand orange or lemon covers should never be used. A little excelsior above and below the fruit may be used but appears to be unnecessary and gave some indication of being injurious. A few fruits which were shipped in individual compartments made of crimped or corrugated straw-board arrived at their destination in excellent condition but scarcely better than those wrapped simply in paper. One hundred and sixty-seven fruits packed in this simple manner with nothing but paper wrappings, arrived in Portland with a loss of only 2.9 per cent. Some fruits were packed in bottle covers of tule. These appeared to be wholly unsatisfactory and although they occupied more space, were far more expensive and less attractive; the fruits packed in them showed a loss of 71.4 per cent.

Placing the fruits. The fruits should be placed as closely together as possible. It does not appear to be advisable to put them under as much pressure as is produced in the packing of some temperate zone fruits, for example apples, but there should be no vacant spaces and the fruit should be snugly packed together.

Conditions on Steamships. The degree of temperature which is best for the preservation of avocados has not been determined. This may be said to be true of most tropical fruits. It is not improbable that a temperature higher than that to

which temperate zone fruits are subjected, would be desirable. Experiments made by this Station and which are confirmed by reports from elsewhere, show that prolonged storage in temperatures such as are used for peaches, grapes, plums, etc., results in the blackening of the interior of the avocado. These temperatures appear to be endured without injury for about three or four weeks. It is recommended that the mercury should not fall below 40° F. It is important that the room on the ship should be cooled as rapidly as possible so that the fruit will immediately give off its heat and a uniform temperature should be maintained throughout the voyage. If through inattention the mercury should long remain below 40°, it would be at great risk to the fruit.

Shipping on deck without any refrigeration cannot be recommended for avocados. Of the several crates so carried on the voyage in question, none arrived in condition to be put on the wholesale market. Many of the fruits were over-ripe and all were fully ripened.

PAPAIAS.

Objects of the Experiment. The objects of the experiment were much the same as those outlined above, in the case of the avocados. It was first desired to determine whether the shipping of papaias is practicable and if so, to determine what methods will give the best results, what varieties are the best shippers and at what stage of maturity the fruit can be shipped. The papaias were subjected to the same unusually trying conditions as described above in the case of avocados. It should be remembered that this was not a commercial venture, for no one acquainted with perishable fruits would think of shipping such, six days in refrigeration followed by two days through extremely warm weather by ordinary express.

Results of Experiment. The results of the different trials are shown in the following table:

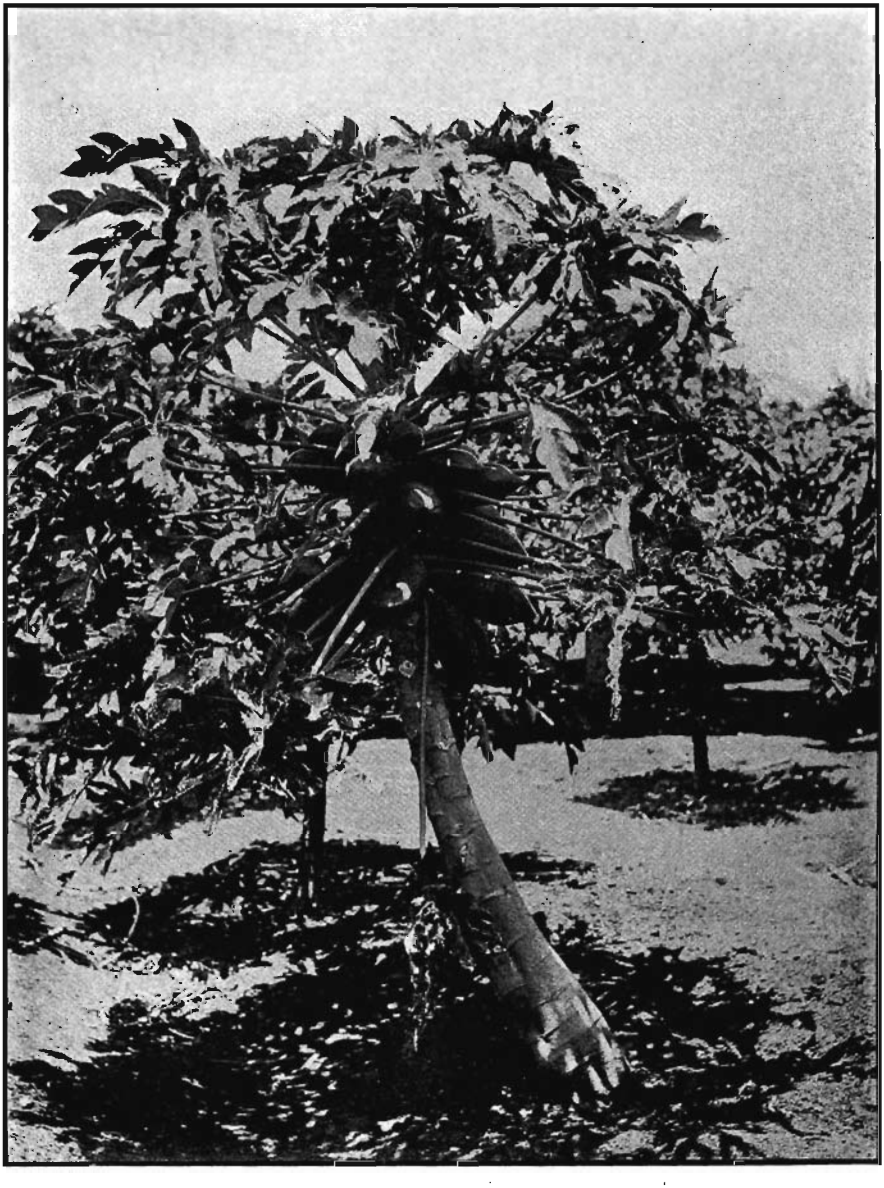

Plate III.—Young Papaia Tree of the Long Variety.

