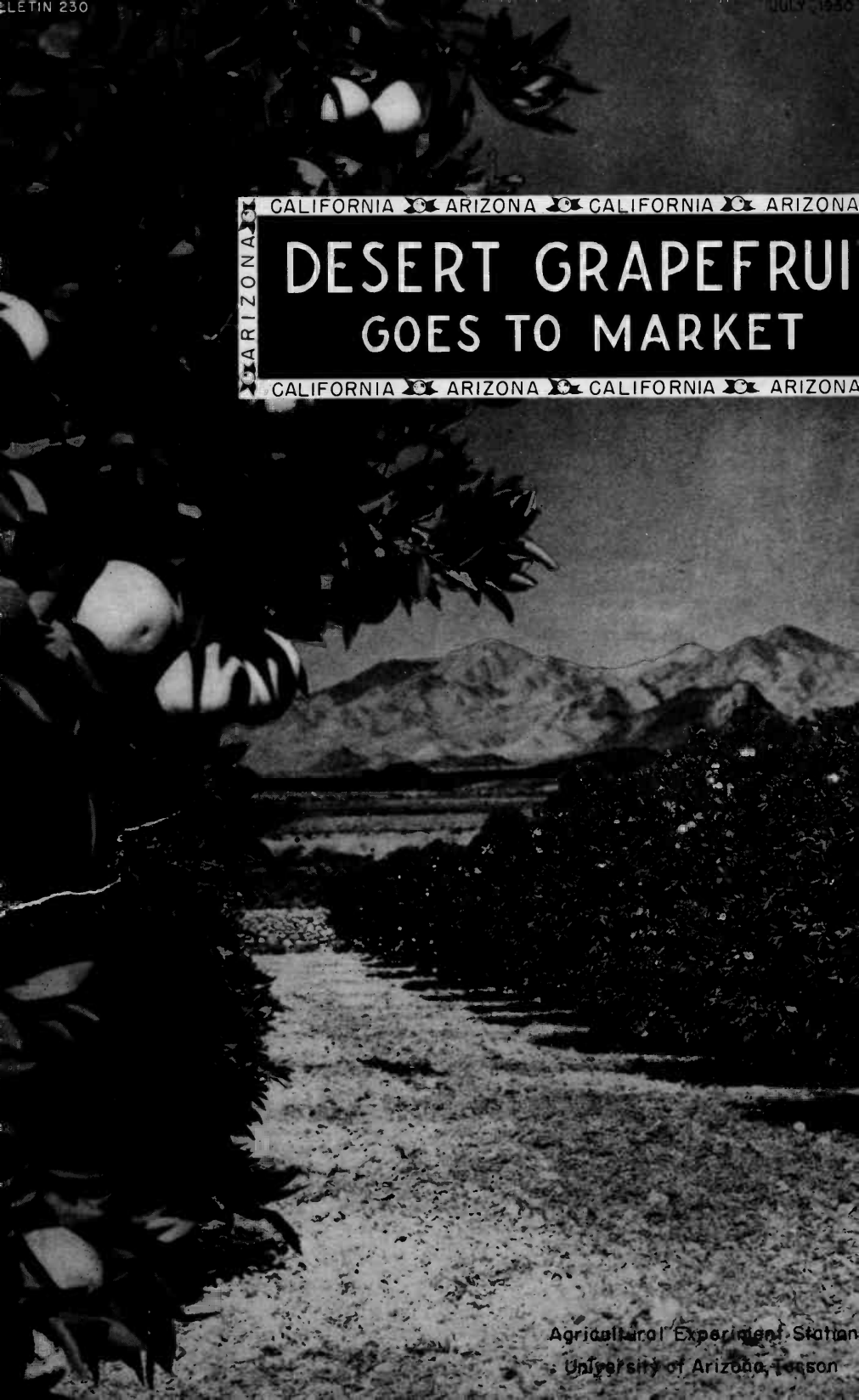

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SUMMARY

1. Acreage of bearing grapefruit in the United States more than doubled during the period 1930-1950.
2. Within the desert, there has been a substantial reduction in grapefruit acreage from the peak in 1935-37 to 1950.
3. The composition of desert citrus acreage is changing as Valencia oranges and lemons are replacing grapefruit.
4. Among the desert producing districts there exists a wide variation in yields. Yuma groves yield about 16 tons to the acre, Coachella Valley groves 11 tons, Salt River Valley 9, and the Imperial Valley 6.
5. Grapefruit production in the United States in 1945-46 was over seven times as great as it was in 1925-26. During the same period Texas production increased from a few thousand boxes to nearly 40 per cent of the total U.S. crop.
6. In the desert, about 65 per cent of the total production is grown in the Salt River Valley, 12 per cent at Yuma, 7 per cent in the Imperial Valley and 16 per cent in the Coachella Valley.
7. Grapefruit is produced primarily for the fresh fruit trade, but processing has grown over the past twenty years until, for the country as a whole, it now takes as much fruit as is sold in fresh form. Florida normally processes about 65 per cent of her grapefruit, Texas 40 per cent, and the desert about 35 per cent.
8. The marketing season for winter grapefruit normally begins in October and ends early in July. All producing areas normally begin shipments in October; Texas is nearly through by the first of June, Florida in June, and the desert normally ships until the middle of July. Within the desert, Yuma begins shipping first, then the Salt River and Imperial valleys, with Coachella beginning much later than the rest.
9. The principal market for desert grapefruit lies in the West and only late in the season, when Texas and Florida shipments are reduced, does the desert ship any appreciable amount of fruit to the Midwest and the East.
10. Desert grapefruit prices have been characterized by extreme year-to-year fluctuations.
11. "On tree" returns since World War II have failed to cover cost of production.
12. There exists a consistent price differential between producing areas within the desert. The Coachella Valley gets a substantial premium for its fruit, while Yuma receives the lowest average price.
13. Desert grapefruit has a pronounced and consistent pattern of seasonal price variation. Early and late season prices are always high relative to mid-season prices.
14. Desert fresh grapefruit shipments, nonagricultural income, and total U.S. grapefruit utilization are all important factors in the determination of f.o.b. prices of desert grapefruit.

15. Most retailers prefer medium to small-sized grapefruit, and the larger sizes generally sell at a discount.
16. The demand for desert grapefruit is elastic at the f.o.b. price level and inelastic at the "on tree" price level.
17. The desert grapefruit industry operates under a grade and size proration program the purpose of which is to limit sales of fresh fruit to the point where a reasonably satisfactory price will be maintained.
18. The present measure of maturity of desert grapefruit (the solids-acid ratio) does not reflect the actual taste of the fruit. A trained taste panel is able to determine, with a usable degree of accuracy, the level of consumer acceptance of this fruit.
19. Bulk-handling compared with the use of field boxes in the harvesting of desert grapefruit saves an appreciable part of the hauling cost. One packing house, handling 700,000 field boxes of fruit, saved $23,000 per year through the use of bulk-handling.
20. Packing costs for desert grapefruit are now approximately double those of ten years ago, most of this increase being due to higher material and labor costs.
21. During 1946-47, there was a 46-cent range in packing costs among thirteen desert citrus packing houses studied. The lowest packing cost was $.64 per packed box; the highest cost, $1.10.
22. A new-type paperboard citrus box has been developed which is mechanically capable of carrying desert grapefruit to any market in as good condition as would be obtained with the standard wooden box. Use of the paperboard box would result in savings of 10 to 15 cents per box shipped. The desert grapefruit industry should seriously consider the possibilities of this new container.
23. Yellow grapefruit bags are more attractive to the consumer than are red bags.
24. Freight constitutes a major item of expense in the marketing of desert grapefruit. It costs approximately 50 cents per box, on the average, to move this fruit to market.
25. Approximately two-thirds of all desert grapefruit moves by truck.
26. The former 76-pound estimated weight of the packed box of desert grapefruit, as used in calculating freight charges was found by this study to be 6 pounds too high. A 70-pound weight is now going into effect, saving about $75,000 per year in truck and rail freight charges.
27. Ton-mile freight rates favor the movement of Texas grapefruit over desert grapefruit to all major markets in the Intermountain and Pacific Northwest States. In the interest of desert grapefruit further study of this situation seems advisable.
28. The wholesaling of desert grapefruit is performed largely through co-operative sales agencies.

29. Over one-third of the consumer's dollar spent for fresh desert grapefruit goes to the retailer. In view of the fact that grapefruit is not a highly perishable item, and since the more perishable products, such as apples, have comparable mark-ups, it might seem that grapefruit helps "carry" some of these more perishable items. This situation operates to the direct disadvantage of the grapefruit industry.
30. Dried grapefruit pulp is a palatable feed for livestock, and compares favorably in feeding value with rolled barley and other carbohydrate concentrates. It sells at a price equal to about 75 per cent of the price of those feeds. Feeders generally like the dried grapefruit pulp and many say that it has an added "conditioning" effect not found in feed grains.

DESERT GRAPEFRUIT GOES TO MARKET

R. E. SELTZER[1]

INTRODUCTION

Desert grapefruit is produced in Maricopa and Yuma counties in Arizona and in California in Imperial County and the Coachella Valley, which is that part of Riverside County lying south and east of the San Gorgonio Pass. The desert, Florida, and Texas produce winter grapefruit and a small area in Southern California produces summer grapefruit.

The commercial production of grapefruit is a relatively new agricultural industry. The first plantings of this fruit in the United States were made in Florida about 1809 by a Spanish nobleman, but the fruit was produced mainly as a curiosity and for home use. The early varieties were of good flavor, but filled with seeds. The Marsh Seedless variety, developed about 1880, did much to popularize and to create a demand for grapefruit. In 1890 the first planting of importance of Marsh Seedless grapefruit in the West was started at Riverside, California by Twogood and Cutter. Two years later the first grapefruit was planted in Arizona at the Clayson ranch just outside Phoenix. About the same time, H. W. Blaisdell planted citrus at Yuma. Grapefruit entered a new Southern California area when R. Gregg Whitney planted a grove at Oasis in the Coachella Valley in 1916. The success of this grove led many others in the Coachella and Imperial valleys into the growing of grapefruit. Rootstock budded from this grove was planted in Arizona. The desert grapefruit industry grew slowly until the late 20's when a rapid expansion in acreage took place. This expansion resulted in greatly increased production as these trees came into full bearing, and the industry soon found itself with a chronic surplus of production which could only be disposed of at very low prices. During World War II, the high level of consumer demand coupled with large purchases by the armed forces raised the price to a very satisfactory level, but with the end of the war the industry found itself again faced with the problem of surplus production, low prices and this time the situation was further aggravated by high costs of production and marketing. The depressed condition of this industry made necessary this study.

The objectives of this work follow:

1. Trace the history and assemble data on prices, production, and shipments of fresh and processed desert grapefruit.
2. Determine and measure statistically the relative importance of the major factors affecting the demand for desert grapefruit.

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[1]Associate Agricultural Economist, Arizona Agricultural Experiment Station. J. D. Rowell assisted with the work of this project during 1949-50, and R. A. Sherburne during 1948-49.

3. Determine costs and margins involved in marketing from producer to consumer, and point out possible economics which might be made.
4. Sample consumer preferences in the Los Angeles market regarding methods of packaging, quantity of purchases, quality of product and methods of determining quality, and other aspects of consumer preference in regard to fresh and processed grapefruit.
5. Summarize the results of this study and point out the combinations of methods, routes and volumes which will result in the greatest net return to the grower.

As this project developed, the original objectives were followed rather closely, but the work was largely concentrated on fresh fruit problems.

ECONOMIC STATUS OF THE DESERT GRAPEFRUIT INDUSTRY

Acreage

Acreage of bearing grapefruit in the United States and in the desert more than doubled during the period 1930-1950. During the same period, acreage increased by 50 per cent in Florida and 500 per cent in Texas.

The desert grapefruit acreage has developed since World War I. In 1919 there were but 500 acres of grapefruit in the desert. Most of the commercial plantings went in during the period 1929-1933 and the peak of 24,000 acres was reached in the years 1935-37. Since 1938, acreage has been reduced to a point where there were but 13,772 acres in 1949.

The grapefruit industry of Texas has developed over the same period as the desert industry, but at a more rapid rate. In 1919 there were about 100 acres of grapefruit in Texas. In 1947-48 there were 80,500 acres. In the freeze of 1948-49 a large acreage of trees were killed or so severely damaged that they were removed. Replanting has replaced much of the damaged acreage, but the total is still down considerably from the 1947-48 acreage.

In 1919, Florida was already well established in the grapefruit business with 26,000 acres in bearing. Florida acreage has gradually expanded to a peak of 93,000 acres in 1950.

Little new grapefruit acreage is being planted except in Texas where new plantings have consisted mostly of pink and Ruby Blush type fruit.

By 1949 within the desert there had been a substantial reduction in grapefruit acreage since the peak in 1935-37. Postwar returns have been so poor that drastic acreage reductions have taken place. Table 1 shows the desert acreage by producing districts for these two periods.

The greatest desert grapefruit acreage reduction has taken place in the Imperial Valley. This district is rapidly going out of citrus production. In 1936 there were 7,754 acres of grapefruit in this area, in 1949, 1,651 acres. Low yields and frost damage have combined to discourage citrus growers.

TABLE 1.—SOME COMPARATIVE DESERT CITRUS ACREAGES, 1935-37 AND 1949

Citrus fruit	Salt River Valley		Yuma		Imperial Valley		Coachella Valley		Desert total	
	1935 (acreage)	1949	1935 (acreage)	1949	1936 (acreage)	1949	1937 (acreage)	1949	1935-37 (acreage)	1949
Grapefruit	12,918	9,189	1,111	1,034	7,754	1,651	2,555	1,822	24,338	13,722
Oranges	6,844	8,582	232	496	1,161	550	118	87	8,355	9,775
Tangerines	58	235	1	22	347	249	150	379	556	885
Lemons	185	629	9	178	208	68	.....	68	402	943
Limes & other	17	10	15	5	3	.....	.....	58	35	73
Total	20,022	18,645	1,368	1,735	9,473	2,518	2,823	2,414	33,686	25,398

Sources: Arizona 1935, "Arizona Citrus Tree and Acreage Survey of 1935," USDA-BAE, Division of Crop and Livestock Estimates, Washington, D.C. October 1935.
Arizona 1949, "Arizona Citrus—A Co-operative Survey," USDA-BAE, Dept. of Agr. Econ. of the Univ. of Arizona Agr. Exp. Sta. and Desert Grapefruit Industry Committee, Inc. June 1949.
Imperial Valley, Imperial County Agricultural Commissioner, El Centro, Cal.
Coachella Valley, Riverside County Agricultural Commissioner, Riverside, Cal.

The Salt River Valley has also made a substantial reduction in grapefruit acreage. In 1935 there were 12,918 acres of grapefruit in the valley, in 1949, 9,189 acres. Comparatively low yields and high costs have worked toward grapefruit acreage reduction. However, the Salt River Valley is not going out of citrus production, as much of the grapefruit acreage has been shifted to oranges and lemons.

The Coachella Valley has made some reduction in grapefruit acreage, from 2,555 acres in 1937 to 1,822 acres in 1949. About half of this reduction has been replaced with other citrus fruits.

Grapefruit acreage at Yuma has remained about the same, but considerable acreage of oranges and lemons has been added.

The composition of desert citrus acreage changed considerably during the period 1935-37 through 1949-50. In the period 1935-37 there were 33,686 acres of citrus in the desert; in 1949 there were but 25,468 acres. This reduction has been entirely in grapefruit acreage. As seen from Figure 1, in 1935-37, 24,338 acres or 72.3 per cent of the desert total citrus acreage was in grapefruit. In 1949, 13,772 acres were in grapefruit, or 54.1 per cent of the total desert citrus acreage. Oranges increased from 8,355 acres, or 24.8 per cent of the 1935-37 desert citrus acreage, to 9,775 acres or 38.4 per cent of the 1949 total. Other citrus acreage (mostly lemons and tangerines) about doubled, increasing from 993 acres in 1935-37 to 1,921 acres in 1949.

Some further reductions in desert grapefruit acreage may reasonably be expected during the next few years. An increase in orange acreage, and a substantial increase in lemon acreage appears to be taking place.

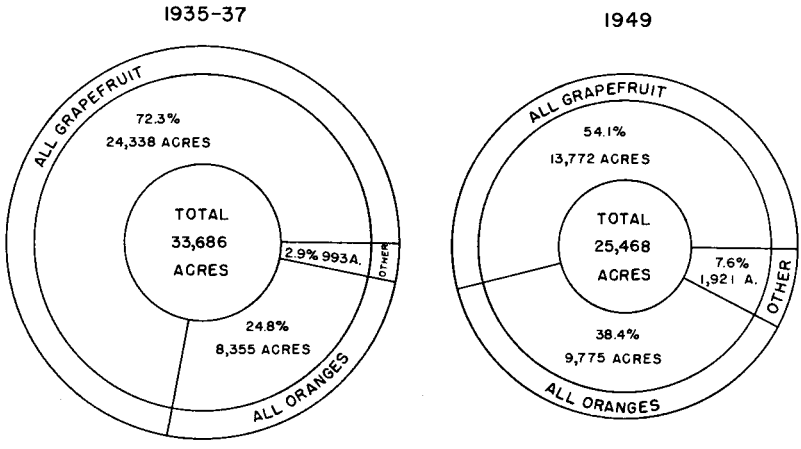

Figure 1.—Desert citrus acreage, 1935-37 and 1949.

Yields

No general producing area has an apparent advantage in yield over the others. Among the three areas producing winter grapefruit in the United States there appears to be a very little difference in yield. In recent years the desert, Texas and Florida have all had yields of grapefruit of 8 to 10 tons per acre.

Within the desert there exists a wide variation in yield among the four producing districts. During the period 1941-42 through 1947-48, the average production in tons per acre for the desert by districts was: Salt River Valley, 8.5; Yuma, 15.8; Imperial Valley, 5.7; and Coachella Valley, 10.8. This variation in yield appears to be a major factor in determining whether or not the grapefruit industry in each of these districts is to be maintained.

Production

Grapefruit production in the United States in 1945-46 was over seven times as great as it was in 1925-26 (Figure 2). Over the same period, Texas production increased 125 times.