TABLE VIII. *Results of experiment in shipping papaias.*

STYLE OF PACKING	Sound	Unsound ..	Loss, per cent. ....
LOT A. Round fruit, green but full grown, wrapped in glazed paper, packed on ends in excelsior and one tier deep	18	5	21.7
LOT B. The same as "Lot A," but beginning to ripen, as indicated by slight tinges of yellow.....	14	8	36.3
LOT C. Round fruit, full grown but green, wrapped in porous paper and packed on sides in rice chaff in a tight box and headed without any pressure ..	13	5	27.7
LOT D. The same as "Lot C," except fruit beginning to ripen, as indicated by slight tinges of yellow...	14	11	44.
LOT E. Mature fruit of the long type, wrapped in glazed paper and packed one tier deep in flat crate and with excelsior.....	37	3	7.5
LOT F. Mature fruit the same as "E," except wrappped in porous paper	30	20[1]	40.
LOT G. Mature fruit of the long type, wrapped in porous paper and packed six in a crate, each fruit being surrounded by wrapping of corrugated or crimped strawboard.[2] (Figure).....	50	10	16.6

Round versus Long Fruits. The fruit of the long type (Plate III) is better for shipping than the round. It chambers more readily, leaving less vacant space. It is difficult to pack round fruit of the size of papaias so that there will not be too much vacant space and too much motion of the fruit within the crate. The round fruit having a larger hollow space within, in proportion to the surrounding pulp is more likely to break down in ripening or to telescope if it is standing on the stem. By having crates varying slightly in dimensions and by cutting the stems reasonably long when the fruit is gathered and shortening it as required to fit the crate, the papaias of the long type pack very nicely, make a neat and attractive appearance in the crate and appear to withstand shipment better than the round forms. Wide variation in the length of the stems would not be permissible.

Green versus Tinged Fruit. At the present stage of the in-

[1] 16 out of the 20 were badly bruised.

[2] Such material as is used in the packing of glass preserve bottles.

vestigations in shipping papaias, it is recommended that fruit just beginning to show the indications of ripening by the presence of slight tinges of yellow, should be shipped to San Francisco or other port which is reached by immediate journey. It is not to be recommended at present that such fruit be used where transhipment would be required. Commercial shipments in the immediate future, should be confined to markets reached by direct journey from Honolulu, Hilo, or other Island ports. The fruit that is gathered green where there is no indication of yellowing, does not acquire as fine a color as that which has just begun to ripen on the tree, though it will become ripe and marketable if fully grown.

Paper for Wrapping. Referring to Lots "E" and "F" in Table VIII, it will be seen that there was a very heavy loss on the fruit wrapped in porous paper. These results, however, are modified by the fact that sixteen out of the twenty unsound fruits in lot "F," were badly bruised. This is one of the factors which does not admit of explanation and must be regarded as purely accidental so far as the wrapping is concerned. It certainly bears no relation to the fact that the fruit was wrapped in porous paper. Even excluding the sixteen bruised fruits, the percentage of loss on papaias wrapped in porous paper is rather larger than on the fruit wrapped in glazed paper but the difference is so slight that no conclusions could be based on these results. For the present, it is recommended that glazed paper be used. It does not so readily communicate moisture from fruit to fruit as unglazed wrappers and has given the best results as a wrapper for some other fruits.

Crimped Straw-Board. The use of crimped straw-board as an exterior wrapper to go about each fruit in addition to the paper wrapping, is recommended. This provides a very valuable elastic cushion against which the fruit rests and which saves the fruit much bruising. Crimped straw-board is not expensive and may be purchased by the roll or cut in sizes to fit the fruit. The strips should be a little narrower than the length of the fruit, to allow of good ventilation and should be long enough to encircle the average fruit and slightly lap at the edges.

Refrigeration. Refrigeration can be recommended for the shipping of papaias. No deterioration in the flavor of the fruit

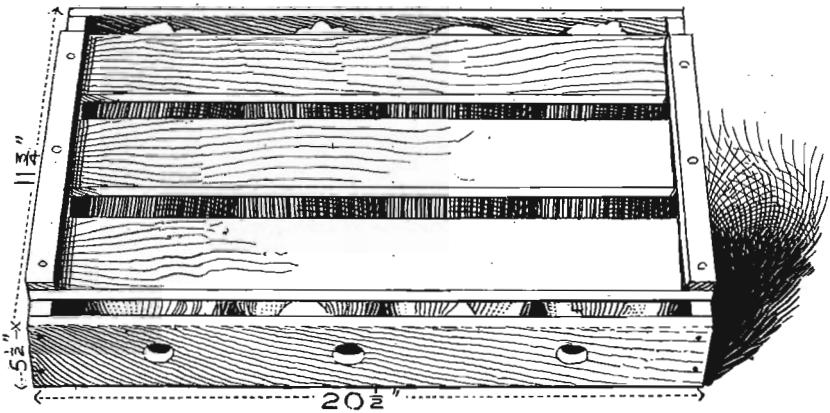

Fig. 1.

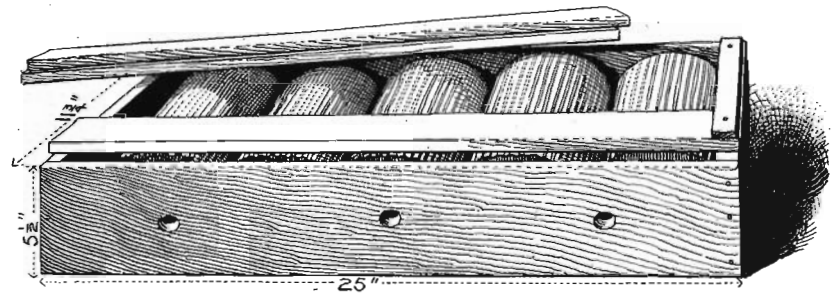

Fig. 2.

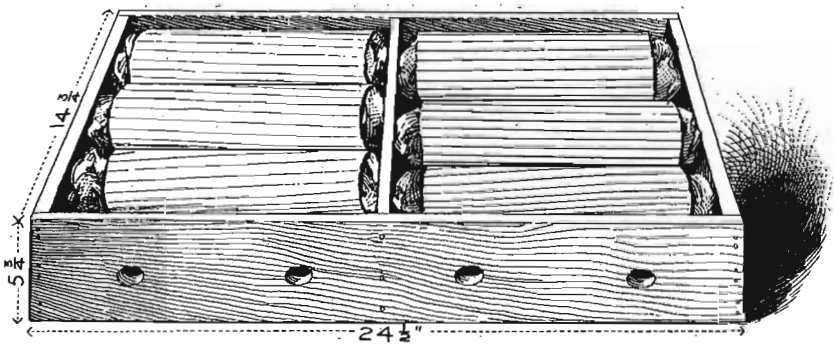

Fig. 3.

Plate IV.—Crates for Papaias. The measurements are outside dimensions.

could be detected after it had been in refrigeration throughout the voyage to San Francisco; nor were there any other evil effects apparent.

Crates. Only flat crates containing one layer of fruit should be used. The sizes described below are found to be convenient and are recommended for further trial. These are essentially the same dimensions as shown in Plate IV, but are made of lighter material. These are for rather large fruit.

Crate to hold 4 papaias (Long variety).

Dimensions 5½″ by 11¾″ by 20½″.

Materials

2 pcs. ¾″ by 4¼″ by 11″ ends,
2 pcs. ⅜″ by 4¼″ by 20½″ sides.
6 pcs. ⅜″ by 2½″ by 20½″ tops and bottoms.
2 or 4 pcs. ¼″ by ¾″ by 9½″ cleats.

Crate to hold 6 papaias (Long variety).

Dimensions 5¾″ by 14¾″ by 24½″.

Materials

2 pcs. ¾″ by 4½″ by 14″ ends,
1 pc. ¼″ by 4½″ by 14″ partition,
2 pcs. ⅜″ by 4½″ by 24½″ sides,
6 pcs. ⅜″ by 3½″ by 24½″ tops and bottom,
2 or 4 pcs. ¼″ by ¾″ by 12½″ cleats.

Market Prospects. Observing the above recommendations and being extremely careful to handle the fruit with the utmost care to avoid bruising, there will be no difficulty about shipping papaias to any direct Coast market. The papaia was found to meet with favor among those who ate it even for the first time in the markets visited during the past summer. A ready market could be made for papaias in any of the Pacific Coast cities and especially in the season when muskmelons are not plentiful. Only first class specimens should be shipped. To send insipid, worthless papaias would do great injury to the whole future industry.

BANANAS.

Source of Supply.

Excepting San Francisco, practically all the markets visited and in fact the whole of the Pacific Coast is supplied with bananas from the East. These are spoken of as the "Eastern" bananas or the "New Orleans" bananas because they are ship-

ped through New Orleans. The fruit is grown chiefly in Central America and is shipped in steamers owned and controlled by the owners of the fruit and discharged at New Orleans. Here they are loaded into cars containing about three hundred and forty bunches and are trans-shipped by rail to the entire West. As has been stated elsewhere, the fruit is sold on order. The agencies in New Orleans, by telegraphic advices, know exactly what fruits are required, what are on the way to New Orleans and what are obtainable. The prices quoted for these differ according to the quality of the fruit. Prices are quoted by the name of the port from which the bananas are shipped but they are all of the Jamaica or Martinique variety. For the week beginning June 16, 1906, they were as follows:

Limon	$2.40	per	cwt.
Changuinola	2.30	"	"
Bluefields	2.20	"	"
Chiriqui	2.20	"	"
Barrios	2.20	"	"
Ceiba	1.90	"	"

The cars containing bananas are sent through by fast freight and are accompanied by an attendant who is an employee of the company shipping the fruit and whose business it is to look after the interests of the fruit in transit, opening or closing the ventilators as required by varying climatic conditions, in order to maintain a uniformly cool temperature. In the hottest weather refrigerator cars are used, but simply for cooling, since low temperatures destroy bananas. The freight rate which the buyer pays for transportation from New Orleans to any port on the Pacific slope, be it Los Angeles, San Francisco or even Vancouver, B. C., is $1.25 per hundred weight. On the average the cost of the freight, and other charges brings the price to the wholesaler, to approximately 4½ cents per pound for the best fruit.

San Francisco receives bananas from Hawaii, from the East and a few from Mexico. From Hawaii there are shipped to San Francisco approximately 15,000 bunches per month. Only a few bananas are received from Mexico. There are two or three banana plantations in Mexico owned or controlled by San Francisco capital and which ship bananas to that market. These fruits are of the Chinese variety and are in some respects fine bananas. They usually open up with a clear yellow rind if the shipping has been at all satisfactory. This is due to

Plate V.—Young Papaia Orchard Coming into Bearing.

comparative freedom from ripe rot disease or banana anthracnose, *Glœosporium musarum*, Cke. and Massee, which is the cause of the black speckled condition of some bananas. The Mexican bananas are affected recently with a disease which appears to be more serious than the ripe rot; it affects the stem of the bunch causing it to decay, which decay extends into the stem of the individual fruits causing them to drop from the bunch with blackened ends. The main stem may break off midway of the bunch so that the whole bunch goes to pieces. This disease, however, can probably be controlled and Hawaii must reckon upon Mexico as a competitor in the market.

Comparing the Chinese variety from these Islands and the varieties with which they come into competition in San Francisco (Plate VII), it may be said that no banana in the market is superior in point of flavor to those from Hawaii. If they arrive in good condition they find a ready market. It is a well recognized fact that the best class of trade in San Francisco calls for the bananas from Hawaii. Here their good qualities are known and recognized. It must be said, however, that growers in Hawaii have acted against their own interests, in shipping inferior bunches. As fine bananas can be produced today as were ever grown here if intelligence and care is brought to bear upon every detail of the industry. The cost of production of a small bunch is nearly as great as for a large one. The freight, which represents about one-third of the selling price of a good bunch, is precisely the same figure for the smallest bunch shipped. A small bunch is difficult to sell at any price and often does not bring enough to pay the 40 cents freight. A dealer who handles a very large number of the Hawaiian product has made the statement that Hawaii would practically supply the whole San Francisco market, if such bananas were shipped as formerly. The Chinese banana, however, is not so good a shipper as those of the Jamaica or Central American variety with which they come in competition. The Hawaiian bananas are wrapped in leaves and sometimes in straw, while those from the East are shipped without any wrapping. One of the steamship companies has offered to coöperate in an experiment in the shipping of bananas from Honolulu without wrapping. If this can be accomplished it will save an expense of approximately 5 cents per bunch for wrapping. It may cause a more careful handling of the fruit by all parties, from the plantation to the wholesale warehouse and it may also allow a better circulation of air to the fruit in the ship.

Exclusive of Hawaiian bananas, there are shipped to the Pacific Coast, approximately 1900 carloads of bananas per year. This includes those supplied to Arizona and New Mexico through Los Angeles; those to California, Oregon, Washington, British Columbia, Montana and Idaho. A carload averages about 340 bunches, making a total of 646,000 bunches per year consumed within this territory, exclusive of bananas from Hawaii. This is the equivalent of approximately 53,833 bunches per month. If these bananas were grown in Hawaii within the territory of the United States, they would represent an annual value of over half a million dollars to this Territory directly. In addition to this, they would supply the chief freight to two steamers making regular trips between the Islands and the mainland. All the markets west of the Great Plains might be supplied with bananas grown here on United States soil. The importance of this trade in the future may be estimated from the fact that the annual consumption of bananas in the United States is and has been increasing at the rate of more than one million dollars per year in value. From an agricultural and economic point of view there is no good reason why the Pacific Slope trade in bananas should not be supplied from Hawaii.

COOKING BANANAS.

The cooking banana is in its use so unlike the banana which is eaten without cooking as to be quite a distinct product upon the market. During the past twenty years, as has been seen, a large trade has been built up in the banana which is eaten raw. The cooking banana which takes the place of fresh vegetables and cooking fruit has not as yet been introduced to the American markets, except in New Orleans and about the Gulf Coast. There can be no doubt that during the winter season when there is a lack of fresh vegetables in the markets, there would be large demand for the cooking bananas that are grown now in a small way in Hawaii. The merits of the Hawaiian cooking bananas are but little understood even by a large number of people who have resided in the Islands for a considerable period. To the people of the mainland they are practically unknown. Active efforts to introduce and acquaint the people with this fruit could build up a large trade in these fruits.