Production of grapefruit in the United States has increased from 8,500,000 boxes in 1925-26 to 63,000,000 boxes in 1945-46, an increase of 750 per cent (Table 2).

Florida is the leading state in the production of grapefruit followed closely by Texas, with Arizona and California producing the remainder of the commercial crop. Florida produces about 50 per cent of the total crop, Texas 35 to 40 per cent, the desert about 9 per cent and the California summer grapefruit area the remainder.

Production in Texas has increased much more rapidly than in any other producing area. In 1925 Texas produced 200,000 boxes —in 1946, 24,000,000 boxes. The major part of any subsequent production increases will come from Texas. There is a considerable

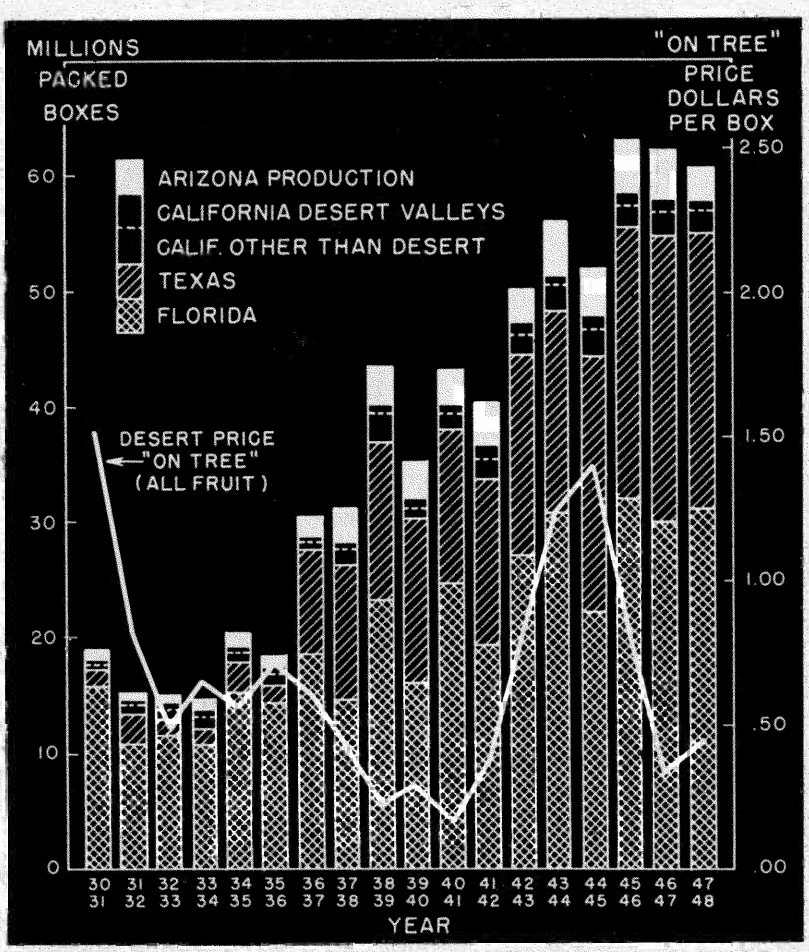

Figure 2.—Grapefruit production by states and desert "on-tree" price, 1930-31 through 1947-48.

acreage of grapefruit in Texas not yet in bearing, and the trees now in bearing are relatively young. Most of this young acreage is planted in pink or Ruby-blush type fruit.

In the desert area, about 65 per cent of the total production is grown in the Salt River Valley, about 12 per cent at Yuma, 7 per cent in the Imperial Valley and 16 per cent in the Coachella Valley. Accompanying the expected reduction in desert acreage will be a shift in the relative importance of the four producing areas. Yuma and the Coachella Valley appear to have an advantage over the Salt River Valley and Imperial Valley areas. Yuma has the highest yields and the lowest f.o.b. costs in the desert. Coachella also has a high yield, but gains most of its advantage from the premium which it receives for its fruit. Such advantages, result-

TABLE 2.—GRAPEFRUIT: PRODUCTION BY STATES BY YEARS IN PACKED BOXES. 1925-26 THROUGH 1947-48*

Crop year	Arizona 60 lb.	California 60 lb.	Florida 80 lb.	Texas 80 lb.	United States
	(thousands)	(thousands)	(thousands)	(thousands)	(thousands)
1925-26	150	600	7,600	200	8,550
1926-27	120	672	8,600	361	9,753
1927-28	176	720	6,500	524	8,920
1928-29	211	972	11,300	753	13,236
1929-30	365	1,000	8,300	1,550	11,215
1930-31	400	1,290	15,800	1,200	18,690
1931-32	450	1,431	10,700	2,600	15,181
1932-33	614	3,150	11,600	1,440	15,004
1933-34	800	1,772	10,900	1,200	14,672
1934-35	1,240	2,167	15,200	2,740	21,347
1935-36	1,800	2,267	11,500	2,780	18,347
1936-37	1,400	1,540	18,100	9,630	30,670
1937-38	2,750	1,943	14,600	11,840	31,133
1938-39	2,700	1,924	23,300	15,670	43,594
1939-40	2,900	2,000	15,900	14,400	35,200
1940-41	2,650	2,500	24,600	13,650	43,400
1941-42	3,450	3,111	19,200	14,500	40,261
1942-43	2,600	3,071	27,300	17,510	50,481
1943-44	4,080	3,300	31,000	17,710	56,090
1944-45	3,750	3,830	22,300	22,300	52,180
1945-46	4,100	3,350	32,000	24,000	63,450
1946-47	4,100	3,120	29,000	23,300	59,520
1947-48	3,000	2,430	33,000	23,200	61,630
1948-49	1,835	2,050	30,200	12,000	46,050

*Source: "Production, Disposition, and Value of Citrus Fruits." U.S.D.A., Bureau of Agricultural Economics.

ing in higher returns, should enable these two producing areas to maintain production at a time when low "on tree" returns are forcing acreage out of production in the Salt River and Imperial valleys.

Utilization

As production of grapefruit in the United States increased, and as there came to be a surplus of fresh fruit, more and more of the total crop went into processing channels. Grapefruit is produced

TABLE 3.—GRAPEFRUIT PRODUCTION, ARIZONA-CALIFORNIA DESERT, 1941-48 BY PRODUCING DISTRICTS. (THOUSANDS OF PACKED BOXES)*

Year	Salt River Valley	Yuma	Imperial Valley	Coachella Valley	Total Desert
	(000)	(000)	(000)	(000)	(000)
1941-42	2,800	450	670	680	4,600
1942-43	2,000	550	520	730	3,800
1943-44	3,600	440	510	690	5,240
1944-45	3,100	620	750	900	5,370
1945-46	3,500	600	580	690	5,370
1946-47	3,500	550	480	740	5,270
1947-48	2,500	660	390	620	4,170
1948-49	1,215	620	192	587	2,614

*Source: Annual Reports of Desert Grapefruit Administrative Committee.

primarily for the fresh fruit trade. However, processing has increased over the past twenty years until now it takes as much fruit as is sold in fresh form. The processing industry took 15 per cent of the total U.S. grapefruit crop during the 1930-31 season. Processing increased to a peak of 56 per cent in 1943-44. Since the end of World War II about 45 to 48 per cent of the U.S. crop has gone into the can. Florida normally processes about 65 per cent of her grapefruit crop, Texas 40 per cent, and the desert about 35 per cent.

Within the desert, Arizona producing districts process more of their fruit than do the California desert valleys. During the period 1941-42 through 1947-48, the Salt River Valley processed 41 per cent of its grapefruit crop, Yuma 38 per cent, Imperial Valley 27 per cent and the Coachella Valley 22 per cent.

During the period 1941-42 through 1947-48 the utilization of the desert grapefruit crop was as follows:

Disposition	Per cent of total crop
Fresh shipments	
Interstate and Canada	33.4 per cent
Intrastate	18.6
Export	3.0
Express and miscellaneous	3.2
Total fresh shipments	55.2 per cent
Processed	36.0 per cent
Unsold	8.8 per cent
Total	100.0 per cent

Shipments

The marketing season for winter grapefruit normally begins in October and ends early in July. The season in Florida and Texas usually gets started a little earlier than in the desert. The season in Texas is practically over by the last of May, Florida continues into June, and the desert normally ships into the first week or two of July. A small area in Southern California produces summer grapefruit which normally enjoys a very attractive market throughout the summer months.

Among the producing districts within the desert there exists a consistent difference in the seasonal pattern of shipments from each area. Fruit in the Yuma area matures early, shipments normally begin in October, gain volume rapidly and continue strong through March. The Yuma deal then tapers off and the season normally ends the latter part of May. Salt River Valley is the next to start, beginning later in October. Volume builds up steadily until March when a sharp increase in shipments occurs. The greatest volume is reached in May, volume of shipments declines in June and the season normally ends about the second week in July. The Imperial Valley normally begins shipments

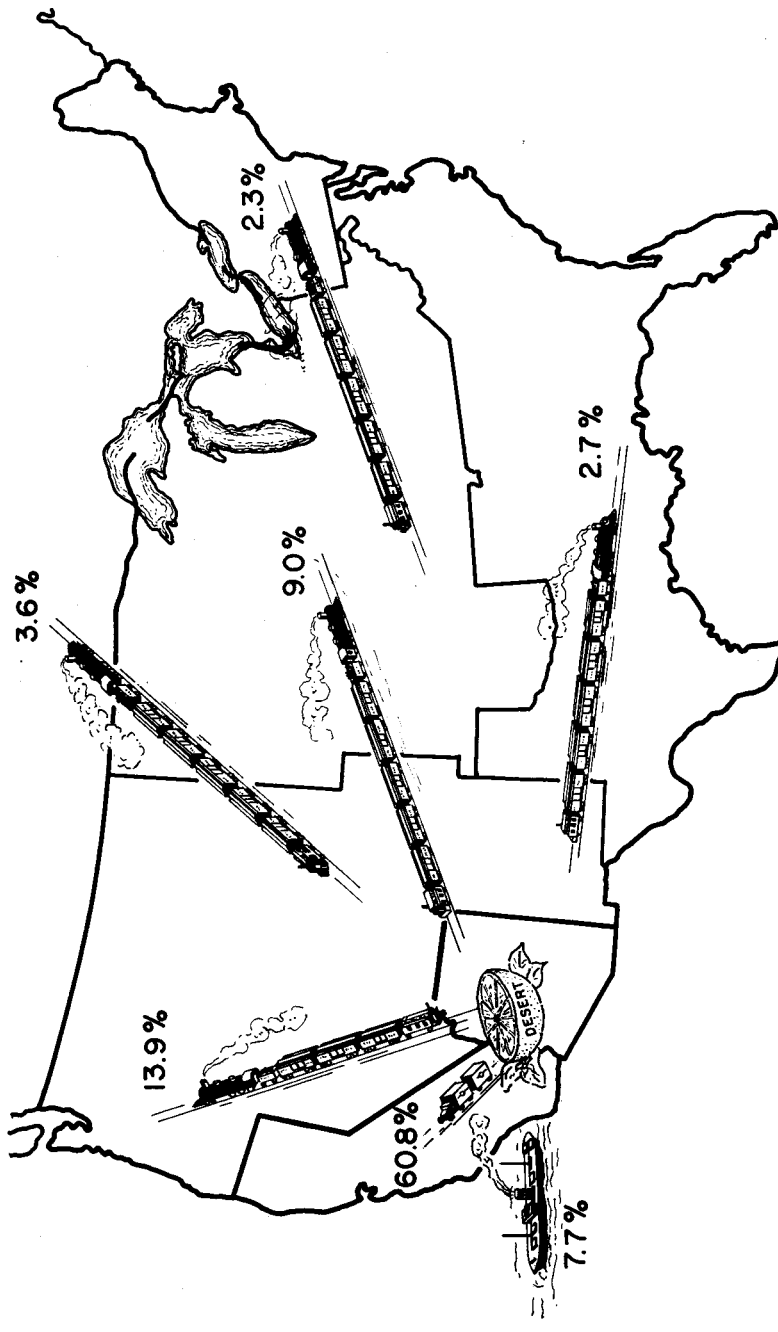

Figure 3.—Markets for desert grapefruit. Per cent of total desert shipments that went to each market area. Average of years 1943-44 through 1947-48.

early in November, increases steadily to a maximum in April and then falls off rapidly, the season ending early in June. The Coachella Valley is the last to start shipments. Coachella fruit begins to move late in November or early in December. Shipments increase steadily until a peak is reached in April, and the season ends early in June.

Movement of grapefruit to the canneries begins later than fresh fruit movement. Yuma is again first, the greatest volume from Yuma going to the processing plant in January and February. The other desert areas begin movement to processing plants in volume in March and continue through May.

Markets

The principal market for desert grapefruit lies in the western states. During the period 1943-44 through 1947-48, approximately 75 per cent of all desert shipments went to the eleven western states, over 60 per cent of the total going to California alone. The remaining 25 per cent was widely scattered (Figure 3). During the past few years desert grapefruit has been shipped into forty-five states, the District of Columbia, Hawaii, Alaska, Canada, Europe, and the Orient.

The relative importance of the major markets differs for each of the desert producing areas. California is the most important single market for all areas but is much more important as a market to the California desert area than it is to Arizona producing districts. During the 1946-47 season, the Coachella Valley shipped 97 per cent of its fresh fruit to California markets; Imperial Valley 85 per cent to California, Yuma 71 per cent, and the Salt River Valley 70 per cent. The Pacific Northwest is an important market for Yuma and Salt River Valley fruit, and the Salt River Valley and Imperial Valley move an appreciable amount of late-season fruit into the middle west. The relative importance of each market area varies as the season progresses. Figure 4 shows the seasonal variation in shipments of desert grapefruit into four market areas.

Seasonal variation in the availability of markets for desert grapefruit is closely associated with the degree of competition from Texas and Florida fruit that exists at any given time. This is especially true of midwestern and eastern markets where, because of its location, the desert ships at a disadvantage compared to Texas or Florida, and it is only at times when Texas and Florida are nearing the end of their crop that the desert can ship into these markets.

Shipments of desert grapefruit to existing markets move according to two seasonal patterns. There is a general seasonal pattern of shipments from the desert into western states and another pattern for shipments into other areas.

Shipments from the desert into western states begin in October and gain volume especially during November. From November to April shipments continue at a rather even rate. During April,

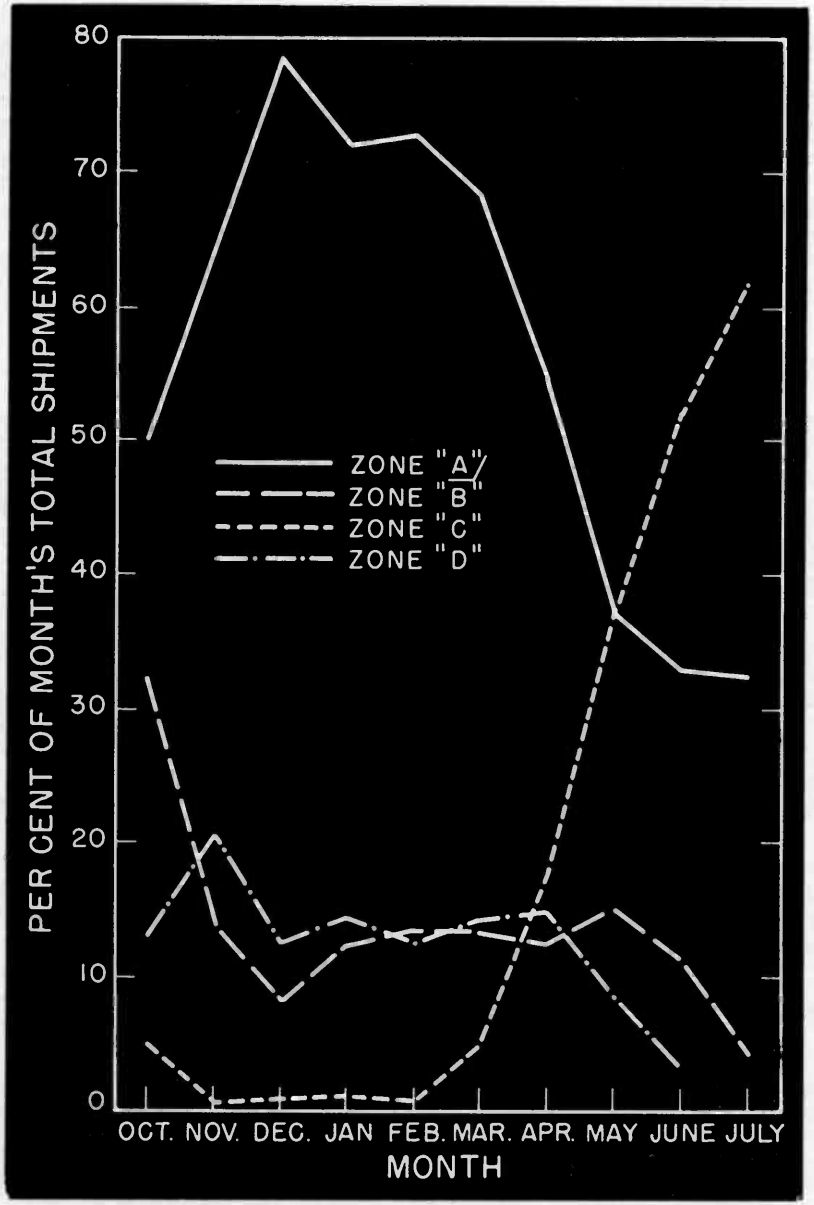

Figure 4.—Seasonal variation in shipments of desert grapefruit. Per cent of each month's total shipments going to each market soon. (Zone "A"—Calif. & Ariz.; zone "B"—Colo., Ida., Mont., Nev., Ore., Utah, Wash., & Wyo.; zone "C"—remaining thirty-eight states; zone "D"—Canada and other exports.