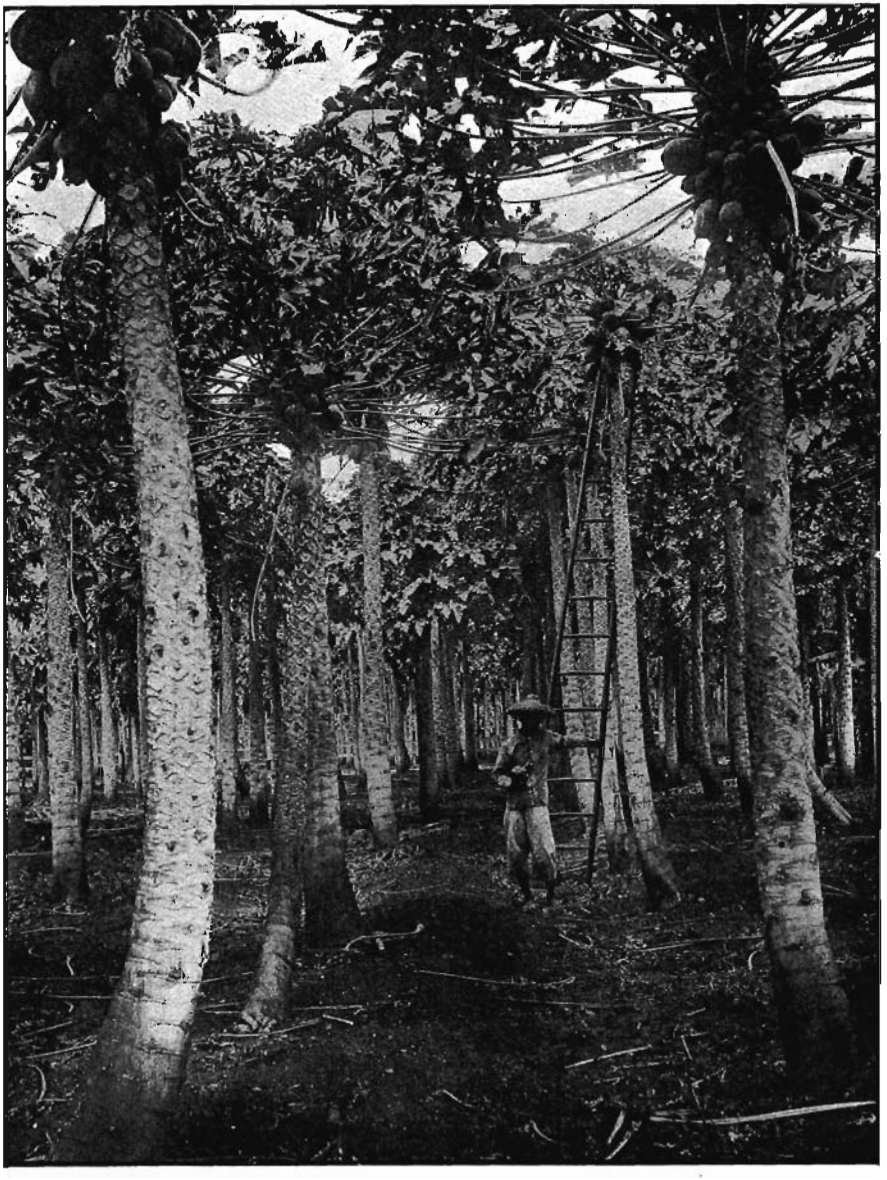

Plate VI.—Old Papaia Orchard.

MANGOES.

The mango will unquestionably become a popular fruit in the markets of the temperate zone. Its beauty of form and coloring, its enchanting aroma and delicious flavor make it a fruit universally appreciated where known. The inferior seedling varieties have been responsible for the unenviable reputation which it has acquired among some travelers. The fine varieties have only recently been introduced in the American tropics and are as yet known to but few. When these shall have been propagated and widely distributed in Hawaii, Florida, Porto Rico, the Philippines, Cuba and Mexico, the growing of the fruit will become an important industry. The demand for it will increase as those who are yet young have seen the markets increase in their capacity for oranges, lemons, pomelos, bananas and many other fruits. Hawaii should grow a large portion of the mangoes for the Western markets.

In the shipments of August, 1906, no mangoes were included. The Station has, however, experimented for several years in the keeping of mangoes in cold storage with most favorable results. Mangoes may be kept much longer than avocados under refrigeration without deterioration in quality. They have been shipped long distances and have arrived in perfect condition.

There is but one obstacle to the development of a large and prosperous mango industry in Hawaii and this one calls for immediate and stringent action on the part of the Government. The mango-weevil, *Cryptorhynchus mangiferæ* threatens the industry and the longer the fight against it is delayed the greater will be its difficulties and expense. It is a short sighted and suicidal policy to withhold immediate action even if its cost should be great.

SWEET POTATOES.

The shipping experiments included only fruits but a study of the markets revealed a promising opening for the shipping of sweet potatoes from Hawaii to the mainland during the time when those grown there are out of season. Almost all of the sweet potatoes used on the Pacific Coast are grown in California. The opening of the season is about the middle of August and it continues until about April 15th. When they first appear on the market the prices are very high, $60. to $80. per ton wholesale being not an uncommon price. During

the latter part of the season the potatoes which have been stored for a long time are of indifferent quality. The time when the Hawaiian product could probably be put on the market at high prices would be from April 15th or earlier, until August 15th.

All these markets at the present time, demand a white or light yellow potato of medium size and dry. The red varieties are almost unknown and though it might be possible in time to place some of our best red varieties, it must be done gradually. The people know the yellow potato and in this case it is much more profitable to grow what the people want than to make the people want what you grow.

The standard crate in which potatoes are shipped in California, contains about one hundred pounds. The ends are 18 by 11¾ inches and are one inch thick. The side slats are 2 feet long and are of ¼ inch lumber. This would be a suitable crate in which to ship from Hawaii. Sacks should not be used.

MARKETING SYSTEM.

Fruit and all agricultural products have in the past been marketed by the commission and consignment system. This system is too common today. By this method the grower ships his fruit to a distant city consigning it to a commission merchant and says in effect "Sell for me these products at such prices as you can secure, take your commission and return to me what is left." Such a method of marketing is manifestly unbusinesslike and does not prevail in the world of commerce except in the handling of agricultural products. Does the manufacturer of shoes or household furniture or any other commodity take great pains in the production of the finest possible manufacture and then ship his goods to a commission merchant with the request that the goods be sold and that whatever may be due him after the transactions are closed, be remitted? Granting that he is assured of the highest integrity on the part of the commission house, he does not care to market his product in this manner. Men in the fruit commission business are as honest as in other lines of enterprise, yet it will be admitted that this system offers unusual opportunity for unscrupulous dealing and it is hardly to be expected that the whole fraternity of commission men will be without an exception, in straight dealing and integrity. For this reason if for no other, the grower should seek other methods of marketing, for many losses will be sustained while the grower

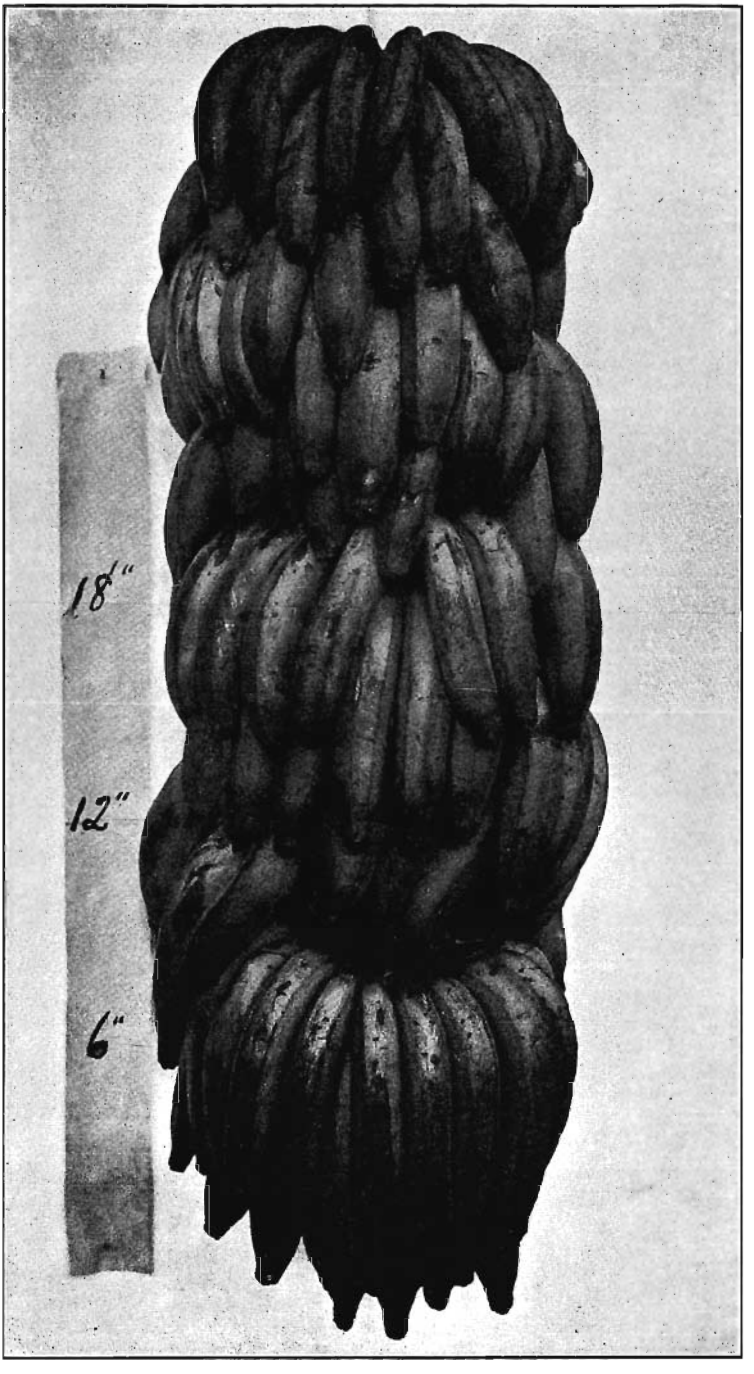

Plate VII.—The Jamaica or Central America Banana.

is finding a man in whom he can rely to do the best for him which this system permits.