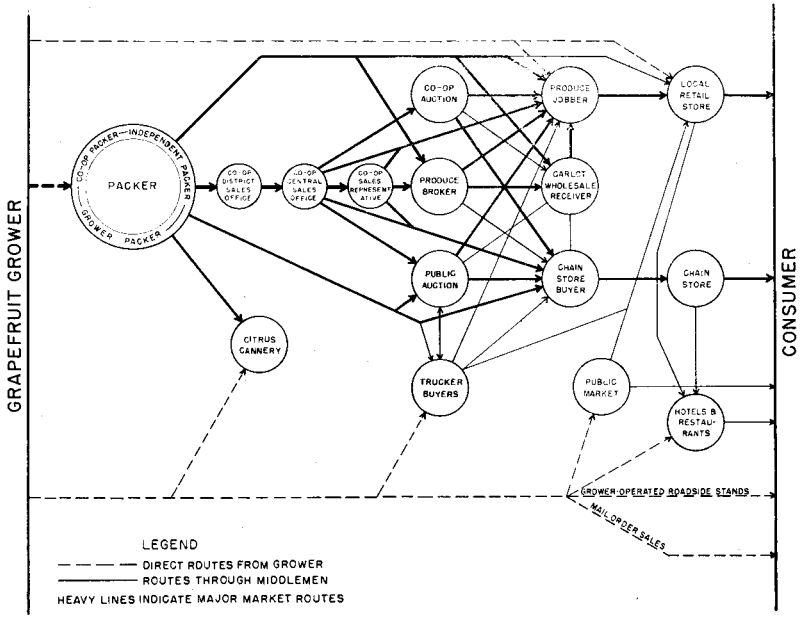

Figure 5.—Major channels of distribution for desert grapefruit.

May, and June shipments reach their peak, and then drop off rapidly during July.

The pattern of shipments into states other than the western group shows a late season market. In most of the states conforming to this pattern, the greatest volume of fruit moves in June with a much smaller amount in May and July.

Desert grapefruit moves primarily to large consuming centers. In 1946-47, 77 per cent of all desert grapefruit shipments went to cities each having over 250,000 population, 49 per cent going to five cities with populations over one million each, primarily to Los Angeles.

Prices

Desert grapefruit prices have been characterized by extreme year-to-year fluctuations. Prior to the 1930-31 season, prices of desert grapefruit had been very satisfactory. The citrus industry was young and the West Coast was a deficit area in regard to grapefruit production. Under these conditions, the limited desert production found a ready market at good prices. Since that time grapefruit production has steadily increased and there has developed a volume in excess of the normal market for desert fruit.

Prices of desert grapefruit started down in 1931-32 and remained at unprofitable levels until World War II demand forced prices upward to a peak in 1944-45. Grapefruit production nearly doubled during the war and with the loss of wartime demand the price ad-

TABLE 4.—PRICES OF DESERT GRAPEFRUIT, 1930-41 THROUGH 1948-49 (PER PACKED BOX)

Year	Fresh fruit F.O.B price	Fresh fruit "on tree" price	Process fruit price	All fruit "on tree" price*	All fruit "on tree" price in purchasing power†
1930-31	$2.25	$1.51	$	$1.51	$1.57
1931-32	1.56	.83	.....	.83	1.00
1932-33	1.18	.48	.....	.48	.62
1933-34	1.28	.67	.20	.66	.73
1934-35	1.13	.60	.17	.54	.55
1935-36	1.36	.78	.28	.73	.73
1936-37	1.38	.81	.13	.61	.61
1937-38	.94	.44	.17	.39	.36
1938-39	.81	.25	.01	.22	.23
1939-40	.89	.34	.11	.30	.31
1940-41	.71	.16	.04	.13	.13
1941-42	1.15	.45	.18	.36	.30
1942-43	2.18	.90	.61	.78	.61
1943-44	2.57	1.52	.84	1.23	.96
1944-45	2.87	1.82	.64	1.42	1.09
1945-46	2.13	1.08	.48	.84	.63
1946-47	1.83	.60	.10	.30	.17
1947-48	2.11	.69	.02	.44	.22
1948-49	2.59	.98	.00	.48	.25
1949-50‡	2.98	....	....	....	....

*Includes both fresh and processed fruit.
†"On tree" price adjusted by B. L. S. index of wholesale prices, 1935-39=100.
‡Preliminary.

vantage gained during the war was lost and the prewar price situation was resumed.

The postwar price decline came at a time when marketing costs were at an all-time high, making the grower's position even worse.

Returns to growers during the period 1946-47 through 1948-49 have been low in dollars and cents, but still lower when expressed in terms of purchasing power. With the single exception of 1940-41, a year when low prices were due to extremely poor quality, these three years have been the lowest in history from the point of purchasing power returned to the grower for each box of grapefruit he sold.

There exists a consistent price differential between producing areas within the desert. The Coachella Valley gets a premium for its fruit while Yuma nearly always receives the lowest average price within the desert. The Salt River Valley and the Imperial Valley receive about the same for their fruit. Over the period 1941-42 through 1948-49, the Coachella Valley has received on the average of $2.51 f.o.b. for its fruit, the Salt River Valley and the Imperial Valley, $2.04, and Yuma, $1.86. The Coachella fruit has built for itself a reputation for quality. Little Coachella fruit is picked until it has reached an acceptable stage of maturity and the fruit has a smoother, thinner skin than other desert grapefruit. The low price received by Yuma is not a reflection of inferior quality, but is due to the timing of harvest. The bulk of

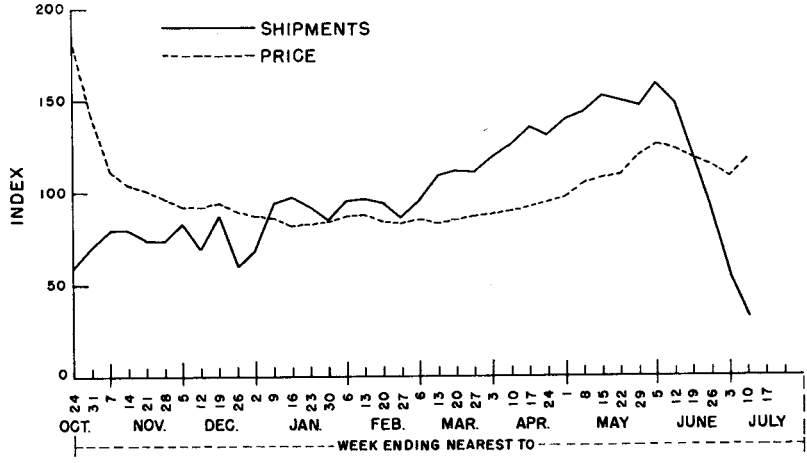

Figure 6.—Seasonal variation in prices and shipments of desert grapefruit. Average of years 1941-42 through 1947-48.

the Yuma fruit must be moved during the winter and early spring when grapefruit prices are at a seasonal low.

Desert grapefruit has a pronounced and consistent pattern of seasonal price variation. In normal years, early-season and late-season prices are consistently high, and mid-season prices are consistently low. Figure 6 shows the seasonal price variation for desert grapefruit.

Price analysis. The price of desert grapefruit is determined by the interaction of a multiplicity of forces. Supply factors, demand factors, quality differences, and competitive interrelationships with competing products all have a place in the price determination. The most important of these price determinants are local and total grapefruit supply factors and demand as indicated by measures of consumer income.

The relationship of price to the following supply and demand factors was measured by graphic multiple correlation: (1) local supply—fresh shipments of desert grapefruit, (2) demand—non-agricultural income, and (3) total supply—total U.S. grapefruit utilization.

Such an analysis has rather definite limitations and the results obtained cannot be projected into the future with absolute certainty. However, it does have value in that it shows the relative importance of each of the factors in regard to their influence on price, and as long as each of the factors used remains within the range encountered in the analysis, the relationships found may be used as a general basis for estimating future price.

Table 5 presents the data by years for each of the factors used in the analysis.

Figures 7, 8, and 9 show the net relationship between each of

TABLE 5.—FACTORS AFFECTING THE PRICE OF DESERT GRAPEFRUIT

Crop year	Desert fresh grapefruit shipments	Non-agricultural income	Index U.S. grapefruit utilization	Desert f.o.b. price
	(000 packed boxes)	(billions dollars)		(per packed box)
1936-37	1,406	67	75	$1.38
1937-38	2,668	62	75	.94
1938-39	2,411	65	98	.81
1939-40	2,611	70	86	.89
1940-41	2,452	80	102	.71
1941-42	2,560	99	95	1.15
1942-43	1,590	128	95	2.18
1943-44	2,204	145	113	2.57
1944-45	2,500	156	104	2.87
1945-46	2,800	153	157	2.13

the factors considered and the f.o.b. price of fresh desert grapefruit.

The relationship of fresh fruit shipments to price is shown in Figure 7. On the average, a change of 1,000,000 boxes in the volume of desert fresh shipments was accompanied by a change in the opposite direction of 40 cents per packed box in the f.o.b. price of desert grapefruit.

Figure 8 shows the relationship of nonagricultural income to the price of desert grapefruit. This relationship, taking as it does the form of a curve, cannot be expressed as constant. As seen from the curve PP′ in Figure 8, a change in nonagricultural income was accompanied by a like change in the price of desert grapefruit. A change in nonagricultural income when income was low was accompanied by but little change in the price of grapefruit, while the same change when income was high was accompanied by a much greater price response.

A change in U.S. grapefruit utilization, as measured by domestic sales of fresh grapefruit and canned grapefruit products, was accompanied by an opposite change in the f.o.b. price of fresh desert grapefruit. This relationship, shown in Figure 9, indicates that a change of 10 points in the index of grapefruit utilization was accompanied by a change of 23 cents per packed box in the f.o.b. price of desert grapefruit during the period of this study.

As a check on the accuracy of the price analysis, a comparison was made between the actual change in the f.o.b. price of desert grapefruit and the change that would be expected to accompany shifts that occurred in each of these factors. This comparison is shown in Figure 10. It appears that the estimated price change and the actual price change agreed reasonably well.

Size and Grade Price Differentials

Size differentials.—Most retailers seem to prefer a medium to small size of grapefruit, and the larger sizes generally sell at a discount. Table 6 shows the price differentials by size of fruit for desert grapefruit over the years 1945-46 through 1947-48.

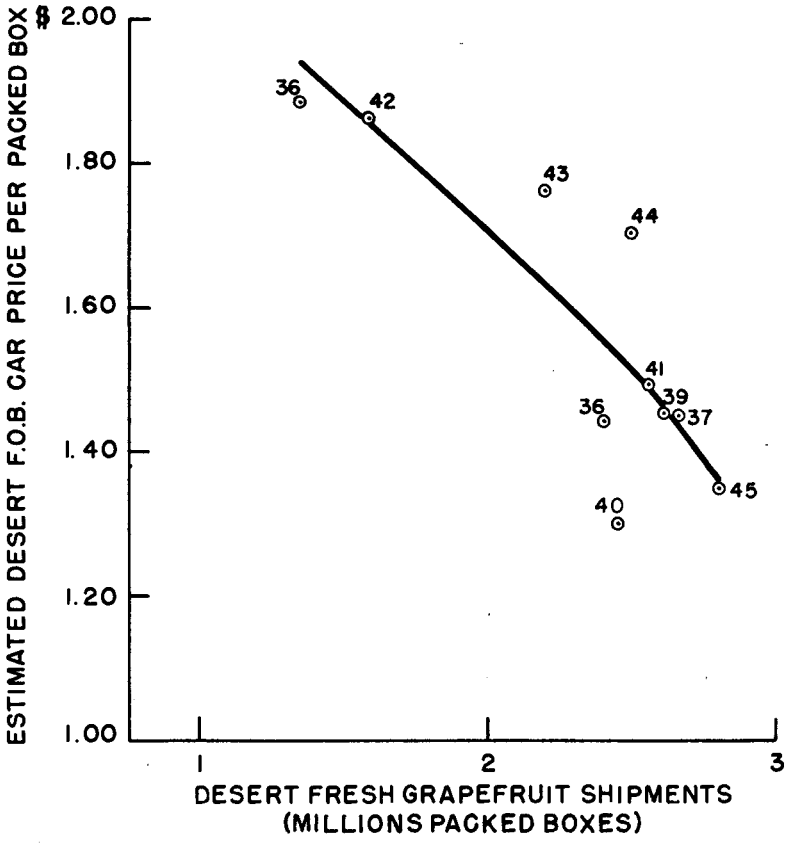

FIGURE 7.–NET RELATIONSHIP OF CALIFORNIA-ARIZONA DESERT FRESH GRAPEFRUIT SHIPMENTS TO THE F.O.B. CAR PRICE OF DESERT GRAPEFRUIT.[1/]

[1/] NET EFFECT AFTER ELIMINATING VARIATIONS IN DESERT F.O.B. PRICES ASSOCIATED WITH VARIATIONS IN NON-AGRICULTURAL INCOME AND VARIATIONS IN U.S. TOTAL GRAPEFRUIT UTILIZATION.

TABLE 6.—PRICE DIFFERENTIALS BY SIZE OF FRUIT, DESERT GRAPEFRUIT, AVERAGE OF YEARS 1945-46 THROUGH 1947-48

Size	Percentage premium or discount over average price of all sizes*
48	—10.6 per cent
54	— 3.0
64	2.0
70	2.7
80	5.0
100	5.2

*U.S. Combination grade.

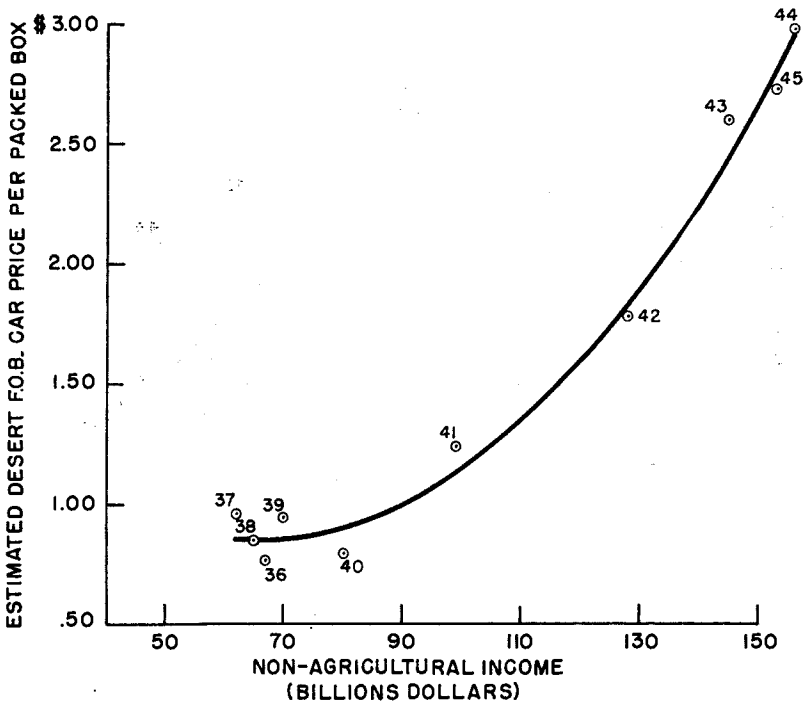

FIGURE 8.–NET RELATIONSHIP OF NON-AGRICULTURAL INCOME TO THE F.O.B. CAR PRICE OF DESERT GRAPEFRUIT. 1/

1/ NET EFFECT AFTER ELIMINATING VARIATIONS IN DESERT F.O.B. PRICES ASSOCIATED WITH VARIATIONS IN DESERT FRESH GRAPEFRUIT SHIPMENTS AND VARIATIONS IN U.S. TOTAL GRAPEFRUIT UTILIZATION.

Some relationship appears to exist between the relative prices and the percentage volume of the various sizes of desert grapefruit available on the market. In general, the smaller the amount of any given size in proportion to all sizes which was on the market at a given time, the higher the price which that size would command. This relationship is most pronounced for the extremely large and extremely small sizes and does not prevail to the same degree for the more popular medium-sized fruit.

Grade differentials.—U.S. No. 1 fruit sold at a substantial premium, bringing a 30 per cent higher price than did U.S. Combination grade (40 per cent U.S. No. 1 and 60 per cent U.S. No. 2). U.S. Combination grade in turn sold for 9 per cent more than U.S. No. 2.

Elasticity of Demand for Desert Grapefruit

The desert grapefruit industry operates under marketing agreement programs, the purpose of which is to restrict shipments, through grade and size proration, in order to improve the fresh

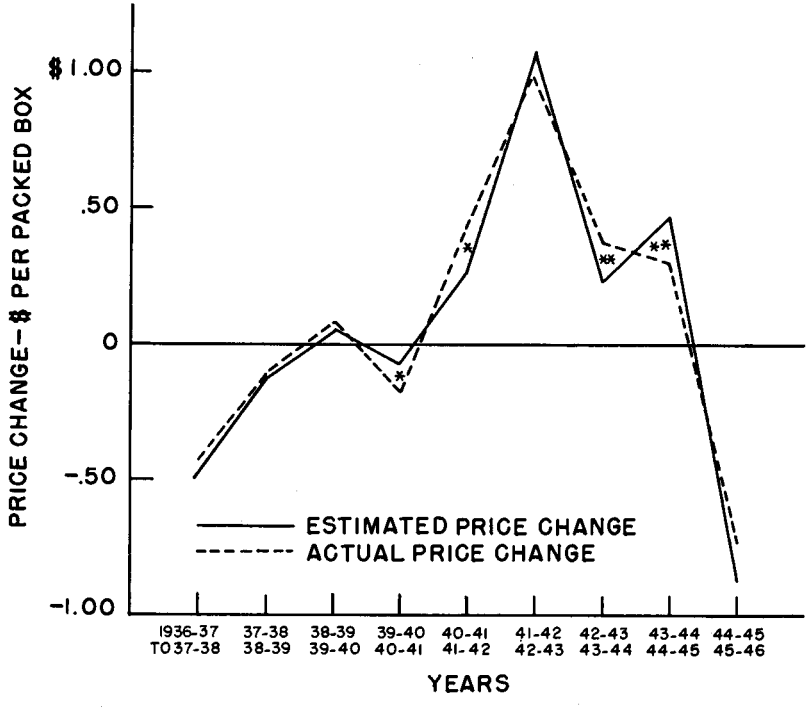

FIGURE 10.—ACTUAL AND ESTIMATED CHANGES IN THE PRICE OF DESERT GRAPEFRUIT.