There are, however, other reasons for condemning this system. The interests of the commission house lie in exactly an opposite direction to that of the producer or shipper. Manifestly the interest of the commission house lies in the direction of commissions. Much more money can frequently be made in the form of commissions, on fruit selling at a low than at high price. It is of course to the advantage of the shipper that the fruit be sold at the highest possible price. At first sight it may appear that this will also be to the best interest of the commission merchant, but it is not the case. Low prices mean many sales and an easy market, high prices mean fewer sales. As prices drop, the sales increase very rapidly. Suppose for example, that a pineapple grower in Hawaii ships to San Francisco one hundred dozen pineapples. If these are all sound and sell at $4. per dozen the account not considering minor charges should stand as follows on a 10 per cent. commission basis:

100 doz. pineapples at $4	$400.00
Commission at 10 per cent	40.00
Remittance to grower	$360.00

Suppose the same pineapples should be put on the market at $3. per dozen the account would stand:

100 doz. pineapples at $3	$300.00
Commission at 10 per cent	30.00
Remittance	$270.00.

By this fall in prices the shipper has sustained a loss of $90. and the commission merchant an apparent loss of $10. Provided, however, that there is a sufficient supply of pineapples available, this loss of $10. is only an apparent loss. By selling thirty-three and one-third dozen more pineapples, the $10. is made up. This difference of $1. per dozen in the price will increase the sales far more than 33 1-3 per cent. so that the commission house has really profited by this low price and has not lost. The larger the volume of trade as a general rule, the larger will be the net income of the commission house. It will be granted that the commission house will wish to do the best possible for the man who consigns to it, provided that in so doing its own business interests are not interfered with, be-

cause it wishes to please him and secure his future business, but the fact remains that its interests are in the line of large sales even at low prices and would frequently be interfered with by doing the best possible for the shipper. Greater activity in distribution might dispose of the supposed one hundred dozen pines at $4. per dozen, but would it pay? From the standpoint of the owner of the fruit it would, but from the point of view of commissions, it might not. If not, who will charge the commission merchant with anything other than honorable business dealings when he sells at $3. per dozen? If the careful distribution at the higher price costs him more than the $10. it would be akin to philanthropy for him to maintain that figure. The fault is not with the men but with the system.

It must further be admitted that the care in handling which fruit receives in being taken from the ship to the store rooms will be greater if performed by or under the supervision of the owner of the fruit. This again is saying nothing derogatory of the commission merchants but nobody expects another party to look after his interests as well as he, personally, or through his agents, could do. Business is not done on this plan. For example the writer has seen bananas from Hawaii loaded on wagons on the docks in San Francisco being placed five or six tiers high and the men loading the fruit walking over the lower bunches while reaching to place other bunches on the higher tiers. When these bunches begin to ripen the bruises which have been caused by being walked upon and by the deep stacking, are very apparent and probably a large portion of the bunch is worthless. These bunches have to be sold for almost nothing and returns are made to the shipper for so many bunches spoiled. Probably the managers of the houses for whom these draymen were working would not approve of the fruit being treated in this manner, but if the ownership of the fruit were transferred to the commission house and the destruction of each bunch represented a dollar or two to them, no one will dispute that the incentive to enforcing proper handling upon those driving the fruit wagons, would be greatly increased. In other words, the commission house makes cash returns for only the fruit that is opened up at its show rooms in fit condition for sale and so remains until a sale has been made.

In other lines of commerce, goods are sold on order. The owner or his agent interviews the buyers and secures orders

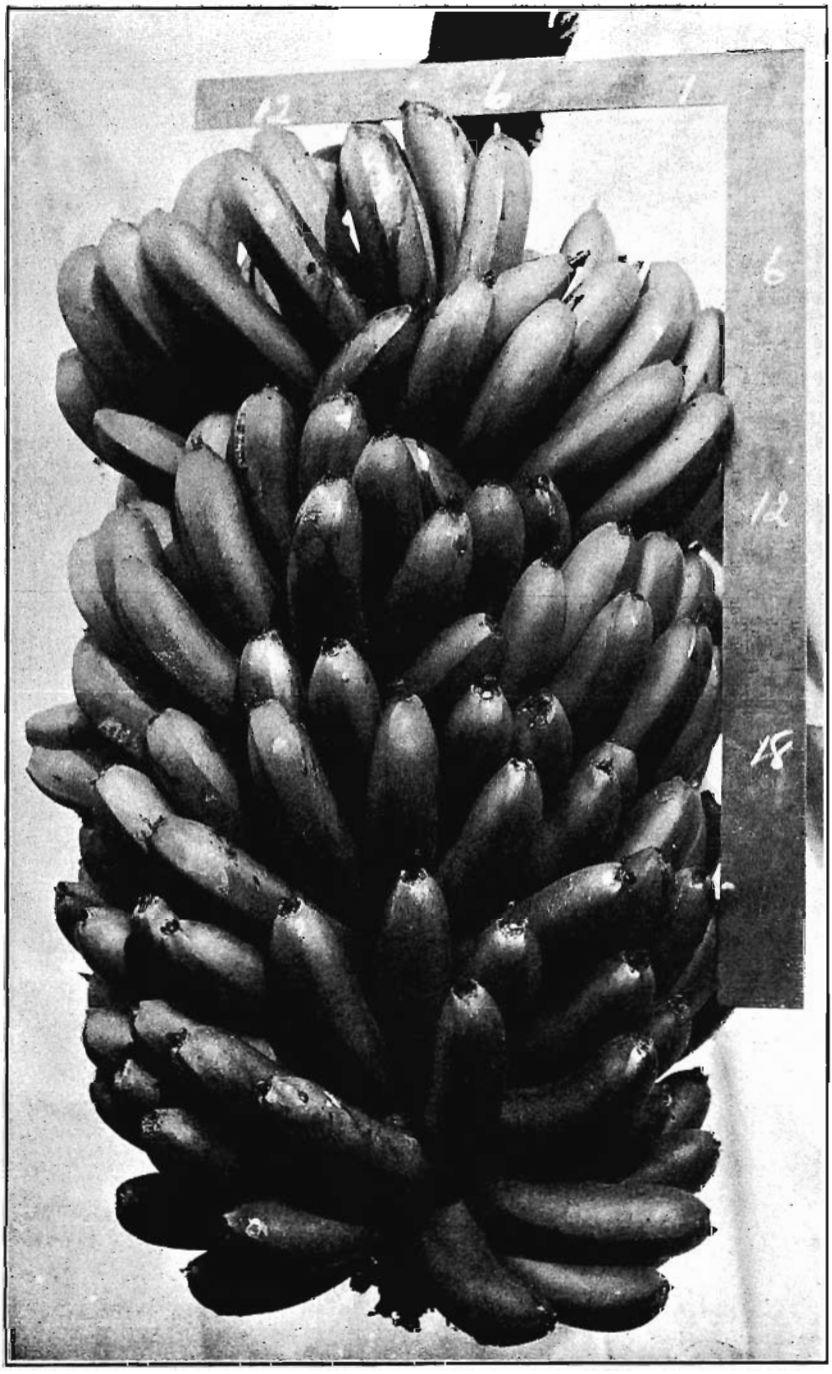

Plate VIII.—The Chinese or Cavendish Banana as grown in Hawaii.

from each. Is there any good reason why the fruit growers of Hawaii should not sell their fruit on this plan? It is business-like, it avoids glutting the markets and provides for a far more general and wide distribution than the system described above. This is the method which is pursued by the competitors of Hawaii in the banana and pineapple markets. Those who control the "Eastern" bananas sell to a given commission house in San Francisco, Seattle, Portland or other market, a carload of bananas at a given price f. o. b. New Orleans. This fruit then becomes the property of the Pacific Coast firm which, in the transaction, acts not as a commission house, but as a wholesale dealer in fruits. Pineapples from Florida, which compete with the Hawaiian product, are sold in the same manner as these bananas. The different wholesale dealers unite in ordering a carload when one firm cannot handle that quantity but they are sold in Florida to be shipped to the West and ownership in the fruit is there transferred to the different firms who buy.

This method of disposing of fruit is growing in favor. Nothing further need be said to show that it is far more desirable for the producer than the commission system. It is also satisfactory to the commission merchants who are to a large extent at the present time, wholesale dealers in fruit, which they buy and sell in the same manner as any other commodity. A very large portion of their business is done in this way. Provided the fruit is up to the standard, well packed, sold at a reasonable price, and arrives in reasonably good condition, this method cannot fail to give satisfaction to those who buy at wholesale.

In order that such a plan may be carried out to the best advantage, it is important that the Hawaiian fruit growers should organize for the marketing of their product. By so doing, an agent on salary and wholly responsible to them, could be maintained in San Francisco who could for the present attend to the taking of orders on the Pacific Coast. This being his exclusive business he could without a doubt, place large quantities of fruit in cities and small towns where our fruits are scarcely known. This would not necessitate the establishing of a wholesale fruit house, for the fruits could go, as now, to the wholesale dealers. Another agent should be appointed to attend to the proper shipping of the fruit from

Honolulu, who need give only a part of his time to this work. This plan need not entail much expense and would certainly save to the growers and shippers, a sum far in excess of that expended.

The fruit growers of California have organized themselves into very strong combinations conspicuous among which are the California Fruit Exchange and the California Fruit-Growers' Exchange, the former for the handling of deciduous fruits chiefly, and the latter for citrus fruits. These two bodies now market a very large portion of the fruit of the State. Their agents are in every important market in the United States and keep the growers and shippers informed by telegraphic advices as to prices and the general condition of the markets.

The Hawaiian growers could doubtless avail themselves of the advantages of this whole California system if an organization could be effected along the lines followed by the local associations throughout California. These local associations together constitute the central organization. In conversation with Mr. A. R. Sprague, President and Manager of the California Fruit Exchange, the writer was assured that it would be possible for an association in Hawaii to be taken into the general organization on the same basis as the local branches in the different parts of the State. This opportunity is well worthy of consideration by those interested in Hawaiian fruit industries.