*—1940-41 CROP OF UNUSUALLY POOR QUALITY.
**—OPA PRICE CEILINGS IN EFFECT.

boxes sold, the smaller the gross income that would be realized by the industry.

The grower is not primarily concerned with f.o.b. price elasticity but rather with the elasticity of the demand for the fruit at his grove, the elasticity relating to "on tree" prices. The middleman's margin in the marketing of desert grapefruit is large and remains relatively stable when compared to fruit prices. The wider and more stable this margin, the less elastic is the demand at the grove. For desert grapefruit, the demand "on tree" is inelastic, the coefficient of elasticity being —0.79. This means that a decrease of approximately 8 per cent in the quantity offered would be accompanied by a 10 per cent increase in price, and small shipments may result in larger total returns to growers than would have been obtained with the shipment of more fruit.

Total Cost of Marketing Desert Grapefruit

Throughout this report, 1946-47 will be found used as a representative postwar year. The postwar years have all been abnormal

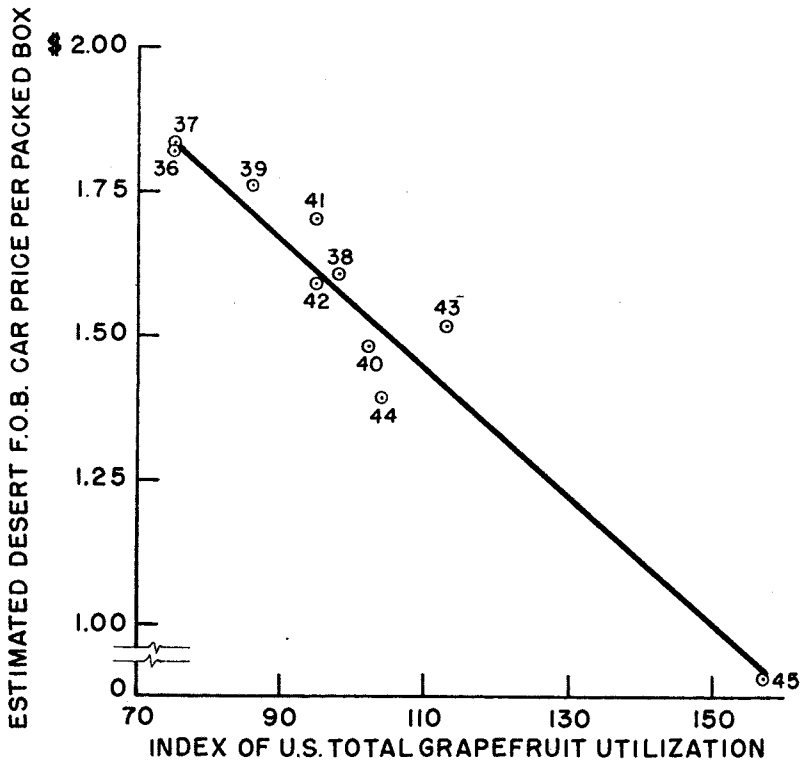

FIGURE 9.—NET RELATIONSHIP OF U.S. TOTAL GRAPEFRUIT UTILIZATION (FRESH & CANNED) TO THE F.O.B. CAR PRICE OF DESERT GRAPEFRUIT. 1/

1/ NET EFFECT AFTER ELIMINATING VARIATIONS IN DESERT F.O.B. PRICES ASSOCIATED WITH VARIATIONS IN DESERT FRESH GRAPEFRUIT SHIPMENTS AND NON-AGRICULTURAL INCOME.

fruit price. The success of the proration program is dependent upon an inelastic demand for desert grapefruit on the tree.[2]

At the f.o.b. price level, the demand for desert grapefruit has an elasticity of —1.75. This means that a 17.5 per cent decrease in the quantity offered would increase the f.o.b. price but 10.0 per cent (an elastic demand), and that the smaller the number of

[2]The elasticity of demand is the proportionate change in price associated with a change in the quantity offered for sale. In the case of products having an "inelastic" demand, a decrease in production of 10 per cent may be accompanied by a price increase of 20 per cent. In such a case, a small crop brings a higher total income than an average crop. For those products having an elastic demand, the price falls less than the percentage production increase, and a small crop is worth less than the average.

insofar as the desert grapefruit industry is concerned. Freezes damaged the crop in 1947-48, 1948-49, and 1949-50. It was felt that 1946-47 was perhaps the least abnormal of the postwar years, and for that reason it has been used to illustrate certain points in this study.

Table 7 shows the distribution of the retail dollar spent for desert grapefruit during 1946-47.

TABLE 7.—THE CONSUMER'S DESERT GRAPEFRUIT DOLLAR, 1946-47*

Cost item	Cost per packed box	Per cent of total price
Consumer paid	$ 3.60	100 per cent
Retailer's margin	1.20	33
Wholesaler's margin	.18	5
Transportation and refrigeration	.61	17
Selling and advertising	.14	4
Packing	.81	23
Picking and hauling	.19	5
Grower received	.47	13

*Data not applicable to fruit from Coachella Valley.

Three-quarters of the selling price of desert grapefruit is accounted for by three items: retailing, transportation, and packing. The greatest opportunities for cost reduction would appear to lie in these items.

In the following sections of this bulletin, each of these cost items will be discussed in detail, and possible economics which might be made will be pointed out.

MARKETING PROGRAMS

The Agricultural Marketing Agreement Act of 1937 makes it possible for growers of certain agricultural products to put into effect compulsory industry programs designed to reduce marketings and to increase prices up to, but not above, parity.

The depressed condition of the desert grapefruit industry prior to World War II made it necessary that growers take every means possible of improving prices. The adoption of a marketing agreement program seemed to offer some possibilities, and accordingly in 1941 the desert growers voted in a Federal grade and size proration program limiting the shipment of fresh desert grapefruit in interstate commerce to certain grades and sizes. In the same year the California growers adopted a similar program with respect to intrastate shipments, and in 1944 the Arizona growers voted in a program regulating intrastate shipments in Arizona. The Arizona program was amended in 1947 to include volume proration.

These programs are put into effect after hearings at which both sides may state their case and after a vote has been taken of all growers involved. If two-thirds of the growers and handlers representing 50 per cent of the volume vote in favor of the proposed agreement it stands as approved. In certain cases, the agreement may be approved without the consent of the handlers. The agree-

ment itself does not put the program in effect. To activate the program a marketing order must be issued, by the Secretary of Agriculture in the case of Federal programs, or by the State Prorate Commissioner.

A grade and size proration program regulates the rate of shipment of a crop to the extent that it prescribes the grades and sizes of the commodity which may be shipped, either in a given period of time or throughout the season. The grade and size proration program attempts to withhold the lower grades and undesirable sizes from the market in order to improve the quality of the fruit offered for sale, to improve the price, and to prevent producers from shipping fruit of such low quality that the price received will not cover handling costs. This is the type of marketing program now in effect in the desert grapefruit area.

Volume proration programs propose to regulate the volume of fresh fruit that may be shipped, in total or to any specific markets, with the aim of restricting the flow of fruit at certain times sufficiently to increase market prices.

Both volume proration and grade and size proration have as their aim, not necessarily the restricting of the total amount of fruit moved, but rather the promotion of orderly marketing in an attempt to eliminate the recurring gluts and scarcities so characteristic of the citrus market.

At the present time the volume proration program as originally administered in Arizona has been declared unconstitutional by the Superior Court at Yuma. However, this case is not finally settled. The grade and size programs are the only ones currently active in the desert.

Merchandising program of the Desert Grapefruit Industry.— The promotion of desert grapefruit on an industry-wide basis was begun early in 1944 with the formation of the Desert Grapefruit Industry Committee, Inc. This organization was a nonprofit company originated solely for the advertising of desert grapefruit, and financed by leading growers and handlers of grapefruit in Arizona and Southern California. A program was instituted by this organization under the same management as that of the Grapefruit Administrative Committee. Advertising was started in Western grocery trade journals, and display material advertising desert brands of grapefruit juice was placed in over 700 Southern California super-markets.

Since the organized promotion of desert grapefruit would benefit all growers and handlers in the desert area, it would have been unfair to burden only a part of the growers and handlers with the expense of a program, the benefits of which would be equally shared by all. Therefore, steps were taken towards the securing of marketing programs established by law in Arizona and California, requiring the support of all growers. Since the majority of the growers were in favor of such a program, hearings were held and the proposed marketing orders were successfully put through; in Arizona in October, 1944, and in California in November. In

November, 1944, the Arizona Grapefruit Program Committee and the California Desert Grapefruit Industry Board met together for the first time to organize and plant the combined desert program. Out of this meeting came the following purposes and objectives:

1. The improvement of desert grapefruit and its processed products by research, and the improvement of growing, packaging, and processing methods.
2. The maintenance of high quality of desert grapefruit and its products by the promotion of co-operation with the various grade and size programs, and by the use of the identifying mark of quality—the desert mark.
3. The improvement of relations with the trade and consumers by continuous study of their needs and by an aggressive promotional campaign to acquaint both with the individual and distinctive characteristics of desert grapefruit.

The first year an assessment of four cents per box was levied on all growers and a total of $209,000.00 was raised. The greatest part of the desert grapefruit advertising dollar was spent in California, primarily in the Los Angeles and San Francisco areas. However, relatively large amounts were also spent in Washington and Oregon. Expenditures in these three states accounted for over 80 per cent of all money spent for advertising desert grapefruit.

A well-rounded advertising program aided grocers in pushing desert grapefruit. Newspaper advertisements were used as the principal advertising media, supplemented by billboards, magazine advertisements, radio spot announcements, and retail store display material. The general advertising program was followed up and implemented by dealer servicemen working out of Los Angeles, San Francisco, Portland, Seattle, and Phoenix. These men maintained personal contact with jobbers and retailers, distributed display materials, built selling displays, organized sales, and promoted "tie-in" advertising with the grocery trade in their area. In addition to the program's own dealer service work, the Pacific Indoor Advertising Company placed desert display material in nearly 800 super-markets in Southern California.

An appreciable amount of free advertising was obtained through editorials, cooking schools, window displays, "tie-in" advertising used by retailers. A publicity department was established in March, 1944, with two principal functions:

1. To implement paid advertising with news, publicity, and recipe material in the news columns of newspapers, magazines, and radio.
2. To keep the growers fully informed on all developments within and outside of the industry, using as media, newspapers, radio, citrus, and farm magazines, and the industry's publication, *Desert Grapefruit.*

In February, 1946, a home economics department was established for the purpose of preparing and distributing informative bulletins on nutritive values, the preparation and serving of desert grapefruit for distribution to food editors of newspapers, radios, and magazines.

In the field of research concerning the chemical and physical characteristics of desert grapefruit, the industry employed a research chemist who worked in co-operation with the U.S. Department of Agriculture's Fruit and Vegetable Laboratory at Los Angeles.

In 1947, because of the low prices received for desert grapefruit, the growers felt that they were no longer financially able to support this program as they had been doing. Accordingly, the program was, for all practical purposes, ended with the 1946-47 season and since that time has been maintained on an inactive basis with only a fractional-cent assessment in order to keep it in effect.

GRADES AND STANDARDS

Over a period of years, certain grades and standards have been developed for desert grapefruit. The fact that such established grades and standards exist affords a certain degree of protection to both shipper and buyer and speeds up the marketing process in that it permits sale without personal inspection, the buyer having confidence that the fruit will conform to the grades specified.

Size Regulations

The basic size specifications in inches diameter for the most important sizes of desert grapefruit are as follows:

Size count	Minimum	Maximum	Average
	(inches)	(inches)	(inches)
126	3-3/16	3-10/16	3-6/16
100	3-6/16	3-13/16	3-9/16
80	3-11/16	4-2/16	3-14/16
70	3-14/16	4-4/16	4-1/16
64	4	4-6/16	4-3/16
54	4-2/16	4-10/16	4-6/16
48	4-8/16	4-14/16	4-11/16

The size count indicates the number of fruit per packed box.

Grade Regulations

The U.S. grades for desert grapefruit are: U.S. Fancy, U.S. No. 1, U.S. Combination (40 per cent No. 1, 60 per cent No. 2), U.S. No. 2, and U.S. No. 3. Only U.S. No. 1, Combination, and No. 2 are commonly used. Very little fruit would ever make U.S. Fancy, and under the grade and size proration program U.S. No. 3 seldom moves as fresh fruit.

To meet these grade requirements, desert grapefruit must be within certain limits: (1) mature; (2) well colored; (3) firm; (4) well formed; (5) of smooth texture; (6) fairly thin-skinned; (7) free from decay, broken skins which are not healed, hard or dry skins, bruises, dryness or mushy condition; and (8) free from

injury caused by freezing, sprayburn, fumigation, ammoniation, scars, green spots, scale, sunburn, sprouting, dirt, or other foreign materials, disease, insects, and mechanical or other serious injuries.

These qualifications apply to all grades, but in varying degrees, the better grades allowing less tolerance for defects.

Other Regulations

Other regulations pertaining to the shipment of fresh desert grapefruit have to do with such items as standard containers, labeling of containers, stamping of fruit as to locality, shipping-point inspection, grower sales, frost tolerances, field boxes, and other miscellaneous items.

Maturity Standards

Each of the grapefruit producing areas in the United States has adopted maturity standards which have as a purpose the prohibiting of the sale of immature fruit. The maturity standards now in use have been developed on the basis of certain minimum requirements which the fruit must develop before it can be considered as mature. Although the standards have been established as law, there exists considerable doubt in the minds of many people as to whether these standards actually reflect the acceptability of the fruit insofar as the consumer is concerned. Early in the marketing season (October and November) most groves meet the current maturity requirements. The fresh grapefruit price is very attractive at that time, and growers are anxious to sell on this early market, the result being that the fruit is offered for sale as soon as it makes the minimum maturity requirements.

The present desert maturity standards are as follows: Under both California and Arizona law the desert grapefruit must have developed to a point that it has a solids-acid ratio of at least six to one. That is, the fruit must contain at least six parts of total soluble solids (mostly sugars) to each part of anhydrous citric acid. Also at least 90 per cent of the fruit, by count, must have attained the characteristic yellow grapefruit color on at least two-thirds of the fruit surface.

The maturity standards as summarized in the above paragraph are intended to prevent the marketing of immature, bitter-tasting fruit. However, it is doubtful that this purpose is entirely accomplished under the present standards. To most people, the early-season desert grapefruit tastes very bitter and immature. The marketing of this sour, early-season fruit appears to have hurt the reputation of desert grapefruit and may have considerable bearing on the sharp seasonal price break that normally occurs shortly after the opening of the desert grapefruit marketing season. Retail sales of desert fruit drop off rapidly once the customer has sampled the sour fruit.

There is also some fruit that fails to meet the required maturity standards but is nevertheless quite acceptable in regards to its

taste. As a matter of fact, some groves may meet the required standards early in the fall, and then as their fruit matures, the acid may build up in the fruit faster than the solids, and the fruit no longer meets the established standards. This "immature" fruit in January or February, is much more acceptable in regards to taste than "mature" fruit in October or November.

Many men in the citrus industry do not feel that the present maturity standards are satisfactory, and industry research is in progress aimed at evaluating the standards for fresh oranges. No such work was being done on desert grapefruit, and since the standards for this fruit did not appear to reflect consumer acceptance this study was entered into in an attempt to evaluate the present standard and to indicate the usefulness of the taste panel as a measure of maturity.

The conclusions reached in this work cannot be accepted as final, but may be used as indications of results to be expected in the event that this study is repeated in subsequent years. One of the major purposes of this study was to investigate the possibilities of this type of research and to develop methods for conducting such studies in the future.

Procedure.—The study was conducted through a series of tests made at two-week intervals over the period December 8 to June 1, 1950. One of the purposes was to develop procedures used in future studies of this sort, and because of this, the methods followed changed somewhat as the work progressed. By February, the method of procedure used during the rest of the study had been established. This procedure was as follows: For each test two samples of fruit were picked. One sample was from a grove which has a history of producing a mild, rather sweet type of fruit. The other sample was picked from a grove which produces a rather tart, acid fruit. In picking each sample, care was taken to secure uniform-sized fruit from the same position on all trees used. At the University, a part of this sample was used in a taste test in which a panel of eight to ten people tasted small samples of the two fruits and rated the fruit on the basis of an arbitrary score card. The samples of fruit were cut out as individual segments with the membrane which separates each section being removed. It is in this membrane that most of the bitter substance (naringen) is found. This was removed as this bitterness would mask the true flavor of the fruit. It was felt that using the fruit itself rather than the juice was preferable in that the juice would contain this bitter principal when extracted by a burr type reamer and rapidly develop off flavors when allowed to stand.

Each member of the taste panel was given four small pieces of fruit. Two of these pieces were from the mild fruit and two from the tart fruit. In the taste test, they were required to pair the samples correctly and then rate each as to their acceptability. Each of the fruit used in the taste panel was then tested for solids-acid ratio.

SCORE CARD FOR TESTING TASTE OR FLAVOR OF GRAPEFRUIT

Arbitrary standard	Taste or flavor of fruit	Numerical rating range corresponding to description
Very acid	Very acid, raw, immature flavor	20 - 39
Acid	Acid with absence of raw immature flavor	40 - 59
Tart	Too tart for consumer approval	60 - 59
Pleasantly tart	Minimum stage of acceptability for consumer	70 - 79
Pleasantly tart to sweet	Pleasant blend of sugars and acid, with very good texture and flavor	80 - 100
Insipid (aged)	Very sweet, watery, lacking in flavor, low in acidity, aged	50 - 100

The remainder of each sample of fruit was then used for a consumer acceptance study made at retail grocery stores in Tucson and Phoenix. A booth was set up in the store and each customer interviewed was offered three pieces of fruit. The customer was told that two of the pieces were alike and one different and was asked to tell which of the two pieces were alike, which of the two kinds of fruit was preferred and why that particular kind was preferred. From fifty to sixty customers were interviewed during each test. Half of each grapefruit used in the retail stores was saved. Using these halves, solids-acid ratio tests were made for a composite sample of each of the two kinds of fruit, and five separate halves from each kind of fruit were tested to determine the approximate degree of variation within each sample.

Evaluation of solids-acid ratio as a measure of taste.—On the basis of this one-year study, there appears a constant relationship between the solids-acid ratio and the taste rating of desert grapefruit as indicated by the taste panel. However, this relationship is not sufficiently close to permit the use of the solids-acid ratio as a practical measure of the taste of the fruit. The coefficient of correlation between the solids-acid ratio (omitting ratios of 8.5:1 and over) and the taste rating is r=.263 with 84 degrees of freedom,[3] and indicates that a relationship of the type shown in Figure 11 would be expected to occur ninety-eight times out of 100 if the study were repeated. The relationship between the solids-acid ratio and the taste, while statistically constant, was not close. On the basis of perfect correlation being 100 per cent, the correlation existing in this study was 3.5 per cent.[4] As seen in Figure 11, there was a wide range in taste ratings for a given solids-acid ratio except when the ratio was 8.5:1 or higher. For example, ratios of 6.4:1 were rated as low as 57 per cent while ratios of 5.1:1 were rated as high as 90 per cent.

[3] $r = \frac{2xy}{\sqrt{(2x^2)\ (2y^2)}}$

[4] $\%r = 1 - \sqrt{1 - r^2}$

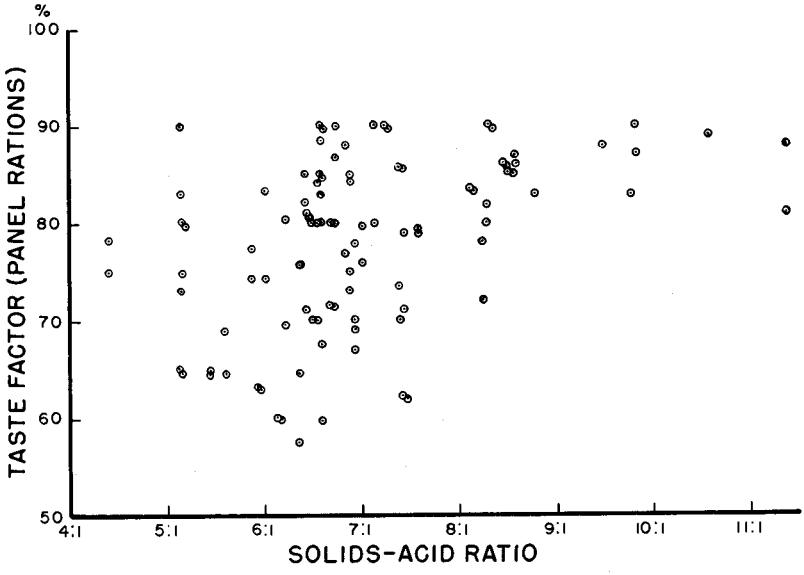

Figure 11.—Relationship between solids-acid ratio and taste panel rating, desert grapefruit 1949-50.

Evaluation of the taste panel as a measure of taste.—Of the consumers tested in the retail store, about half were able to accurately distinguish between the two samples of fruit used. That is, they were able to correctly match the two samples that were alike and correctly distinguish between the two relatively immature samples and the one relatively mature sample. This ability to distinguish was almost the same for those preferring the milder, more mature sample, as for those preferring the tart, relatively immature sample. By chance alone there was only one chance in six that the consumer would correctly match and correctly identify the samples of fruit. The fact that one out of two were able to do so would indicate that there was a noticeable difference in the taste of the two samples of fruit and that approximately one-half of the people can accurately distinguish rather slight differences in the taste of desert grapefruit.

The value of the trained taste panel as a measure of maturity (or taste) would be indicated by their ability to correctly match and identify samples of fruit of varying taste. The taste panel used in this test received no special training, but the individuals used (both men and women) were picked after being tested for their ability to match samples, and were all people who were interested in this study or who were accustomed to thinking out and comparing relationships. The record made by the taste panel shows that it is possible to assemble a group of people who have the ability to detect differences in tastes and to describe these tastes by objective ratings. By chance alone, the taste panel members

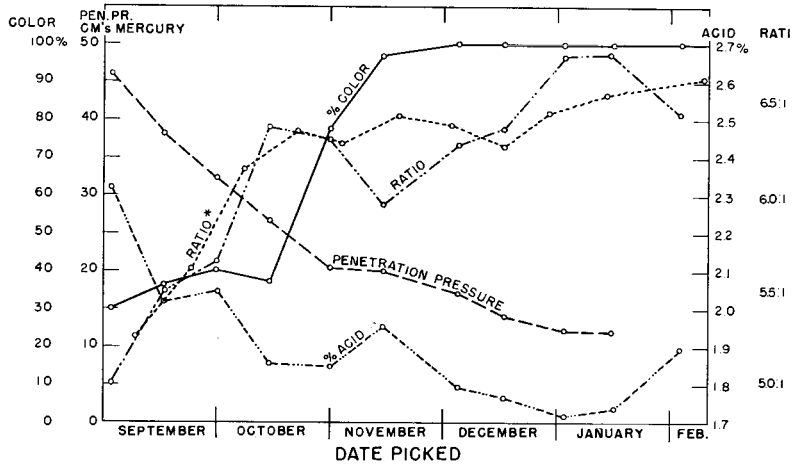

Figure 12.—Development of desert grapefruit from a typical desert location.

could have correctly matched the samples and associated them with the correct relative degree of maturity one time in six. Actually taste panel members correctly matched and identified the samples about three out of four times on the average, indicating that they could detect differences in the two fruit samples much more accurately than the average consumer.

Two individuals, who participated in the tests, were never incorrect. Two others missed just one time out of eleven tests. This would indicate that certain people can consistently detect, by taste, differences in the maturity of grapefruit. A taste panel composed of such individuals might be a useful and valuable means of establishing the level of acceptability of desert grapefruit.

Seventy-nine per cent of the consumers interviewed said that they preferred the sweet fruit, 11 per cent preferred tart fruit, and 10 per cent did not express a preference. It was interesting to note that the percentage preferring tart fruit increased as the season progressed, and late in the season some of the consumers interviewed began to say that the more mature sample tasted flat or insipid.

Seasonal changes in the composition of desert grapefruit.—As grapefruit matures, certain physical and chemical changes occur. Figure 12 indicates the development of grapefruit from a typical desert location.

Variations in the solids-acid ratio are principally due to decreases in the percentage of acid rather than to changes in the amount of soluble solids (sugar). Whereas the percentage of total soluble solids (Brix) remains fairly constant throughout the season, the percentage of acid drops rapidly at the beginning of the season and is slowly reduced to a still lower percentage as the season progresses. The solids-acid ratio increases sharply early in the season, then levels off somewhat and slowly continues to climb

throughout the remainder of the marketing year. This change in ratio is principally due to the decreasing percentage of acid rather than an increasing percentage of soluble solids.

Color development has also been used as an indicator of maturity. Coloring develops most rapidly during October and November, and full color is usually developed by the first part of December.

There appears to be an inverse relationship between juice volume and penetration pressure required to penetrate the cut surface of a half grapefruit as ordinarily prepared for eating. Juice percentage increases rapidly and uniformly during September, October, and early November, penetration pressure decreases rapidly and uniformly during the same period. After mid-November the change in each of these measures gradually diminishes.

Both penetration pressure and juice volume would seem to be good measures of the texture of the fruit. Consumer acceptability is dependent upon both the taste and the texture of the fruit. A sweet but coarse, dry fruit is not acceptable. In view of this, consideration might well be given to juice volume or penetrability as a measure of texture to be incorporated in a maturity standard for desert grapefruit.

HARVESTING

Picking

Picking is the first step in the marketing of desert grapefruit. Picking is done by hand, the fruit being either pulled from the tree or clipped off. The picker, working from a ladder, picks the fruit and drops it into a canvas bag which is slung from a shoulder strap. When the bag is full he climbs down the ladder and dumps his bag of fruit into a truck elevator, trailer, or field box.

Studies made at the University of California show that the picker spends about half of his time climbing up and down the ladder. Research is in progress on the development of a movable picking platform that will keep the picker up in the tree and eliminate the time lost in climbing up and down the ladder. Pickers are generally hired through a "contractor" who assembles a crew of men and may, to a certain extent, supervise their work.

Two methods of paying the pickers are in effect. Where the fruit is hauled away in field boxes the pickers are paid at a certain rate per field box. The contractor is also paid per box picked by his crew. The 1948-49 total picking cost per field box (⅔ of a packed box) for desert grapefruit averaged about 9 cents. The second method of paying pickers is used where the fruit is hauled in bulk to the packing house. In this method pickers are paid as a crew, the rate being per ton of fruit picked.

Hauling

After the fruit is picked, it is hauled to the packing house. There are two general systems of handling the fruit from the grove to

the packing house.

Field box system.—Grapefruit is most commonly hauled from the grove to the packing house in field boxes. These are sturdily constructed wooden boxes 11½ inches wide, 11½ inches deep, and 24 inches long. Each of these field boxes, when filled in the grove, holds about two-thirds of a packed box.

Plate I shows photographs of the field box system. After the fruit is picked, it is dumped from the picker's bag into the field box. The field boxes are stacked in the grove until they are picked up by a truck (*A*) and hauled to the packing house where they are unloaded and placed in a conveyor which takes the box into the packing house (*B*). When the fruit reaches the packing house it is either stored in the field box, or automatically dumped and moved directly into the packing operation (*C*). The empty field boxes are moved by another conveyor to a yard where they are stacked until loaded on trucks returning to the groves. Upon reaching the grove, the boxes are scattered along the rows of trees convenient to the pickers.

Bulk-handling systems.—The purpose of the bulk-handling system is to eliminate the field box. Two systems are in most common use (Plates II, III).

Bulk-handling in trucks (Plate II) is a system used by the larger packing houses where the area served is great and the fruit must be hauled considerable distances. When picked, the fruit is dumped into a mechanical elevator which takes it up into the truck (*A*). The fruit does not drop directly from the top of the elevator into the truck, but rolls down a chute which helps prevent damaging the fruit. This chute is made with a series of hinged sections which can be opened to permit even loading of the truck. The elevator is detachable, and when the truck is loaded, the elevator is taken off and the truck hauls the load of fruit to the packing house. One driver handles two trucks, one truck being left in the field to be filled while he takes the second, which has been loaded, to the packing house. At the packing house the truck is driven onto a ramp which tips the load toward the conveyor. The truck box is made with the lower half of one side hinged at the bottom. This sideboard is opened and drops, allowing the fruit to roll out onto a broad, roller-type conveyer (*B*) which slowly moves the load into the plant. The fruit drops off this conveyor onto a wide belt which completes the job of moving the fruit into the packing house (*C*).

Bulk-handling in trailers requires less expensive equipment and is most generally used by smaller packing houses where the distance from the grove is not so great. The fruit is dumped by the picker directly into low, specially-constructed trailers (Plate III, *A*). No elevator is needed as the trailer box is low. When filled, the trailer is towed to the packing house and onto an inclined ramp which tips it toward the conveyor. The trailer box is constructed with a hinged panel in one side which opens and

Plate I.—Field box system of handling citrus from grove to packing house.

Plate II.—Bulk-handling citrus from grove to packing house, where hauling is done in trucks.

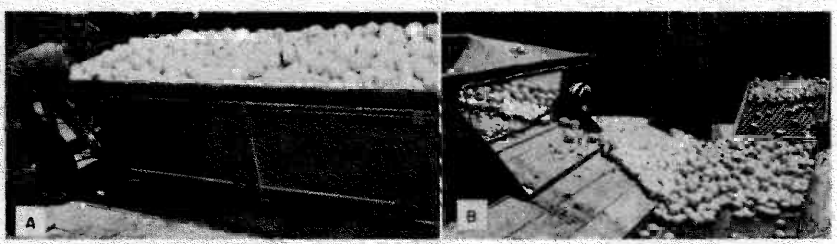

Plate III.—Bulk-handling citrus, where hauling is done in trailers.

drops, allowing the fruit to roll out onto a wide conveyor belt which takes it into the packing house (*B*).

There is in use a variation of the trailer method of handling. In this method, each trailer carries two removable boxes which are filled with fruit. At the packing house these large boxes are lifted from the trailer with a power lift truck and empty boxes are placed on the trailer in a similar manner. The boxes of fruit are placed on an inclined platform by the lift truck and emptied in a manner similar to that already described. This method allows more complete use of the trailers.

Saving possible through the use of bolk-handling.—A study made under this project showed that a substantial saving is possible by substituting the bulk system for the field box. For a packing house handling approximately 700,000 field boxes per year, the first-year savings through the use of the bulk system amounted to $23,000, an amount approximately equal to the original equipment and installation cost of the bulk system. Table 8 shows the manner in which this saving was calculated.

TABLE 8.—A COMPARISON OF THE COSTS OF HANDLING DESERT GRAPEFRIUT WITH FIELD BOX AND BULK SYSTEMS

Cost item	Field box amount	Bulk-handling amount
Field box replacement	$ 3,000	$ 0
Field box repair	2,500	0
Hauling cost (700,000 field box basis)*	31,000	21,400
Receiving labor	9,600	1,200
Power for loaders and plant conveyor	0	500
Depreciation (5 per cent)†	1,000	1,000
Total	$47,100	$24,100
Saving through use of bulk handling		$23,000

*This item is calculated on the basis of the total hauling cost per field box for the years 1944-45 and 1945-46. Since the volume hauled at the packing house studied was 75,000 field boxes less in 1945-46 than in 1944-45, the cost of hauling per field box would tend to be higher in 1945-46. Therefore, it is probable that a saving in cost of hauling even greater than indicated in this table might have been realized.

†Depreciation only on equipment and does not include depreciation on trucks or field boxes.

In addition to savings which can be calculated in dollars and cents, other advantages offered by the bulk system are: (1) it is easier to keep the packing house clean, (2) the fire hazard created by the wooden boxes is reduced, and (3) fewer accidents and injuries result. From the grower's side of the picture, there is an additional advantage in that the use of the bulk system reduces truck travel in the grove since it is no longer necessary for the truck to drive through the grove scattering the field boxes. The reduction of truck traffic in the grove reduces the packing of cultivated soil between the rows of trees and further reduces tree damage due to the trucks breaking limbs and knocking off fruit as they are driven through the grove.

PACKING

Description of Packing Operation

Upon reaching the packing house, the grapefruit moves through a series of operations which end with the packed fruit loaded in the car or truck.

The fruit arrives in the packing house either in field boxes or loaded in a truck or trailer. The box or truck is dumped and the fruit is moved into the packing house. Some of the larger packing houses have as a first step a pre-sizing machine which eliminates the undersized fruit. In the desert, grapefruit is not normally washed but passes over a series of rotary brushes which remove

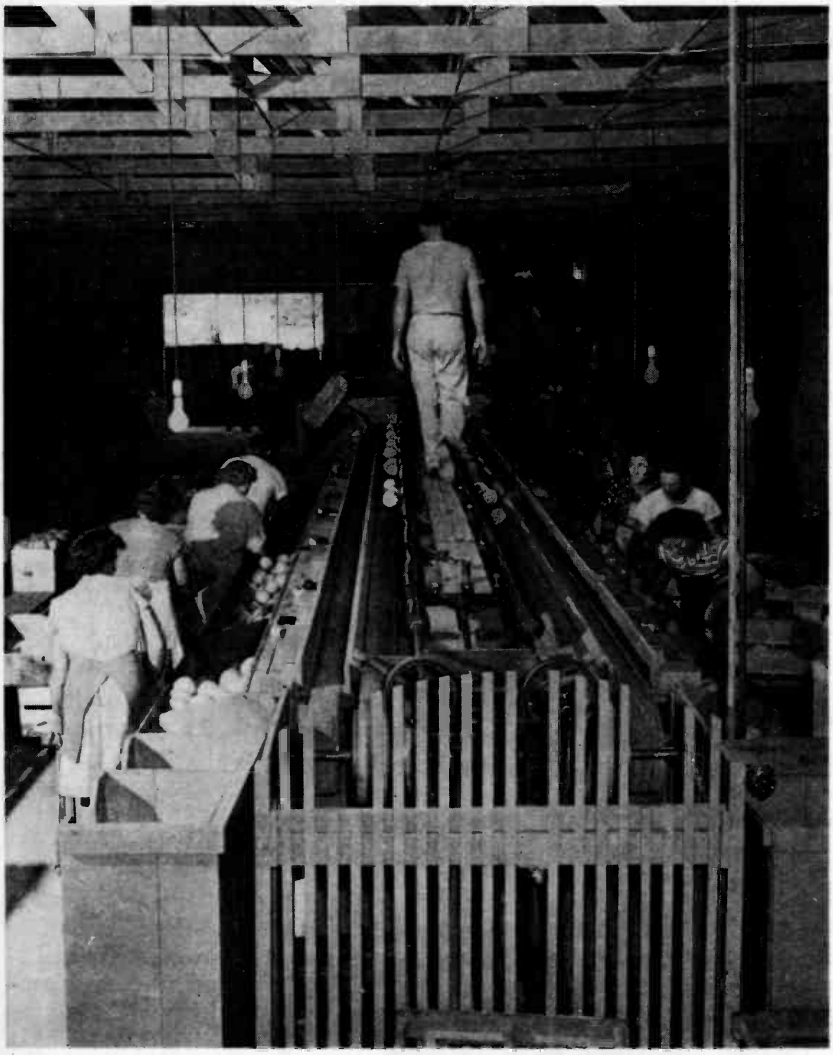

Plate IV.—Packing operation in a small desert packing house.

the dust and dirt from the fruit. From the brushing operation the fruit moves through a waxing machine where a protective wax is sprayed on, partially sealing the pores in the fruit and partially protecting it from spoilage or drying. In this operation the fruit is also brushed. The cleaned, waxed and polished fruit then moves on a series of belts across the grading tables where expert graders (usually women) sort the fruit according to grade. At the grading table the culls are discarded and move by a conveyor to the cull bin from which they normally are trucked to the juice cannery. The acceptable fruit then moves through a battery of

rotary stamping machines which stamp a brand on the fruit in a purple vegetable ink. The next operation is that of sizing. The fruit moves down a series of graduated rollers until it comes to an opening large enough to permit its falling into the packing bin located immediately under the sizer. The small fruit drop through first, the next size second, and so on until only the largest sizes are left at the end of the sizer. There is a bin for each size fruit being packed. The packers then place the fruit by hand in the packing boxes, each size fruit being packed according to a definite pattern. The fruit may be wrapped and packed or it may be packed without wraps. The packed box is then placed on a conveyor belt which takes it around to the lidder. This machine nails on the lid, puts a metal strap crosswise at the center of the box, and stamps the variety and size on the end. The box of fruit is now packed and ready to load. It may be stacked and stored temporarily on the packing house floor while awaiting loading, or it may be moved directly into the refrigerator car or truck. The fruit is moved by hand trucks, four or five boxes to the load. Truck loads vary greatly in size, but the standard load for a rail refrigerator car is 462 boxes.

There are two other packing house operations which are incidental to the actual packing operation. The wooden boxes are assembled at the packing house. The sides and ends of the boxes come precut. The labels are pasted on one box end and the pieces of the box are then assembled by an automatic box making machine which can turn out about 600 boxes per hour. In the fall, when the fruit first comes on the market, it is not fully mature and has not yet developed its natural yellow color. Since the consumer would not buy this green fruit, the fruit is gassed with ethylene gas, and this operation turns it an attractive yellow color. The gassing is done either before or after packing. Those plants with bulk-handling equipment usually gas their fruit after packing.

In certain seasons frost damages a part of the fruit in the groves. The separation of this frozen fruit must be made as part of the packing house operation. Two general methods of frost detection are in use. The first method is primarily a sampling procedure in which a number of fruit from each lot are cut and examined for frost damage. In the event that too much of the sample is frozen, the entire lot is discarded. The second method involves detection of frost damage through a fluorscopic machine. The fruit moves slowly through the machine, and looking through view plates the operators examine each fruit. A good fruit appears as a solid dark ball while frost damaged segments appear lighter in color. This process, while accurate, is very slow and rather expensive.

Packing Costs

Packing costs for desert citrus are now approximately double those of ten years ago. In 1939-40, the cost of packing desert grape-

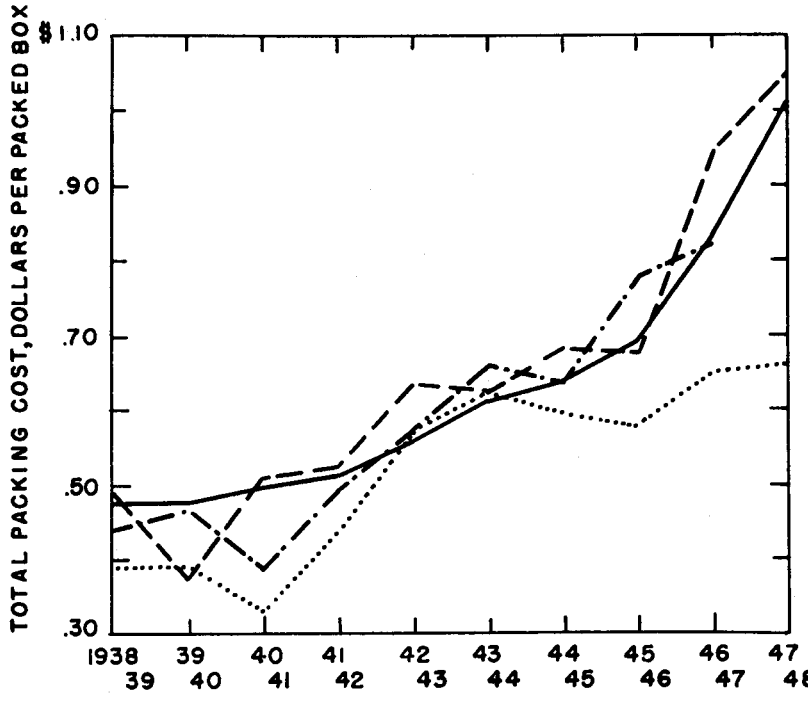

Figure 13.—Changes in cost of packing desert citrus, four packing houses, 1938-39 through 1947-48.

fruit was about 41 cents per box. In 1946-47 the cost was 85 cents per box, over twice the original rate. Increases in prices have failed to keep pace with increases in cost, and this fact has been an important factor in depressing growers' "on tree" returns. Figure 13 shows changes in total packing cost of four desert citrus packing houses during the period 1938-39 through 1947-48.

Most of the increase was due to higher costs of materials and labor. The greatest single increase was in the cost of the wooden box and lid. In 1947-48, the cost for box and lid was 291 per cent of the 1939-40 figure.

Table 9 itemizes the cost of packing desert grapefruit for the year 1946-47.

As seen from Table 9, materials accounted for 48.7 per cent of the total packing cost, 43.2 per cent of this being the cost of the box. Labor costs amount to 25.4 per cent of the total packing cost, packing labor (7.1 per cent) being the largest single labor item. Administrative expense was 11.4 per cent of the total, general house expense 4.9 per cent, depreciation 3.5 per cent, taxes 1.9 per cent, interest 1.1 per cent, and other expense 3.1 per cent.

There was a 46-cent range in packing costs among the thirteen packing houses studied. The low cost house packed its citrus for

TABLE 9.—ITEMIZED COST OF PACKING DESERT GRAPEFRUIT, THIRTEEN PLANTS, 1946-47

Item of expense	Cost per packed box	Per cent of total packing cost
	($ per box)	(% of total)
Materials		
Shook and lids	$ .3534	41.6%
Nails and straps	.0063	0.7
Wraps	.0285	3.4
Labels and paste	.0080	0.9
Other materials	.0177	2.1
Total materials	.4139	48.7
Labor		
Receiving	.0162	1.9
Grading	.0258	3.0
Packing	.0600	7.1
Lidding and loading	.0243	2.9
Box making	.0081	1.0
Other labor	.0811	9.5
Total labor	.2155	25.4
Administrative expense		
Salaries	.0310	3.7
Office expense	.0045	0.5
Professional fees	.0018	0.2
Other administrative expense	.0595	7.0
Total administrative expense	.0968	11.4
General house expense		
Utilities	.0097	1.1
Repairs	.0152	1.8
Insurance	.0148	1.7
Other house expense	.0023	0.3
Total general house expense	.0420	4.9
Depreciation	.0298	3.5
Taxes	.0163	1.9
Interest	.0090	1.1
Other expense	.0267	3.1
Total packing expense	$ .8500	100.0

$.64 per box. The high cost house put $1.10 into each box as packing costs.

The range for the major cost items was as follows:

Cost item	High cost (per packed box)	Low cost (per packed box)
Shook and lids	$ .45	$ .30
Packing labor	.08	.06
Labor other than packing	.21	.09
Administrative expense	.17	.06
General house expense	.07	.02

The range in the cost of shook and lids can be accounted for by differences in the source of supply and by differences in the proportion of new to used boxes packed by each house. There was little range in packing labor costs, the variation that did exist being due to local differences in wage rates.

The greatest difference was in the cost of labor other than packing labor. Part of this range was due to differences in receiving labor costs. Houses using the bulk-handling system had lower

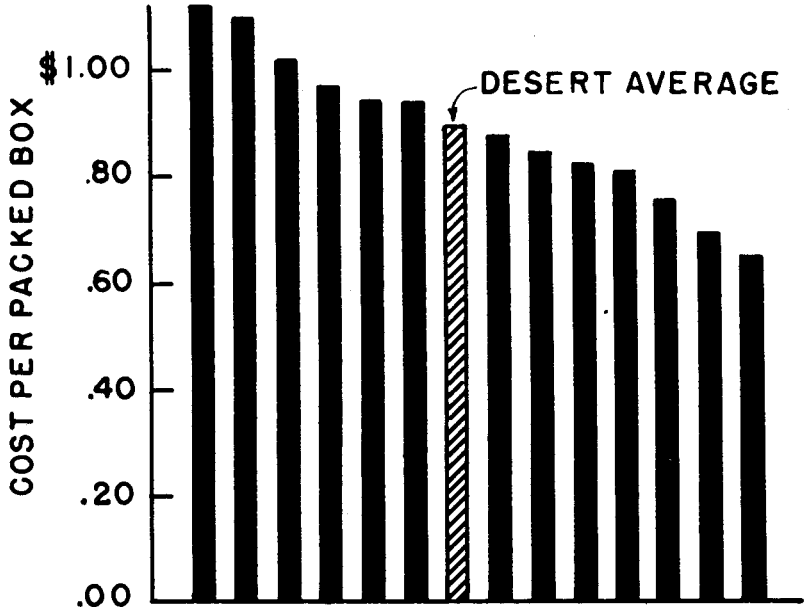

Figure 14.—Total cost of packing desert citrus, thirteen packing houses, 1946-47.

receiving labor costs. Grading labor also varied widely depending on the variations in the quality of the fruit and the quality of the pack. Variations in overhead labor were accounted for by differences in the amount of repairs, painting, housekeeping, and other maintenance among the packing houses studied.

Administrative expense varied primarily with variations in volume of operations of the individual plants. General house expense was dependent upon the amount of repairs and other maintenance. Some of the packing houses with low general house expense were neglecting maintenance of their physical plant while others were keeping their house up in good shape.

Cost of handling loose fruit.—On the average, only about half of the desert grapefruit crop is packed, and the remainder must be handled as loose fruit. The cost of handling loose fruit is shown in Table 10.

Paperboard Citrus Boxes for Desert Grapefruit

Objective three of this study was to determine costs and margins involved in marketing desert grapefruit from the producer to the consumer, and to point out possible economies which might be made.

Cost of packing data collected in this study indicated that the cost of the box constituted 43.2 per cent of the total packing cost, and was the largest single item of packing expense. The wooden box in use was practically the same box used sixty years ago. It

TABLE 10.—COST OF HANDLING LOOSE DESERT GRAPEFRUIT, 1946-47

Item of expense	Cost per packed box equivalent	Per cent of total cost
	($ per box)	(% of total)
Labor	$ .0264	18.5%
Administrative expense	.0448	31.4
General house expense	.0264	18.5
Depreciation	.0163	11.4
Taxes, interest, and other expense	.0289	20.2
Total packing house cost	$ .1428	100.0

was felt that perhaps the best opportunity for effecting a reduction of packing costs was in the development of a cheaper box which would still move fruit to market in a satisfactory manner. Paperboard has been the most common material substituted for wood. With this thought in mind, contacts were made with a number of paperboard box companies in December, 1947. One of these companies, the California Container Corporation, a branch of the Container Corporation of America, was interested in developing such a box. In 1949, the Lawrence Paper Company also participated in two test shipments with their "Freezer Board" box.

It was realized from the start that ordinary corrugated paperboard would not carry the fruit. The high relative humidity prevailing in refrigerated cars would result in a loss of rigidity in ordinary paperboard to the point where the boxes in the bottom of each tier would collapse because of the weight stacked on them.

However, during World War II the paper industry successfully developed types of paperboard which were practically waterproof and which would stand up under the cold, damp conditions existing in the refrigerator car.

In the experimental containers used in this study a corrugated type paperboard was used incorporating a bituminous compound in the corrugating medium. This type of construction resulted in a high-strength, waterproof board. Containers constructed of such board provide maximum rigidity compared with other paperboard boxes when under highly humid conditions for a long period of time.

Savings possible.—It was realized that the primary reason for considering the paperboard box was the existence of a possible saving in container cost. The wooden box, now in use, has been firmly established as a standard container over a long period of time and is, in most respects, a reasonably satisfactory package. Therefore, if a new container were to be introduced, it must be made available at a cost substantially below that of the present wooden box.

It is estimated that a saving of approximately 15 cents per box might be possible through the use of the paperboard box. This would mean a saving of $69.30 per car.

The 15-cent estimated saving was secured in the following manner:

Cost of wooden box assembled complete with lid, straps, nails, and label	$ .42
Estimated cost of complete, printed paperboard box	.30
Saving on container	.12
Saving on freight	.02½
Saving in packing house operation	.00½
Total savings per box	$ .15

The 42-cent figure represents an average wooden box cost for the entire desert. This cost includes: shook, nails, straps, chipboard, labels, assembling, paste, and the lid.

The cost of the paperboard box was derived purely by estimate based on prices of comparable paperboard boxes.

The saving in freight was calculated on the basis of the saving in container weight, the paperboard box being approximately 3½ pounds lighter than the wooden box. The average freight rate per box for desert grapefruit to all destinations is 51 cents, and the average weight per box is 70 pounds. Thus a saving of 3½ pounds of freight would be worth 2½ cents per box.

The ½-cent saving in packing house operation might come through the elimination of two operations—lidding and labeling. Since the box would be already printed when received from the paper company, no labeling would be necessary at the packing house. The box would be closed by an automatic top-sealer, and this would eliminate the necessity for the present operator of the lidding machine.

Test shipments.—Test shipments in paperboard boxes were made in 1948, 1949, and 1950. All of the test shipments with grapefruit were made late in the season. It was felt that a late-season shipment provided the most severe test of the paperboard box since the late-season fruit, being fully ripe and relatively soft is the most easily damaged and most subject to spoilage.

If the paperboard box carried this type of fruit successfully, there should be no question regarding the ability of the container to carry firm, early-season fruit.

The 1948 test shipments originated at the Arizona Citrus Growers in Phoenix and were shipped to the Atlantic Commission Company in Chicago. The boxes were designed and furnished by the California Container Corporation. Two carloads of fruit were shipped, half of each car in paperboard boxes and the other half in wire-bound wooden "Bruce" type boxes. Packing was started June 10. In these shipments, the fruit was packed in 8-pound mesh bags and the bags then packed in the master containers.

Two types of paperboard boxes were used. Type "A" was a three-piece (Bliss style) box consisting of a body sheet and two end-panels. This type of construction gave corners of double thickness, greatly increasing the ability of the box to support an overhead load. Three holes 1 inch in diameter were cut in each end panel of this box and four slits 3 inches long by ¼-inch wide were made in each side panel to allow for ventilation.

Type "B" was a regular standard one-piece container, stitched on one corner, and with overlapping top and bottom flaps. Two pads, made of the same material as the outer container, were placed in each end of the box. This provided a double wall at each end, increasing the strength of the box when subjected to an overhead load. Four vertical slits the same as in type "A" were cut in each of the two side panels to permit ventilation. The boxes were loaded five high in the car.

Both cars were iced before loading, re-iced before leaving Phoenix and iced twice during the five days en route to Chicago. The weather was hot (102 degrees) in Phoenix the day the fruit was packed. Loading was completed June 11 and the first car was opened at Chicago June 16 at 1 P.M. The second car was opened June 17 at 11 A.M.

On arrival at Chicago it was found that condition of the fruit in both cars was excellent. There was no damage to any of the paperboard containers inspected. None of the paperboard boxes were collapsed or broken and, in the opinion of everyone inspecting the load, the paperboard boxes had done as good or a better job than the wire-bound wooden boxes in carrying the fruit.

Handlers in the Atlantic Commission Company warehouse indicated that the paperboard boxes were easier to handle and could be unloaded faster than the wire-bound wooden box. The paperboard was lighter and free from splinters. In loading the wooden boxes on pallets, some fruit in wooden boxes was damaged when the corner of a box would break through the top of the one onto which it was thrown and crush some of the fruit in the box below. The lighter paperboard boxes did not show such damage.

Twenty retailers receiving paperboard boxes in these shipments were contacted. Of these, sixteen liked the box, two reported spoiled fruit, and three thought the carton needed more ventilation.

Some of the comments of those who liked the paperboard boxes were as follows:

1. Eliminates damage.
2. Keeps fruit nice and clean.
3. Fruit in perfect condition.
4. Very little packing indentations.
5. Also good to pack (carry out) groceries in.
6. Handy pack, nice to handle this way.
7. They are easy to handle.
8. This is the best pack of grapefruit in our years of produce experience.

1949 shipments.—During the 1948-49 marketing season two experimental shipments were made in co-operation with the California Container Corporation.

The first of these shipments was made from the La Verne Citrus Growers Association at La Verne, California to the Atlantic Com-

mission Company in Toledo, Ohio, in February, 1949. Because much of the desert grapefruit crop had been damaged by frost, this shipment was made with oranges. The oranges were bagged in 7-pound mesh bags which were then packed six to a paperboard box. The box used was the same (Bliss style) as type "A" in the 1948 shipments but a 200-pound test board instead of 275-pound test was used. The boxes were attractively printed. Ninety boxes were included in the car, the remainder of which was loaded with oranges in the standard wooden box. The boxes were ventilated with a slit ¼-inch wide by 5 inches long in each end and by cutting the top flaps short so that it left a ½-inch opening down the center of the top of the box. The boxes were loaded tightly in the car.

Some difficulty was experienced with moisture condensation in this shipment. The oranges were washed at about 120 degrees F., immediately packed in the box and the boxes loaded into a precooled car. The tight load prevented the evaporation of the condensed moisture and the hot, moist fruit "sweated" in the load. Although the fruit was moist and the boxes damp when the load arrived at Toledo, the fruit was in good condition. The boxes were loaded six high and in spite of the excessive moisture, there was no crushing or bulging due to the overhead weight. Some boxes were slightly crushed due to an improperly constructed gate between the paperboard and the wooden boxes in the load.

The second 1949 shipment was made June 11 from the Yuma Mesa Fruit Growers Association at Yuma, Arizona, to the Chas. Reuter Produce Company at San Francisco. In this shipment the fruit was packed in a standard place pack in the paperboard boxes each of which was equivalent to half of a standard wooden box. The inside dimensions of the paperboard box were the same as one compartment of the standard wooden box, except for depth. Since the paperboard box is not packed with a bulged lid as is the wooden box, it was necessary to make the paperboard box approximately 1½ inches deeper than the wooden box. The box again was the "Bliss" style with three 1-inch holes in each end panel. Both 200-pound and 275-pound test board was used. A total of 412 of the paperboard boxes were packed under the "Desert King" label. The boxes were loaded four high in one half of the refrigerator car, the other half being loaded with the standard wooden box. The weather was hot (107 degrees), the car was precooled, and moved, under standard refrigeration. When the car arrived in San Francisco, the fruit and boxes appeared in excellent condition. While the fruit in the paperboard boxes was about 15 degrees F. warmer than the fruit in the wooden boxes, the fruit temperature in the paperboard containers at the time car was opened in San Francisco was about 65 degrees F. compared with a temperature of 90 degrees at the time of loading.

Several small truck shipments of grapefruit packed in the paperboard box were made from Yuma to Los Angeles. The fruit was sold on the California Fruit Growers Exchange auction there and

brought prices comparable with fruit packed in wooden boxes or, as in some cases, even commanded a premium. For example, on June 20, size 54 "Desert Prince" brand in wooden boxes sold for $3.50, "Desert Prince" size 54 in paperboard sold for $1.95 per half box or $3.90 per box. On June 17 size 54 "Desert Prince" in wood sold for $2.85 while one-half boxes size 54 "Desert Prince" in paperboard brought $1.70 each or $3.40 per box. On June 20 one-half boxes of size 54 "Desert Prince" in paperboard sold for $2.00 while full wooden boxes of size 64 "Desert Prince" sold for $3.70.

1950 shipments.—During May, 1950, two shipments of grapefruit packed in paperboard boxes were sent to Safeway Stores, Inc. in Salt Lake City. The box used was the "Freezur Board" box made by the Lawrence Paper Box Company of Lawrence, Kansas and distributed in the West through the Dixon Paper Company of Salt Lake City.

The box used in these tests was a one-piece, regular standard type carton stitched on one corner with four top and four bottom flaps. The inside dimensions of the container were: 25 inches long, 12 inches wide, and 13½ inches deep. The box was fitted with a liner which divided it into two compartments each 12 inches long, 11½ inches wide and 13½ inches deep. Except for depth, these are the same dimensions as each compartment of the standard California-Arizona wooden citrus box.

The paperboard used in this box was a patented board made by the Lawrence Paper Company and known as "Freezur Board." This is a corrugated type board in which the pulp from which the corrugating medium is made has been impregnated with a bituminous compound resulting in a moisture-resistant or "weatherproof" type of paperboard. The board used had a bursting strength of 200 pounds to the square inch.

In constructing the box, the top and bottom flaps running lengthwise of the box were made but 5¾ inches wide which left an opening ½-inch wide and 12½ inches long in both the top and bottom of the box, the purpose of which was to provide ventilation through the packed box.

The first shipment of eight boxes was packed May 8 at Tal-Wi-Wi Ranch, Peoria, Arizona and shipped the same day by Utah-Arizona Motor Freight, arriving in Salt Lake City late the night of May 9. This shipment was unloaded about 11 A.M. May 10. In this shipment the bottom flaps of the box were stitched on an Acme Silverstitcher and the top flaps glued.

The second shipment of fifty paperboard boxes was packed at the Mesa Citrus Growers, Mesa, Arizona, May 13, shipped by Utah-Arizona Motor Freight arriving in Salt Lake City late May 14. This shipment was unloaded about 10 A.M. May 15. In this shipment both the top and the bottom flaps were glued.

In both shipments, the paperboard boxes were included as a part of a larger shipment of fruit in wooden boxes. The standard

packing arrangement was used in the paperboard box. The flaps were held down by a band which fitted over the top of the box, and the girls packing the fruit experienced no difficulty in filling the box in their usual manner.

The boxes were unloaded at the Safeway warehouse and moved out to the stores during the night. The greatest difficulty encountered during the shipment was in handling the paperboard boxes in the warehouse. The hand trucks used for handling wooden citrus boxes were unsuitable for moving paperboard and while the wooden citrus boxes were kept in an area where the floors were wet, the paperboard boxes had to be set on boards to keep them out of the water. However, these difficulties would be easy to remedy, and this same warehouse was handling apples and eggs in paperboard boxes with no apparent difficulty.

In order to check the condition of the boxes and fruit, each store in Salt Lake City receiving fruit in the paperboard box was visited. In each store the manager or produce manager was interviewed. Every person interviewed thought the paperboard box was as good or better than the present wooden box.

Of the twelve questionnaires completed, nine said that they preferred the paperboard box to the present wooden box, and three thought that the paperboard was just as good as the wood. The general opinion of the paperboard box was well stated by one of the men interviewed who said, "We have long felt that the wooden citrus box was antiquated and I am glad to see the trend toward the easier to handle paper boxes. We are successfully handling considerable volumes of apples in paper boxes."

The principal reasons given for preferring the paperboard box were as follows:

1. Lighter, faster, and easier to handle.
2. Easier and faster opening.
3. No nails or splinters to injure employees.
4. Less mess in opening.
5. Good carry-out box—wood splinters and nails in wooden box tear customer's car upholstery.
6. Fruit arrives in better condition in paperboard box—sharp edges and pressure lidding of wooden box damages fruit.
7. Box will not split or break if dropped.
8. Easier to dispose of—wooden boxes must be carried back to storeroom.
9. Most other products arrive in paperboard.

The fruit in the paperboard boxes arrived in good condition. In the twenty-five boxes examined there were but five damaged fruit (⅓ of 1 per cent). Two of these damaged fruit were in the center of the box and the nature of the bruise was such that the damage could not be attributed to failure of the box. One fruit was damaged where one corner of the box had been crushed, apparently from dropping the box on some sharp edge. The other two damaged fruit were on the top layer and since the box showed

no damage, these fruit must have been bruised through the opening left in the top for ventilation.

The general condition of the fruit was excellent. There was no noticeable moisture condensation in the box or on the fruit, and the fruit was as cool as that in the wooden box. The fruit temperature was 72 degrees F., approximate air temperature, and the load moved without refrigeration.

The mechanical condition of the boxes on arrival was very good. They were stacked five high in the truck and averaged 66 pounds gross weight per box. Thus the bottom box carried a load of 264 pounds. There was no indication of crushing or bulging in any of the boxes in the load.

Another test shipment was made in May from the Mesa Citrus Growers, Mesa, Arizona to the D. Martini Produce Co. in San Francisco. In this shipment a two-compartment paperboard box designed by the California Container Corporation was used. This box had the same inside dimensions as the Lawrence Paper Co. box, but differed considerably in its construction. The paperboard used in this box incorporated an asphalt compound in the corrugating medium. The corrugating medium was of laminated construction, the asphalt compound being used as the laminating adhesive. This provided the "weatherproof" type of board required. The box was made of 275-pound test board.

This box had two main features. First, it was highly ventilated. The experience with the orange shipment in 1949 had emphasized the necessity for more ventilation. While no trouble had been experienced due to lack of ventilation in grapefruit shipments, it was felt that since this box would be used for both grapefruit and oranges more ventilation would be highly desirable. This ventilation was secured through round holes 1 inch in diameter die-cut in the ends, sides, and inside partition dividing the box in half. Five such holes were cut in each end and in the center partition, and ten in each side. The second feature of this box was that it could be cut into two separate and complete half boxes. This was accomplished by making the center partition double and providing top flaps attached to this partition. Many small retailers would prefer to buy citrus in less than full box lots since they sell so little fruit that the last of a full box becomes old before it is sold. This is especially true of lemons. This box was designed as an answer to this problem. The corners of this box were reinforced with the same type of paperboard, making all corners of double thickness.

Eight of these boxes were shipped by rail as a part of a full car shipment to San Francisco and arrived in excellent condition. The fruit was dry and cool. One of the boxes was reshipped by express to Los Angeles and was still in excellent condition when it arrived there.

Plate V shows the condition of each of the test shipments of desert grapefruit made in the paperboard boxes upon arrival at

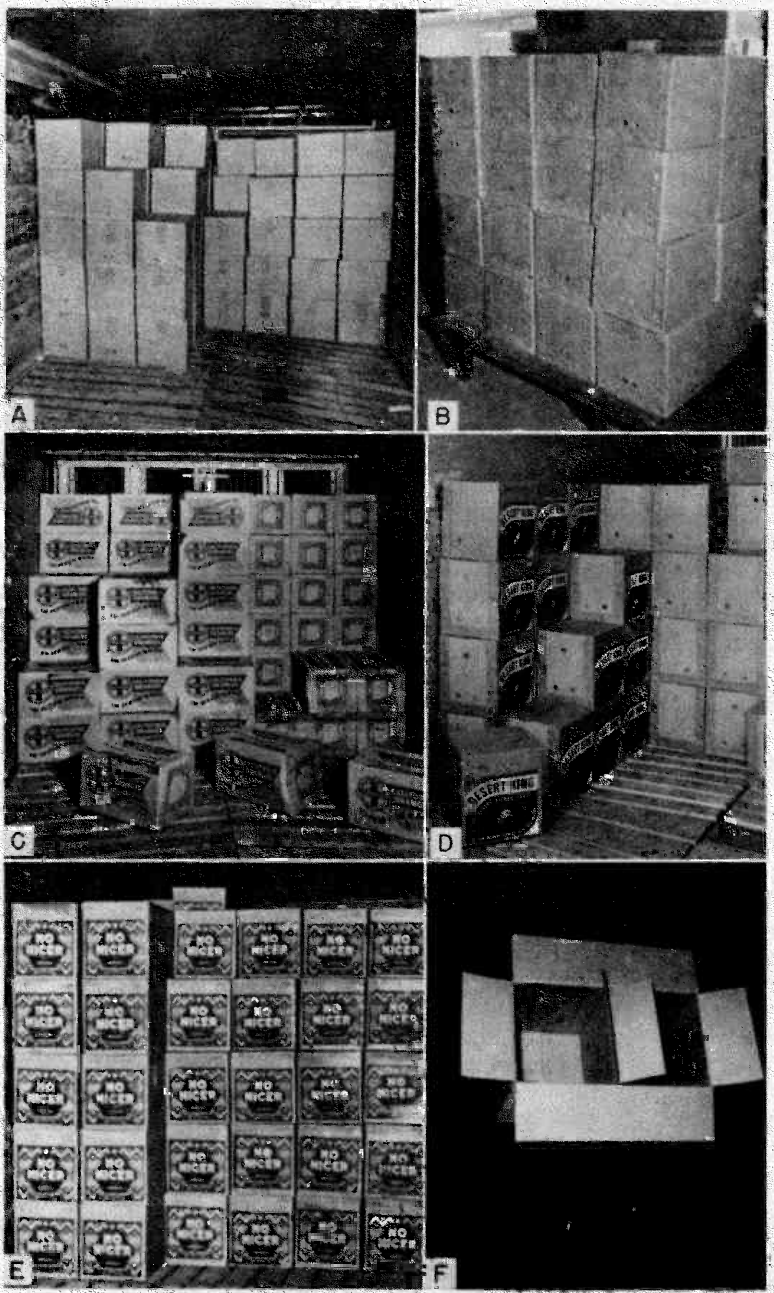

Plate V.—Test shipments of desert grapefruit packed in paperboard boxes.

the destination. Photos *A* and *B* show the condition of the 1948 shipments upon arrival at Chicago. *C* shows the 1949 orange shipment at Toledo, and *D* shows the 1949 grapefruit shipment on track at San Francisco. *E* shows the 1950 truck shipment to Salt Lake City, and photo *F* shows the box used in the 1950 shipment to San Francisco.

Consumer Packages for Desert Grapefruit

The principal consumer package used in the marketing of desert grapefruit is the 8-pound mesh bag. These are either made of cotton twine or paper twine woven to about a ½-inch mesh. The bag has a band around the middle either of closely woven cotton material or of paper strips woven through the mesh. On this band is printed the necessary labeling information.

The original bags were colored a tangerine red. This color was carefully developed to enhance the natural color of oranges, but grapefruit being yellow, this red bag did not improve the appearance of grapefruit as it did oranges. As a matter of fact, the red bag made the grapefruit take on a bronze cast, the color of grapefruit that has been picked for a long time. The logical conclusion was that since a tangerine red bag had been developed to add to the attractiveness of oranges, a yellow bag might do the same thing for grapefruit. The Bemis Bag Company generously supplied the University of Arizona with 500 yellow bags, and a consumer acceptance test of the yellow bags vs. the red bags was made in five Tucson, Arizona, Safeway Stores. The result of this test was that the consumer definitely preferred the yellow bag for grapefruit. In the consumer's opinion, the yellow bag made the fruit look brighter, fresher, cleaner, easier to see, and more nearly approached the natural color of the fruit. As a result of this test, the yellow bag has been adopted by the desert grapefruit industry and is also being used in other grapefruit-producing areas.

The principal advantage of the mesh bag is its convenience although a few people have valued the bag for use as a shopping bag, dish rag, etc. The principal disadvantage of the mesh bag now in use is that it contains too much grapefruit for the average family. Each bag holds nine or more fruit, enough for most people for at least two weeks. They prefer to buy fewer at a time and thus have fresher fruit.

TRANSPORTATION

Freight constitutes a major item of expense in the marketing of desert grapefruit. It costs approximately 50 cents per box to transport this fruit to market.

Approximately two-thirds of the total of all desert grapefruit shipped now goes by truck. Arizona ships about 60 per cent of its fruit by truck while the California desert area ships 80 to 90 per cent by truck.

Truck shipments from the desert are mostly to Los Angeles, Salt Lake City, Denver, and intermediate points. Some fruit is trans-

shipped at Los Angeles and moves on another truck line to San Francisco.

The standard load for a refrigerator car is 462 boxes. During the war 561 boxes per car were loaded, but this heavier load is no longer required. The load carried by trucks varies widely. However, some of the larger trucks will carry 500 boxes or more.

Since most of the truck hauls are one or two day trips, very few truck shipments are refrigerated. Rail shipments, which move longer distances and are often en route four or five days are almost always refrigerated during hot weather. While the necessity of refrigeration varies from year to year, normally fruit moving by rail after the middle of May is refrigerated. Standard refrigeration (full ice bunkers) is the type most commonly used. During hot weather the empty car is often iced and thus precooled before it is loaded. None of the desert packing houses precool their fruit. Two railroads serve the desert, the Southern Pacific and the Santa Fe.

Desert grapefruit moves under a fixed package weight. Prior to 1940 the estimated weight used was 68 pounds. In that year at the request of the railroads and based on extensive weighing studies conducted by the Transcontinental Freight Bureau, an agency of the railroads, the estimated weight was increased to 76 pounds. This increase was opposed by the citrus industry, but was approved by the Interstate Commerce Commission and became effective. The desert grapefruit industry has always felt that the 76-pound weight used did not represent the true weight of the packed box.

One of the problems considered in this project was that of this controversial estimated weight. The University of Arizona weighed fruit in all four of the desert producing areas over a three-year period. Over 14,000 boxes were weighed, and the average weight resulting was 69.96 pounds. The desert grapefruit industry has requested a revision in the estimated weight of the packed box of desert grapefruit from the 76-pound figure now in use to 70 pounds, the true weight of the average box. The truck lines adopted the 70-pound weight November 21, 1949 and the railroads have proposed the adoption of the new weight. This weight reduction would save the desert grapefruit industry approximately $75,000 per year in freight overcharges.

There are three reasons for the reduction of the estimated weight of the standard packed box of desert grapefruit from 76 down to 70 pounds. One reason is that the weights made by the Transcontinental Freight Bureau, which established the 76-pound estimate, represented a sampling of all grapefruit produced in California and Arizona including the relatively small-sized and therefore heavier per box summer grapefruit produced in California.

Another reason is that the average size of grapefruit shipped from the desert is now larger than at the time the 76-pound esti-

mate was established. This is due to the establishment of the grade and size proration program in 1941 which severely restricted shipment of the small sizes 100 and 126 from the desert.

The third reason why the standard packed box of desert grapefruit weighs less now than when the 76-pound estimate was established is because the length of the lid has been shortened which has reduced the "bulge" and decreased the weight of fruit which could be packed in the box.

Current freight rates on desert grapefruit are the highest in the history of the industry. The existing freight rate structure favors the movement of Texas citrus over desert citrus to all of the principal markets where fruit from the two areas competes. Table 11 shows rail mileages and rates for fresh grapefruit from Phoenix, Arizona and Harlingen, Texas to the principal markets in which fruit from these two areas is competitive. California markets are omitted since in normal years Texas can offer the desert but little competition in this area.

TABLE 11.—RAIL MILEAGES AND RATES FOR FRESH GRAPEFRUIT FROM PHOENIX, ARIZONA AND HARLINGEN, TEXAS TO SELECTED DESIGNATIONS

Destination	Short line rail mileage*		Rate per Cwt.†		Rate per ton mile‡	
	From Phoenix	From Harlingen	From Phoenix	From Harlingen	From Phoenix	From Harlingen
	(miles)	(miles)			(cents)	(cents)
Chicago, Illinois	1805	1389	$1.73	$1.29	1.92	1.86
Kansas City, Mo.	1369	1023	1.58	.92	2.31	1.80
Denver, Colo.	1046	1238	1.35	.92	2.58	1.49
Cheyenne, Wyo.	1153	1405	1.35	1.21	2.34	1.72
Butte, Mont.	1329	2160	1.39	1.75	2.09	1.62
Boise, Idaho	1307	2179	1.18	1.75	1.81	1.61
Salt Lake City, Utah	843	1808	.93	1.67	2.21	1.85
Seattle, Wash.	1584	2760	1.14	1.75	1.44	1.27
Portland, Ore.	1404	2662	1.05	1.75	1.50	1.31

*Source: "Comparative Carlot Rail Freight Rates on Citrus Fruit and Canned Grapefruit Juice" U.S.D.A., F. C. A., Misc. Report No. 42, 1941.
†Source: Southern Pacific Railroad, May 10, 1950.
‡Rate × 20 ÷ by mileage, to nearest hundreth of a cent.

To every destination shown in the above table the desert ships at a higher rate per ton mile. Although the intermountain states are difficult to reach by rail from desert shipping points, and more switching is required, it is also true that it is not exactly a through haul from the Lower Rio Grande Valley to these points. If some of this disadvantage were removed more desert fruit might move to these markets.

Truck lines handle much of the desert fruit to a limited number of destinations. Franchise truck lines, hauling a considerable volume of citrus, operate out of the desert to Los Angeles, Salt Lake City, and Denver. Fruit at Los Angeles is frequently transferred to another truck line and moved on up the coast to San

Francisco. Truck rates to these markets are usually lower than rail rates.

WHOLESALING AND RETAILING

Wholesaling

Market agencies wholesaling desert grapefruit fall into two general catagories, co-operative and independent. There are three co-operative sales associations which handle the bulk of the desert grapefruit crop. These are:

(1) The California Fruit Growers' Exchange (Sunkist brand).
(2) The Mutual Orange Distributors (Pure Gold brand), and
(3) The American Fruit Growers (Blue Goose brand).

These three organizations maintain central sales offices in Los Angeles and the California Fruit Growers' Exchange maintains a district sales office in Phoenix.

The co-operative sales agencies sell to jobbers, wholesale carlot receivers, chain store buyers, retailers, hotels, restaurants, truck buyers, and other market middlemen. They sell fruit by three general methods; by their own salaried sales representatives, through brokers or jobbers who represent them on specific markets, and through public or private auctions. The California Fruit Growers' Exchange maintains its own auction in Los Angeles.

Independent wholesale agencies include auctions, brokers, wholesale carlot receivers, jobbers, chain store buyers, and trucker buyers. Auctions and brokers exist merely as facilitating agencies, bringing sellers (the packing house) and buyers (other wholesalers or retailers) together and arranging the terms of trade. Wholesale carlot receivers, jobbers, chain store buyers, and truckers buy direct from growers and packers through brokers or auctions, co-operative sales agencies, etc.

In most instances, the packer can choose the wholesale marketing agency to which or through which he will market his fruit. Packing houses themselves perform a limited wholesale function, often selling direct to local retailers.

Retailing

The retailer's margin constitutes the largest single cost in the marketing of desert grapefruit. Over one-third of the consumer's dollar spent for fresh grapefruit goes to the retailer. In view of the fact that grapefruit is not considered as a highly perishable item and that more perishable produce (such as apples) have a mark-up comparable to that for grapefruit, it might seem that grapefruit helps "carry" some of the more perishable produce items. This situation, which appears to exist, operates to the direct disadvantage of the grapefruit industry.

Two surveys pertaining to the retailing of grapefruit and grapefruit products were made during the period of this study. The first survey made in Tucson, Arizona in the spring of 1948, included 124 stores. The second survey, made in Los Angeles in the spring of 1949, covered 486 stores. The results of the two sur-

veys were very similar. The surveys included fresh grapefruit, canned grapefruit juice, canned grapefruit segments, fresh apples, and canned tomato juice.

The grapefruit products included in the survey were found available in 90 per cent of the stores. Those stores not stocking grapefruit or grapefruit products were primarily small, neighborhood stores in low-income areas. Fresh grapefruit was commonly available eleven months out of the year and the canned products were available at all times.

In these studies it was found that the retailer got approximately 35 cents out of the consumer's dollar spent for fresh grapefruit, and a comparable amount out of the dollar spent for fresh apples. He received 30 cents out of the dollar spent for either canned grapefruit juice or canned tomato juice, and 24 cents out of the consumer's dollar spent for canned grapefruit segments.

There was a wide range in the prices of these grapefruit products in both studies.

TABLE 12.—RANGE IN PRICES OF GRAPEFRUIT AND GRAPEFRUIT PRODUCTS, 1948 AND 1949

Produce	Tucson 1948		Los Angeles 1949	
	High	Low	High	Low
Fresh grapefruit	15c lb.	3c lb.	14c lb.	3.4c lb
Canned grapefruit juice, no. 2	18c can	8⅓c can	17c can	8c can
Canned grapefruit juice, 46-oz.	39c can	18c can	30c can	20c can
Canned grapefruit segments, no. 2	35c can	17c can	35c can	14c can

Some of this range could be accounted for by variations in quality, but extreme price ranges were found for comparable grades of fresh fruit and identical brands of canned products.

Prices for grapefruit and grapefruit products were highest in small stores in low-income areas and lowest in large stores in medium-income areas.

Pricing by the pound rather than by the count was practiced in about three-fourths of the stores selling fresh grapefruit.

The average store carried three brands of canned grapefruit juice. Thirty-three different brands of canned grapefruit juice and nineteen different brands of canned grapefruit segments were found.

DRIED GRAPEFRUIT PULP—FEEDER OPINIONS AND PRICE RELATIONSHIPS

Dried grapefruit pulp has been introduced as a substitute for barley and other carbohydrate concentrates in the rations of dairy cows and beef cattle. In the past the disposition of this cannery refuse (peel, rag, and seeds) has constituted a cost item in the processing of grapefruit juice. The production of dried grapefruit pulp offers a method of converting this cost item into a source of income to the cannery.

Dried grapefruit pulp as a feed for livestock is not a new product. Studies of feeding this product to livestock date back to 1911.[5] Dried grapefruit pulp was placed on the Florida market in commercial quantities in 1932. Since that date, numerous tests of this feed have been made by the Agricultural Experiment Stations of Florida, Texas, California, and Arizona, all aimed at the determination of the feeding value when fed under varying conditions. The results obtained in all of these trials are very similar.[6]

Feeder opinions.—Experimental feeding trials have indicated the relative value of dried grapefruit pulp as a feed for dairy and beef cattle. It was felt that a survey of feeder opinions would serve to indicate actual farm experiences and would provide a

[5]Walker, S. S., and McDermott, F. A., *The Utilization of Cull Citrus Fruits in Florida*, Fla. Agr. Expt. Sta. Bul. 135, 1917.

[6]In a study made at the Florida Agricultural Experiment Station over the period 1936-37 through 1938-39, comparing the feeding value of dried grapefruit pulp with dried beet pulp, it was found that slightly more milk and butterfat were produced when the cows received dried grapefruit pulp, but feed consumption and body weights were slightly greater during the periods on dried beet pulp. Results indicated that the two products were of equal feeding value when supplied as bulky carbohydrate feeds to dairy cows. (Arnold, P. T., Becker, R. D., and Neal, W. M., *The Feeding Value and Nutritive Properties of Citrus By-Products*, Fla. Ag. Expt. Sta. Bul. 354, 1941.)

Texas tests in 1944, comparing a concentrate ration of 50 per cent dried grapefruit pulp and another ration containing 50 per cent corn and cob meal, showed a slight difference favoring the corn ration. However, the test did indicate that the citrus meal was equally palatable when fed in moderate amounts and had a conditioning effect not found in the corn ration. (Copeland, O. C. and Shepardson, C. N., *Dried Citrus Peel and Pulp as a Feed for Lactating Cows*, Texas Agr. Expt. Sta. Bul. 658, 1944.)

Tests made at the University of Arizona in 1948, comparing a ration in which 50 per cent of the concentrate was dried grapefruit pulp with the regular herd ration showed that dried grapefruit pulp was an economical, palatable feed for dairy cattle, and that there was no appreciable difference in milk production when the two rations were compared. It was also found that dairy calves did well on a dried grapefruit pulp ration and it was recommended that this feed be used in amounts up to 50 per cent of the total concentrate ration for both milk cows and calves. (Kemmerer, A. R., Harland, F. G., and Davis, R. N., *Dried Citrus By-Products as Feeds in the Rations of Dairy Cows and Calves*, Ariz. Agr. Expt. Sta. General Bulletin 218, 1948.)

Most of the feeding trials with dried grapefruit pulp have been made with dairy cattle. However, two trials, one Texas and the other in Arizona, have both indicated that dried grapefruit pulp is a very satisfactory concentrate in the beef cattle fattening ration. The Texas trials showed that dried citrus pulp, when fed to replace not more than 25 per cent of the ear corn chop with husk, resulted in the production of practically equal gains but slightly higher finish than groups fed ear corn chop with husk as the carbohydrate concentrate portion of the ration. (Jones, J. M., Hall, R. A., Neal, E. M., and Jones, J. H., *Dried Citrus Pulp in Beef Cattle Fattening Rations*, Texas Agr. Expt. Sta. Bul. 613, 1942.)

The tests made at Arizona during 1949 indicated that dried citrus pulp was equivalent to rolled barley when fed in equal portions with this grain in a basal ration of alfalfa, hegari silage, and cottonseed meal for fattening cattle. (Stanley, E. B., and Pahnish, Floyd, "Ration Comparisons for Fattening Cattle in Arizona, 1948-49," Ariz. Agr. Expt. Sta. Mimeo. Rpt. 95.)

further check on the practicability of this feed. For this reason, a survey of feeder opinions of dried grapefruit pulp as a feed was made.

The major feed companies in Phoenix, Glendale, Tempe, Mesa, Chandler, and Tucson, Arizona, were contacted and asked for the names and addresses of their customers using dried citrus pulp. Fifty-seven names were obtained and interviews were held with forty of these. Interviews were held on the users' farms, but sometimes with two or even three visits no one was found at some of the places.

One of the feed companies had changed from grapefruit to orange pulp shortly before this survey. A number of their users were interviewed and it was determined that, in their opinion, there was apparently little difference between the values of dried grapefruit and orange pulps as feeds. The survey was made in May of 1950.

General reaction—like or dislike of dried grapefruit pulp.—The first question asked regarded the users' general like or dislike for dried grapefruit pulp. Of the forty persons interviewed twenty-nine (72½ per cent) indicated that they liked dried grapefruit pulp as a feed. Five said they did not like it and six indicated "no opinion."

Palatability.—The most frequently encountered comments, both favorable and unfavorable, regarding dried grapefruit pulp as a feed concerned its palatability. Most of those interviewed did not mention having any palatability troubles and some remarked about its unusually good palatability. Generally those who did say that they had experienced palatability difficulties said that these occurred when citrus was first included in their ration and that little difficulty was experienced after animals became accustomed to it. Palatability of orange pulp was mentioned by several as being better than grapefruit pulp although there was no indication from any of those interviewed that there was any appreciable difference between orange and grapefruit pulps in feeding value.

One of the feed dealers indicated that there may be a difference in palatability of citrus pulps between breeds of dairy cattle; the larger breeds such as Holsteins accepting it more readily than the smaller breeds such as Jerseys which are more selective. The Dairy Department at the University of Arizona concurs with this observation.

The addition of about 10 per cent molasses apparently overcomes palatability difficulties, since those feeders who reported that about that amount of molasses was included in their rations also reported excellent palatability and some of those who did report trouble with palatability said that they thought the addition of molasses would make dried grapefruit pulp more palatable.

Other remarks—favorable.—Grapefruit pulp seemed to be a good "conditioner" and animals fed it were reported to enjoy good

health, look "slick," and be a little heavier than usual for the time of year (May). Some users said that the color of both milk and butter was richer after feeding of citrus was begun. Dried grapefruit pulp was said to mix well and to stay mixed. It was also credited with: (1) adding variety to rations, and (2) providing needed bulkiness in concentrate rations.

Other remarks—unfavorable.—An objectionable dust was mentioned as being found in dried grapefruit pulp as it comes from the processing plant. Mixture of molasses or cottonseed meal in rations containing dried citrus pulp was reported to absorb this dust. One feeder stated that citrus was no miracle feed and several indicated that they would eliminate citrus from their ration if there were no saving in money by using it. These other comments were mentioned one time each: (1) with citrus in the ration the "cows got fat but not in the bucket," (2) "citrus ration seems to draw flies."

Estimated savings.—Each feeder was asked to estimate his savings (per cwt. or per ton) since the inclusion of citrus in his "mix." A rather wide spread in the estimates was expected because the percentage of citrus in rations varied considerably. Also some feeders made other changes in their rations at the time citrus was added. The lowest estimate of savings was $1.60 per ton and the highest was $15.00 per ton. Most of the estimates were between $3.00 and $5.00 per ton. About one-half (twenty-one) of the users interviewed said that they knew that their citrus ration was less expensive but they did not know just what their savings were.

Feeds for which citrus was substituted.—Rolled barley and beet pulp were the most frequently mentioned feeds replaced by citrus pulp. Feed companies also indicated that those feeds were the major ones for which citrus pulp was substituted. Other feed components that were reduced or eliminated when citrus was added included cottonseed meal, alfalfa meal, alfalfa pellets, molasses, linseed pellets, corn, bran, yeast, miscellaneous grains, and the "bowel regulator." Here also about one-half of the feeders interviewed said that they did not know for which feeds citrus pulp had been substituted in their ration.

Percentage of citrus in ration.—The average feeder was found to be using a rather conservative amount (10-20 per cent) of citrus pulp in his ration. Tests by the University of Arizona resulted in the recommendation to feed dried grapefruit pulp in amounts up to 50 per cent of the concentrate ration for dairy cows. Few rations were found to contain more than 20 per cent of citrus and 37½ per cent was the most citrus reported in any ration. Seven per cent was the least.

Length of time dried citrus fed.—Twenty of the forty feeders interviewed said that they had been using citrus pulp for more than six months and others reported shorter periods of use with two less than one month.

How purchased.—About one-half (twenty-two) of the users reported that they purchased their citrus ration in bulk. Probably one reason for this is that one of the feed companies offered a bulk supply service which included a farm supply bin built at the company's expense. Two feeders reported bulk buying with their own mixing and sacking operations. The remainder of the users bought pre-mixed and pre-sacked rations.

Value of ration containing citrus compared to previous ration without citrus.—Most feeders interviewed did not indicate their opinions regarding the value of citrus pulp itself as compared to other specific feeds such as rolled barley, for instance. Rather they chose to describe the apparent value of their ration containing citrus as compared to their previous ration not containing citrus which was often quite similar. About equal numbers reported that they thought their citrus ration was better (eleven) or equal (fourteen) to their previous non-citrus ration. Three feeders did not believe their citrus ration as good as without citrus. The remainder of the feeders interviewed did not wish to voice any opinion about the comparative value of their citrus ration.

Milk production.—Nearly all (thirty-four) of the dairy feeders interviewed reported that milk production was at least as good with citrus in their ration as it was before the inclusion of citrus. Fourteen of these indicated that milk production increased with citrus although a few said that this increase began to taper off after a few months. Only one feeder reported a lower rate of milk production after changing to citrus and three said that they had been using citrus too short a time to determine how their cows' milk production was affected.

Growth of calves.—Nineteen users said that they had fed citrus pulp to calves. Ten reported as good and eight better growth when it was fed. One feeder said that his calves had "scours" at the time they were being fed citrus and that growth was, of course, very poor. It is doubtful that the sickness was due to the citrus since none of the others had such troubles when feeding citrus to calves. Actually a number of feeders remarked about the unusually good health of their calves when "on citrus" some saying that they had never had calves in better condition.

Beef gains.—Interviews with beef feeders using citrus pulp were limited. However, replies received indicated that gains with citrus rations compared favorably to gains on regular rations. One feeder reported that digestion seemed improved with citrus.

One of the users contacted fed citrus to goats kept for milk. The goats' milk was said to be richer in color and the goats were said to relish the citrus ration.

Competitive Price Relationships

The rapid expansion in the use of dried grapefruit pulp may, in part, be attributed to the fact that it has been cheap per unit of nutrients and compares favorably with rolled barley or dried beet pulp in the ration. During the past two years both barley and

beet pulp have been high in price and feeders and feed manufacturers have used dried grapefruit pulp to lower the cost of their rations without appreciably altering the feeding value. Because of the existence of this situation, no difficulty has been experienced in disposing of the entire supply of dried grapefruit pulp at satisfactory prices.

Feeding trials have shown that dried grapefruit pulp can be used to replace rolled barley or beet pulp as a part of the concentrate ration with no appreciable change resulting in milk production or weight gains. On this basis, dried grapefruit pulp should sell at or near the price of the concentrates which it replaces. However, being a new feed, it must sell at a discount in order to attract feeders and to secure initial acceptance. The present price of dried grapefruit pulp is about 75 per cent of the price of rolled barley. It is this 25 per cent price advantage that is attracting most feeders at the present time. However, there are some feeders who feel that the citrus ration is even better than their old ration and would be willing to pay a price equal to that of rolled barley. As use of dried grapefruit pulp becomes more general, the spread between its price and that of rolled barley may narrow.

PUBLICATIONS AND REPORTS ON THE MARKETING OF DESERT GRAPEFRUIT

It has been the policy throughout the period covered by this project to issue reports as each section of the work has been completed. The following publications and reports have been issued:

1. *Marketing Desert Grapefruit,* Arizona Agricultural Experiment Station Bulletin 221, May, 1949, 29 pages.
[7]2. *Production, Shipments, Markets and Prices of Desert Grapefruit,* Arizona Agricultural Experiment Station Report No. 83, December 1947, 50 pages.
3. *Possibilities of Paperboard Containers for Fresh Grapefruit,* Arizona Agricultural Experiment Station Report No. 84, September 1948, 14 pages.
4. *A Statistical Handbook for the Desert Grapefruit Industry,* Arizona Agricultural Experiment Station Report No. 87, March 1949, 50 pages.
5. *Bulk-Handling Compared with the Use of Field Boxes in the Harvesting of Desert Grapefruit,* Arizona Agricultural Experiment Station Report No. 89, March 1949, 11 pages.
[7]6. *Estimated Weight of Desert Grapefruit,* a revaluation of the 76-pound estimated weight on Desert Grapefruit, packed in the standard two-compartment, nailed wooden box, in effect on shipments from the California-Arizona Desert area to destinations throughout the United States. Arizona Agricultural Experiment Station Report No. 91, June 1949, 13 pages.

[7]Supply of this report exhausted.

7. *Tree to Car Costs of Marketing Desert Citrus Fruit,* Arizona Agricultural Experiment Station Report No. 92, July 1949, 22 pages.
8. *Retailing Grapefruit and Grapefruit Products in Los Angeles,* Arizona Agricultural Experiment Station Report No. 96, March 1950, 12 pages.
9. *Prices and Markets for Desert Grapefruit,* Arizona Agricultural Experiment Station Bulletin No. 98, May 1950,
10. *Consumer Preference for the Yellow Grapefruit Bag,* May 1948, unnumbered, 2 pages.
11. *Retailing Grapefruit and Grapefruit Products in a Sample Area,* May 1948, unnumbered, 11 pages.

These reports present in detail much of the material summarized in this bulletin. Copies may be obtained by writing to: Department of Agricultural Economics, University of Arizona, Tucson, Arizona.